Handoff Latency of Voice over Internet Protocol in Mobile IPv6

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***Abstract* –**Mobile IPv6 (MIPv6) is a protocol that is proposed for the future of the mobile Internet access. The aim of MIPv6 is provide uninterrupted connection while being mobile. VoIP has stringent delay requirement and to improve the performance of VoIP, handoff latency must be keep as low as possible. In this paper the implementation of Fast Handover Mobile IPv6 (FMIPv6) is modeled and simulated using NS2. The performance is analyzed for typical PCM G.711 voice coding scheme for both MIPv6 and FMIPv6.

Keywords: Mobile IPv6; Fast Handover Mobile IPv6; VoIP; handoff

1. Introduction

Voice over Internet Protocol (VoIP) is also known as IP Telephony which enables the transport of voice over data networks such as the Internet. VoIP became a workable alternative to the public switched telephone networks (PSTN) and increasingly deployed on corporate environment and campuses. A number of protocols are used to ensure that voice communication is appropriately established between parties and that voice is transmitted with a quality close to as in PSTN. VoIP involves digitization of voice streams and transmitting the digital voice as packets over conventional IP-based packet networks like the Internet. The quality of VoIP does not yet match the quality of a circuit-switched telephone network due to several challenges such as available bandwidth, delay or network latency, packet loss, jitter, echo, security and reliability. This paper focuses on one of the problem in VoIP implementations, which is in term of latency. The latency which is interested is the handoff or handover latency occurred in MIPv6.

In a mobile Internet environment, when a mobile device intends to move and attach to another network, it needs to obtain a new IP address to continue communications with its correspondents. The IP routing mechanism relies on the information found in IP headers so that they can deliver data to the proper nodes, thus a movement from one location to another requires the old IP connections to be torn down and new connections to be reconstructed. Mobile IP (versions 4 and 6) provides a solution to overcome this problem without major modifications to the routers or the nodes in a network.

There are two types of handoff which are link layer (L2) handoff and network layer (L3) handoff [1]. L2 handoff is a process which a mobile node changes its physical link-layer connection to another. When a mobile node moves to a new Access Point (AP), L2 handoff occurs. L3 handoff usually follows L2 handoff. In L3 handoff, a mobile node identifies that it moves to new link layer where new subnet prefix is used. This mobile node will change its primary CoA to new one. As mobile node moves, change of AP followed by the change of the subnet leads to L3 handoff.

The handoff latency is the primary cause of packet loss in a network and it is found to be a bottleneck in performance studies conducted previously. The performance of real time application such as VoIP, will be effected due to handoff latency. FMIPv6 is a scheme that can reduce handoff latency, which operates either above the IP layer or at the IP layer. This paper will analyze and compare the performance of VoIP in both MIPv6 and FMIPv6.

The paper is organized as follows. Section 2 discuss on the original MIPv6 methods in handover process and agents. Section 3 presents the improved method to reduce handoff latency, which is FMIPv6. Section4 is the simulation methodology and results. Lastly in section 5, conclude the paper.

2. Mobile IPv6

In Mobile IPv6 protocol, each mobile node is identified by a set of IP addresses. When in the home network, a Home Agent (HA) assigns a local address to the mobile node and it is always reachable via its HA. When the node is away from its home, it obtains a Care of Address (CoA) from the foreign router and registers this CoA with its HA. The job of the HA is to intercept any packets destined for the mobile node while it is roaming in a foreign network and tunnel it to the mobile node. The inherent problem in this scenario is that, a timely configuration of CoA is required for continuous communication. The time taken for mobile node to obtain a new address and register it with the HA is the overall handoff latency.

Mobile IP supports mobility of IP hosts by allowing them to make use of two IP addresses: a home address that represents the fixed address of the node and a care-of address (CoA) that changes with the IP subnet the mobile node is currently attached to. An entity is needed that maps a home address to the corresponding currently valid CoA.

In Mobile IPv4 these mappings are exclusively handled by home agents (HA). A correspondent node (CN) that wants to send packets to a mobile node (MN) will send the packets to the MN's home address. In the MN's home network these packets will be intercepted by the home agent and tunneled, such as by IP-in-IP encapsulation, either directly to the MN or to a foreign agent to which the MN has a direct link.

