MOBILE IPV6 EXPERIMENTS ON SIMULTANEOUS AND CONSECUTIVE MOBILITY

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Abstract—Mobility management is crucial for wireless connectivity which has become popular among large and also small organizations. Mobile IP has been developed in order to enable mobile appliances such as notebooks, mobile phones and PDAs. One of the crucial problem that need to be tackle is handover mobile network. Handover in Mobile IPv6 happens when a mobile node moves from one coverage to another. However there are latency and possible packet loss during handover. This paper look at Mobile IPv6 setup using latest MIPL (Mobile IP for Linux) source code and also handover observation, particularly in simultaneous mobile nodes movement and consecutive mobility in Mobile IPv6, by looking on different scenario and aspects.

Keywords: MIPv6, IPv6 Mobility, IPv6 Linux, Mobile IP

I. INTRODUCTION

Mobile IPv6 allows a mobile node to be always addressed by a constant IP address, regardless of where and when the communication takes place. It happens when a mobile node moves from one coverage area to another. Handover process is the process taken by mobile node to establish a connection with new network, provided the original or home Agent of the mobile node knows where the mobile node location. When handover is happening, the mobile device is totally disconnected from the network, whereby any uplink/downlink for the devices is halted. This will reduce the throughput of the mobile communication. Moreover, prolonged handover also causes packet loss. Packet loss will trigger slowdown and resending in TCP that further reduces the throughput. Thus, any new mobility management scheme should reduce the handover latency to a minimum.

In other hands, with explosive growth of internet, the need of larger address is unavoidable. Currently, addresses in IPv4 have almost fully occupied. With IPv6 which has 128-bit addresses compare to IPv4 with 32-bit addresses and many other advantages like auto configuration and IP mobility, IPv6 is highly hoped to solve many of the problems that have in IPv4.

Several other capabilities developed in IPv6 are integrated Quality-of-Services (QoS), improved security and data integrity. The crucial features for mobile wireless network are large number of IP addresses, mandated security header implementation with IP security; address auto-configuration and destination option for efficient routing. The popularity of wireless technologies allows users (hosts) to move freely within large geographical areas but requires good support for mobility. Mobile IPv6 is the more prominent solution for mobility for IP wireless devices.

II. MOBILE IPV6

2.1 Mobile IPv6 Procedures

Figure 1 shows the basic architecture of Mobile IPv6 implementation, with binding update and acknowledgement of mobile node. A mobile node (MN) first needs to determine whether it is currently connected to its home link or a foreign link. If it detects it has moved to a foreign link, it will obtain a care-of-address (COA) through stateless or stateful address auto configuration. The association between a Mobile Node’s home address and COA is known as a “Binding” for the Mobile Node. Mobile Node’s COA is obtained by prefix advertised by Foreign Network router.

When a Home Agent receives a binding update from a Mobile Node, it will register this binding updates, and will respond to the Mobile Node by sending binding acknowledgement to Mobile Node. Figure 1 shows a mobile Node connected with foreign or visited network and
register its current COA with its Home Agent, by sending Binding update to Home agent and receiving binding acknowledgement in return.

Figure 1: Basic Components of Mobile IPv6

An IPv6 mobile Node can inform the Correspondent Node CN), regardless where the CN located, its COA by sending Binding Updates. This allows CN to send packets directly to Mobile Node (Route Optimization), without hassle going through Mobile Node’s Home Agent. This avoids the triangle routing problems that previously occur in Mobile IPv4 (or simply Mobile IP). This will improve routing efficiency and have significant effect if there is more than one Mobile Appliance connecting to Mobile Node. The triangle routing will be eliminated once the Correspondent Node knows the COA of Mobile Node.