In MIPv6 [2,3], home agents no longer exclusively deal with the address mapping, but each CN can have its own binding cache where home address plus care-of address pairs are stored. This enables route optimization compared to the triangle routing via the HA in MIPv4. In route optimization, a CN is able to send packets directly to a MN when the CN has a recent entry for the MN in its corresponding binding cache. When a CN sends a packet directly to a MN, it does not encapsulate the packet as the HA does when receiving a packet from the CN to be forwarded, but makes use of the IPv6 Routing Header Option. When the CN does not have a binding cache entry for the MN, it sends the packet to the MN's home address. The MN's home agent will then forward the packet. The MN, when receiving an encapsulated packet, will inform the corresponding CN about the current CoA.

In order to keep the home address to CoA mappings up-to-date, a mobile node has to signal corresponding changes to its home agent and/or correspondent nodes when performing a handoff to another IP subnet. Since in MIPv6 both, HA and CN, maintain binding caches, a common message format called binding updates (BU) is used to inform HA and CN about changes in the point of attachment. Additionally, since the BUs have associated a certain lifetime, even if the MN does not change its location a BU to its HA and CNs is necessary before the lifetime expires to keep alive the entry in the binding caches. Binding updates can be acknowledged by Binding Acknowledgement (BA).

In contrast to MIPv4, where signaling is done using UDP, Mobile IPv6 signaling is done in extension headers that can also be piggybacked on regular packets. To acquire a CoA in Mobile IPv6, a mobile node can build on IPv6 stateless and stateful auto-configuration methods. The stateless autoconfiguration mechanism is not available in IPv4

3. Fast Handover Mobile IPv6

To reduce delay and packet loss, a Fast Handovers for Mobile IPv6 (FMIPv6) [4] is introduced into MIPv6. In the fast handover, several portions of the layer 3 handover are performed in advance prior to the handover, such as new care of address (CoA) configuration and movement detection to reduce the handover latency. A tunnel is established between a currently attached access router and an anticipated access router not to lose packets from correspondent nodes during the handover. The fast handover enables the mobile node to quickly detect that it has moved to a new subnet by providing the new access point and the associated subnet prefix information when the mobile node is still connected to its current subnet.

The mobile node initiates the fast handover when a layer 2 trigger takes places. Then, the mobile node sends a Router Solicitation for Proxy Advertisement (RtSolPr) message to its access router to resolve one or more access point identifiers to subnet-specific information. In response, the access router (e.g. previous access router) sends a Proxy Router Advertisement (PrRtAdv) message. With the information provided in the Proxy Router Advertisement message, the mobile node forms a prospective new care-of address and sends a Fast Binding Update (FBU) message.

The purpose of the FBU update is to make the previous router to bind the previous care-of address (PCoA) to the new care-of address (NCoA) and establish tunnel between the previous access router (PAR) and the new access router (NAR), so that packets arrived from correspondent nodes can be tunneled to the new location of the mobile node. The FBU message should be sent from the mobile node at the previous access router's link if possible. When the mobile node could not send the FBU message at the previous access router's link, the FBU message is sent from the new link. It is encapsulated within a Fast Neighbor Advertisement (FNA) message to ensure that the NCoA does not conflict with an address already in use by some other node on link.

When the previous access router receives the FBU message, it sends Handover Initiate (HI) message to the new access router (NAR) to determine whether the NCoA is acceptable at the NAR. When the NAR verifies the NCoA, duplicate address detection (DAD) is performed to avoid duplication on links when stateless address autoconfiguration is used. Confirmed NCoA must be returned in the Handover Acknowledge (HAck) message from the NAR. Then, the PAR must in turn provide the NCoA in a Fast Binding Acknowledgment (FBAck). Thus, new care of address is determined by the exchange of HI and HAck messages.

DAD adds delays to a handover. The probability of interface identifier duplication on the same subnet is very low. However, this probability can not be neglected. In the fast handover, certain precautions are necessary to minimize the effects of duplicate address occurrences. In some cases, the NAR may already have the knowledge required to assess whether the mobile node's address is a duplicate or not before the mobile node moves to the new subnet. The result of this search is sent back to the PAR in the HAck message. The NAR can also rely on its trust relationship with the PAR before providing forwarding support for the mobile node. That is, it may create a forwarding entry for the new care-of address subject to approval from the PAR which it trusts.

For preventing packet loss, this protocol provides an option to indicate request for buffering at the NAR in the HI message. When the PAR requests this feature for the mobile node, it should also provide its own support for buffering. Such buffering can be useful when the mobile node leaves without sending the FBU message from the previous access router's link. The PAR should stop buffering after processing the FBU message.

Operations of the fast handover are composed of predictive mode and reactive mode. In this work, only predictive mode for FMIPv6 is considered. The predictive mode of operation is shown in Figure 1. In this mode of operation, the mobile node receives the FBAck message on the previous link. This means that packet tunneling would already be in progress by the time when the mobile node handovers to the new access router. As soon as the mobile node establishes link connectivity with the new access router, it should send a FNA message immediately, so that buffered packets can be forwarded to the mobile node right away.