2.2 Mobile IPv6 Handoff process and latency

When MN travel to foreign network, it will send a Router Solicitation message to respective router in order to acquire routing prefix, and respective router will send Router Advertisement, together with routing prefix and MN will use this prefix to form a new COA. Once COA is form, MN will send a Binding Update message to its Home Agent, until it completes. The whole process of movement, address formed and registration is called handoff process and delay between handoff is called handoff latency [1], and it can be show by formula:

\[
\text{Handoff Latency} = T_A + T_C + T_{BU}
\]

Where \(T_A\) is a attachment delay (probe and authentication process), \(T_C\) is address configuration delay (COA forming process) and \(T_{BU}\) (binding update from MN to HA) [2].

2.3 Mobile IPv6 Current Implementation

At the moment, only MIPL and USAGI are the standard compliant implementation of Mobile IPv6 on Linux or UNIX based systems. The Helsinki University of Technology MIPL project is behind the only up-to-date Mobile IPv6 implementation for Linux. The Lancaster University in the UK has the oldest implementation. The code and website has not been updated since 1998, so it is considered obsolete.

III. HANDOVER ISSUE

Many studies have been done to improve the performance of Mobile IPv6. Claude Castelluccia [3] has suggested the usage of PIM-SM to reduce the overhead of Binding Update during handover, and also working on generic mobility management framework using a special server in the mobility network, named as Mobility Server. This method is exploiting the higher frequency of micro mobility when compared to macro mobility and is helping to reduce handover latency. Jyh-Cheng Chen [4] suggested combining link layer and network layer handover in Mobile IPv6 in order to speed up the handover process.

This paper emphasis a test on 2 major handover problems, simultaneous mobility and consecutive mobility. Simultaneous mobility is the case when both Mobile Node move and change network at the same time while they are communication with each other. The communication breakdown is expected to occur since signaling is lost during mobility. Simultaneous mobility can be best described in figure 2. While simultaneous network changing take places, Mobile Node 1 still sending the message to Home Address of Mobile Node 2 without any aware that Mobile Node 2 also has change its attachment, and the same goes to Mobile Node 2. It’s expected that packet will drop during this time of location changing, while waiting the registration of both Mobile Nodes to its respective Foreign Network router.
Another handover issues that when a mobile node moving too fast, or in technical term ‘consecutive mobility’. This happens when 1 mobile node communicating with other mobile node moving to a new network. Moving mobile node then will begin binding updates and registrations to its new foreign router. However, before it completes the registration, this moving mobile node again travels to e new network (or returning home). This is shown in figure 3. We will study the performance both simultaneous and consecutive mobility using the latest application of Mobile IPv6.

The mobile IPv6 test bed was setup in Linux Environment. Linux Fedora Core 5 and 6 were used in this experiment. The following criteria were considered for the deployment of Mobile IPv6. Both mobile nodes (MN) must be able to communicate with each other after changing its attachment to the foreign network. It’s expected to have higher error rates because of wireless link used instead of wired. Assignment of IP address to MN is through the stateless auto-configuration. The test bed of the setup is shown below in Figure 4:

Our testbed consist of two separate networks, network 1 and network 2. These two networks are purposely built for the MIPv6 implementation; network 1 is named Home Network 1 and network 2 acts as Foreign Network. The PC Router separate both networks and act as IP packet forwarder and 2 MNs are used in this testbed.

All the software and source code are free and downloadable from Mobile IPv6 for Linux (MIPL) website. It is provided by Helsinki University of Technology. All the machines in the test bed have one wireless interface. The wireless IPv6 implementation is run on native IPv6 network. MIPL software version 2.0.2 is used in this test bed, with Kernel 2.6.16 patch into Home Agent and Mobile Node. Both Home Agent and Mobile Node need their kernel patched, but with different option. The Linux Kernel 2.6.16 is downloadable from his FTP site. The MIPL requires kernel patched because it needs to modify the IPv6 kernel stack, so the recompilation of kernel is necessary. The reason
Kernel 2.6.16 was used because the current MIPL software only supports Kernel 2.6.16.