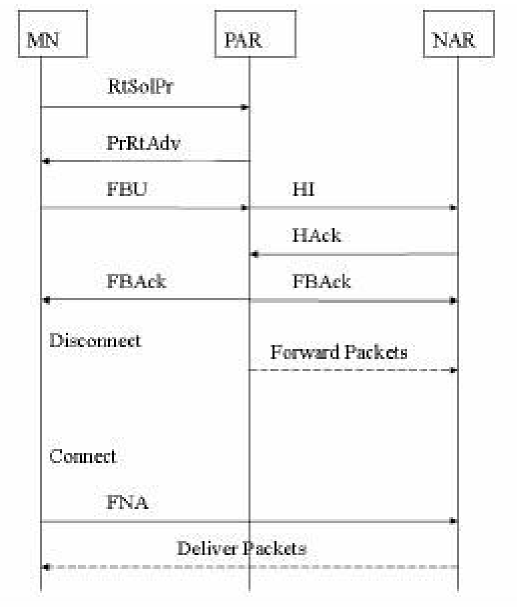

Figure 1: Predictive mode FMIPv6.

For FMIPv6, the registrations of the new care-of address to the home agent and correspondent nodes are performed after it is registered at the new access router. These registrations are the same procedure as MIPv6.

4. Simulation and results

In this section, simulation topology and parameters are presented to compare the handoff latency in MIPv6 and FMIPv6. Previous simulation model based on ns-allinone-2.1b7a as in [5-7], is ported to ns-allinone2.28 according to [8].The network scenario for the simulation is shown in Figure 2.

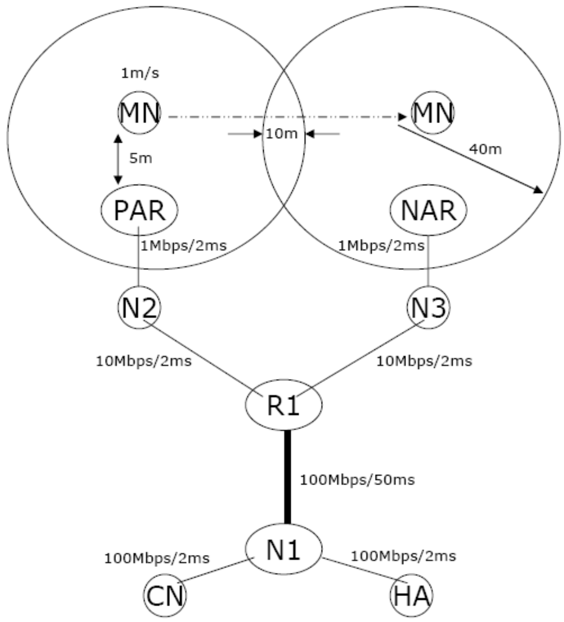

Figure 2: Simulation Model.

The simulation environment consists of a corresponding node (CN), a streaming VoIP traffic over UDP medium setup to a mobile node (MN), home agent (HA), gateway router N1, common router R1, routers N2 and N3, also previous access router (PAR) and new access router (NAR). The IEEE 802.11b is used as access technology and each access router has coverage area of 40 meters in radius with the overlapping region between PAR and NAR is 10 meters. The bandwidth and link delay between two intermediate wired nodes is set as shown in Figure 2. The L2 handoff delay is set to 20ms.

The CN produce a constant bit rate (CBR) traffic source, transmitting packets in an RTP over UDP medium. The MN acts as a sink, by receiving the packets from the CN at a constant inter-arrival rate. Loss monitor agent is attached to the MN to record the packet losses and throughput of the receiving packets.

A one-way VoIP connection is modeled as a stream of packets with a fixed packet size and transmission rate [9]. The CN produces payload of 160 bytes and additional total headers size of 40bytes from RTP, UDP and IP are included to make the total packet size of 200bytes. Each packet is sent every 20ms. This means that 50 packets are sent every second with a packet data rate of 64kbps, correspond to typical PCM G.711 voice coding scheme.

In the beginning of the simulation, MN is situated near the HA. The CN start producing the CBR traffic 5s after the simulation started. One second later, the MN moves toward the transmission range of PAR (5m distance from PAR) at a very high speed of 100m/s. At 10 seconds from simulation time, the MN starts to move toward the NAR at a speed of 1m/s. The handoff process being considered is when MN moves from PAR toward the NAR.