4.1 Methodology

After every machine has been configured properly and be set up based on figure 6, we began by enable the Router Advertisement Daemon (RADVD) on both Home Agents and check whether both Home Agents sending out the Router Advertisement (by radvdump command). After the RADVD service has been enabled, we set the Mobile Nodes networks to respective Home Agents. We began our inspection on Mobile Nodes by checking the stateless auto-configuration effects on the both Mobile Nodes. Both Mobile Nodes should have all this 3 addresses when the ifconfig is issued; that is Global IP address manually configured at interface, Global IP address and link local address that is based on EUI-64 bit identifier.

After the RADVD and stateless auto-configuration checking has been done, the Mobile IPv6 Daemon (MIP6D) can be start, for both Home Agents and Mobile Nodes. All the test indicate in the previous section can be performed and analyse. Wireshark network analyzer is used to monitor the network behaviour.

The following subsections discuss the metrics for the performance evaluation purpose.

A. Simultaneous Mobility

The first experiment determines the Mobile IPv6 connections when it moves simultaneously (handoff issue). Only 1 MN will be involve in movement. Test was done on 4 different environments:

- Both MN in the same room (near to the Access Point), and initially in the same network (both MN in Home or Foreign network).
- Both MN in the same room, but initially in different networks (1 in Home network, and other in foreign Network).
- 1 MN was moved distance from other (outside the room) but initially both in same network.
- 1 MN was moved distance from other (outside the room) but initially both in different network.

B. Consecutive Mobility

The second experiment determines the Mobile IPv6 in condition where fast movement occur. Consecutive mobility is expected to bring down the connection of both MN. 2 conditions will be test:

- Both MN in the same room (near distance)
- 1 MN being moved out (distance way) from other.

In both experiments, ping6 service was employed. Ping6 is a powerful network tool to test the connectivity. It works by sending an ICMP “echo request” packets to destined host and listening to the “echo response”. It will show the Round-Trip-Time (RTT) and packet loss (if any). Apart from ping6, a network protocol analyzer program, Wireshark was installed on both MN to capture all the packets, and show ‘what’s happening’ in packets its captured for both MN.

V. RESULT ANALYSIS

Upon enabling the router advertisement, there is no need for the Mobile Nodes to manually configure their own IPv6 addresses anymore and thus this eases the user’s burden. Together with its stateless phenomenon; no need for special server, also saves up the administrator’s time and effort in setting up DHCP server.

Pre-conditional test must be check first before the actual test take place. The first test conducted is connectivity in Foreign Network. From the result obtained, whenever one of the mobile nodes goes to other networks, it will maintain connection with its Home Agent. The traveling ‘mobile’ host can also communicate with host in that network directly without going through its Home Agent (route optimization). This can be shown when the host in that particular network can ‘ping’ the local-link address of the Mobile Nodes (link local will not pass through the router if it is set to destination address). The result is shown in Table 1.
Table 1: Connectivity test in foreign network

A. Simultaneous Mobility

With reference to figure 2, simultaneous mobility was done by exchanging both MN to other network. To make sure of this, the communication between Mobile Nodes when they are in respective nodes must be established first. This can be done via the ‘ping’ test to see the ICMPv6 echo packet reply. After everything goes well, we can do the ‘simultaneous’ movement of Mobile Nodes. Table 2 and 3 show the summary of experimental results on simultaneous mobility.

- Both MN in the room

<table>
<thead>
<tr>
<th>Before Movement</th>
<th>After Movement</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>MN1: Home</td>
<td>MN1: Foreign</td>
<td>Connected after ≈30ms</td>
</tr>
<tr>
<td>MN2: Home</td>
<td>MN2: Foreign</td>
<td></td>
</tr>
<tr>
<td>MN1: Foreign</td>
<td>MN1: Home</td>
<td>Connected after ≈30ms</td>
</tr>
<tr>
<td>MN2: Foreign</td>
<td>MN2: Home</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Simultaneous Mobility in the same room

- 1 MN being a distance away (outside from room)