For MIPv6 simulation, handoff latency and packet losses are observed during the movement of MN from PAR to NAR in all 10 independent simulation events. The average value for handoff latency in MIPv6 framework is calculated as 1.898s with packet losses of 95 packets. The minimum value of handoff latency obtained during the 10 simulation events is 1.02s while the maximum value is 2.44s. The handoff latency time will result in service disruption for VoIP application. Figure 3 shows the packet number received by MN during the simulation time, sieved from one chosen simulation even.

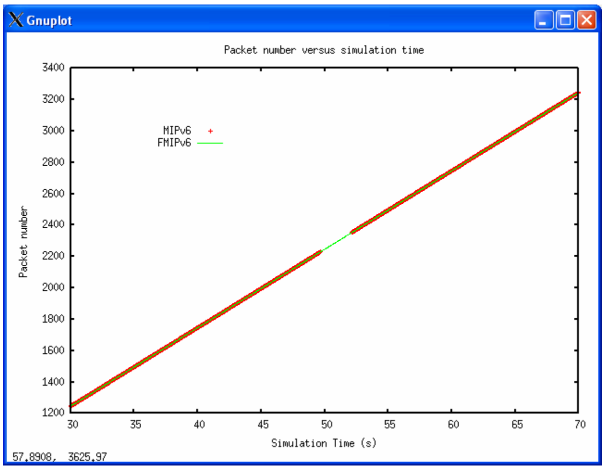

Figure 3: Packet number received by MN.

For FMIPv6 framework, no packet loss is observed during the handoff time. The handoff latency for FMIPv6 is due to the routing when forwarding packet from the PAR to NAR. The average time calculate from the time PAR receives the HACK message from NAR until the NAR receives FNA message is approximately 140ms. Figure 4 shows more details view of packet number received by MN for FMIPv6. In between 40.9s and 41.1s of simulation time, the distraction of time when packet received MN is due to the packet tunneling form PAR to NAR.

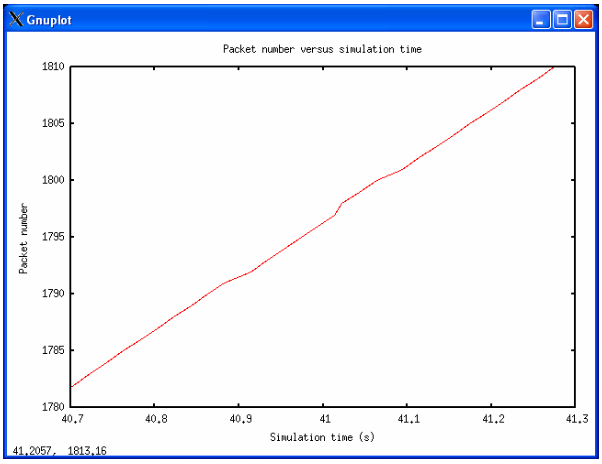

Figure 4: Packet number received by MN in FMIPv6.

Throughput comparison between MIPv6 and FMIPv6 is shown in Figure 5. In terms of average throughput, the FMIPv6 scheme achieves higher system performance. Average throughput obtained for MIPv6 is 60.93 kbps while for FMIPv6, the value is 62.54 kbps.

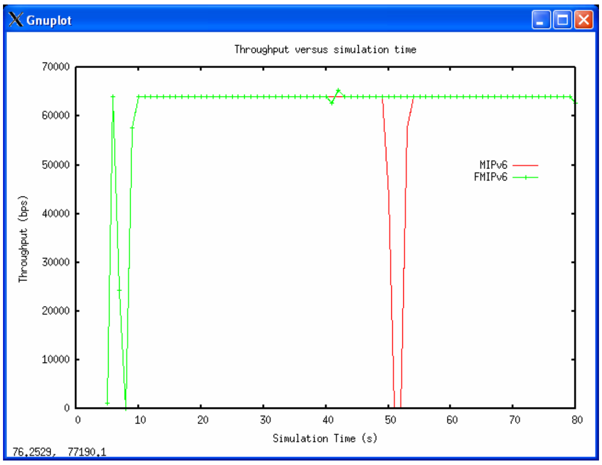

Figure 4: Throughput comparison for both frameworks.

5. Conclusion

Handoff latency in standard MIPv6 normally obtained in more than one second and packet losses occurred during the handoff time. The FMIPv6 is introduced to reduce the handoff latency in MIPv6 that usually occurs in layer 2 and 3. The simulation result shows that FMIPv6 experience transmission delay due to packet routing from PAR to NAR during handoff time and there is no packet loss observed.

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