<table>
<thead>
<tr>
<th>Before Movement</th>
<th>After Movement</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>MN1: Home</td>
<td>MN1: Foreign</td>
<td>Connected after ≈30ms</td>
</tr>
<tr>
<td>MN2: Home</td>
<td>MN2: Foreign</td>
<td></td>
</tr>
<tr>
<td>MN1: Foreign</td>
<td>MN1: Home</td>
<td>Connected after ≈30ms</td>
</tr>
<tr>
<td>MN2: Foreign</td>
<td>MN2: Home</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Simultaneous Mobility in different rooms

From the result obtained, it can be concluded that Mobile IPv6 performance with MIPL application works fine. As expected, when the distance is increase between MN and Access Point (AP), the latency will be higher. It’s worth mentioning that other physical factor like AP power, channel used and signal strength also determined the latency of Handoff. It’s also impossible to shutdown the handoff latency (or handover latency), and concern on this will have to note down seriously.

B. Consecutive Mobility

With reference to figure 2, consecutive mobility is done by moving mobile node to other network, but before MN complete it registration with its new network, it goes back to previous network or other network, and resulted in packet loss for connection between 2 MNs. Table 4 show the summary of the result. 1 MN1 will be static while MN 2 will move consecutively.

<table>
<thead>
<tr>
<th>MN1 Location</th>
<th>MN2 Movement</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td>Home–Foreign–Home</td>
<td>Connection Loss</td>
</tr>
<tr>
<td>Foreign</td>
<td>Home–Foreign–Home</td>
<td>Connection Loss</td>
</tr>
<tr>
<td>Home</td>
<td>Foreign–Home–Foreign</td>
<td>Connection Loss</td>
</tr>
<tr>
<td>Foreign</td>
<td>Foreign–Home–Foreign</td>
<td>Connection Loss</td>
</tr>
</tbody>
</table>

Table 3: Consecutive Mobility Result

Results shows that in fast movement (consecutive mobility), the connection between two MN will be lost. Furthermore, result also shows that connection between the moving MN and its Home Agent was also loss, due to registration problem. We have to restart the service, at both Home Agent and Mobile Node in order to connect it back together.

Meanwhile, with MIPv6 implemented, since it has route optimization capability, the
round trip time is expected to be less than Mobile IP in IPv4. A simulation study conducted by Philips and Hu [5] on the TCP performance over Mobile IPv4 and Mobile IPv6 shows that the throughput of MIPv6 improves by more than 15% through its route optimization. The study also reveals that the triangle routing in MIPv4 increases the Round Trip Time (RTT) required in sending packets which leads to increasing in delay that is drop in performance. However, the on-ground testing is yet to be done to validate these simulation finding.

VI. SUMMARY AND CONCLUSION

Mobile IPv6 has a huge advantage and better performance compare to its predecessor, Mobile IPv4. The really beauty of this protocol is the routing optimization capability, which allows Correspondent node to directly send the packet to Mobile Node. This eliminate the heavy workload of Home Agent, as it only involve in initial process of packet sending process, such as Binding Update and Binding Acknowledgement. Wireless Mobile IPv6 has the potential to grow as more appliances such as PDA’s mobile phones and even refrigerator to be connected to internet. Furthermore, it has many advantages, including large number of addresses in IPv6, auto-configuration, IPSec for security and routing optimization.

However, apart from all improvement and enhancement, it still has weakness ‘holes’ in its implementation. This network setup has some problems with router expiry lifetime, which after several minutes, the destination is unreachable. This is most probably the Router Advertisement problem. Researcher in this area also found that it is vulnerable to security attack; most notable one is address notification process. The bad guy can intercept the packet containing Binding Update from MN and cause MN traffic to be directed to attacker IP address, but the propose solution for this problem had been addressed [6]. Mobile IPv6 also has weakness in simultaneous mobility movement of two Mobile Node from different networks, which causing the packet to be dropped. The problem and details can be found in [7].

With the internet trend moving towards mobility and wireless networks, it is inevitable to Mobile IPv6 to set itself as market future. All the holes and bugs are expected to be fixed very soon. More research would have been conducted, and I can be concluded that the future of Internet Mobility is much depended on successful deployment of Mobile IPv6.

REFERENCES