International Journal of Computing Science and Information Technology, **2013, Vol.1 (02) 22 - 31**
ISSN: 2278-9669,April 2013 (http://ijcsit.org)

OPTIMIZATION OF HARD HANDOFF IN MOBILE COMMUNICATIONS USING IPv6

[1]NWALOZIE G.C, [2]OKOROGU V.N, [3]OGUADINMA C.A, [4]UGWUDA V.O

[1234] DEPARTMENT OF ELECTRONIC & COMPUTER ENGINEERING, NNAMDI AZIKIWE UNIVERSITY,
AWKA ANAMBRA STATE
gechug2002@yahoo.com

okoroguvn@yahoo.com

Abstract

The Mobile IPv6 protocol has drawn a lot of attention and has become one of the most common ways to support IPv6 mobility over the legacy IPv4. In mobile networks, users freely change their service points, while they are communicating with other users. In order to support the mobility of mobile nodes, Mobile IPv6 (MIPv6) is proposed by the Internet Engineering Task Force, in which a mobile node must inform its home agent the binding of its home address and the current care-of-address (CoA). This work proposes a Macro Mobility MIPv6 (3MIPv6) scheme that will leverage on Hierarchical Mobile IPv6 (HMIPv6) and the Fast Handoff (FHMIPV6) to reduce the effect of handoff delays and thus, reduce the handoff time significantly. The 3MIPv6 will address scalability issues as well as throughput, delays, utilization, and packet losses at the event of handoff. The results presented show that the proposed scheme can effectively improve handoff delays and packet loss during macro-mobility. OPNET Modeler is used as the simulation platform for this research work.

Keywords: Handoff, throughput, delay, IPv6

1. Introduction

Today, mobile broadband technologies involve both the air interface and networking architecture. Also, they are being converged to IP-based network architecture with Orthogonal Frequency Division Multiple Access (OFDMA) based air interface technology. Broadband refers to an Internet connection that allows support for data, voice, and video information at high speeds, typically given by land-based high-speed connectivity such as DSL or cable services. On one hand, it is considered broad because multiple types of services can travel across the wideband, and mobile broadband, on the other hand, pushes these services to mobile devices.

Mobile IP (or IP mobility) is an Internet Engineering Task Force (IETF) standard communications protocol that is designed to allow mobile device users to move from one network to another while maintaining a permanent IP address. Mobile IP for IPv4 is described in IETF RFC 5944, and extensions are defined in IETF RFC 4721. Mobile IPv6, the IP mobility implementation for the next generation of the Internet Protocol, IPv6, is described in RFC 6275.The Mobile IP protocol allows location-independent routing of IP datagram on the Internet. Each mobile node is identified by its home address disregarding its current location in the Internet. While away from its home network, a mobile node is associated with a care-of address which identifies its current location and its home address is associated with the local endpoint of a tunnel to its home agent. Mobile IP specifies how a mobile node registers with its home agent and how the home agent routes datagram to the mobile node through the tunnel.

A mobile node has two addresses - a permanent home address and a care-of address (CoA), which is associated with the network the mobile node is visiting. Two kinds of entities comprise a Mobile IP implementation [1]:

- A home agent stores information about mobile nodes whose permanent home address is in the home agent's network.
- A foreign agent stores information about mobile nodes visiting its network. Foreign agents also advertise care-of addresses, which are used by Mobile IP. If there is no foreign agent in the host network, the mobile device has to take care of getting an address and advertising that address by its own means.

A node wanting to communicate with the mobile node uses the permanent home address of the mobile node as the destination address to send packets to. Because the home address logically belongs to the network associated with the home agent, normal IP routing mechanisms forward these packets to the home agent. Instead of forwarding these packets to a destination that is physically in the same network as the home agent, the home agent redirects these packets towards the remote address through an IP tunnel by encapsulating the datagram with a new IP header using the care of address of the mobile node. When acting as transmitter, a mobile node sends packets directly to the other communicating node, without sending the packets through the home agent, using its permanent home address as the source address for the IP packets. Mobility in IPv6 networks [2] has evolved remarkably compared to Mobile IPv4 protocol [3]. Mobile IPv6 (MIPv6) enables transparent routing of IPv6 packets to Mobile Nodes (MNs) from Correspondent Nodes (CNs). The mobility is made possible by using a Home Agent (HA) and a local Care-of-Address (CoA). Unfortunately it is still unsolved how to minimize the handover time between two logical subnets so that the out time is as short as possible.

In the past few years, different proposals have been presented to minimize the handover delay in Mobile-IPv6 networks. Many of the proposed methods require modification of the Access Routers (ARs). Two slightly different handover solutions using multicast routing are presented in [4] and [5]. In [4] the CNs see the MN as a Multicast group. When the MN moves from one subnet to another it joins the Multicast group with its new CoA and if possible, remains connected to the Multicast Group with its previous CoA. In [5] all the CNs, in connection with a particular MN, subscribe to a multicast group. The handoffs of the MN are informed to the CNs via this multicast group. The maintenance of the multicast groups means additional tasks for the network elements.

P.Harini in [6] proposed an Enhanced Hierarchical Mobile IPv6 (E-HMIPv6) architecture based on a novel cross-layer/cross protocol design approach to Improve Handoff Performance in Hierarchical Mobile IPv6. The approach uses Passive Duplicate Address Detection (PDAD) to identify duplicate addresses. The work defined Handoff latency as the time interval from last packet received from serving BS to and new packet received from target BS and explained that Packet loss counts from the MS disconnecting to serving BS to receiving new packets from the target BS.

The authors [7] proposed a novel mobility management scheme, called Handoff Protocol for Integrated Networks (HPIN),that enables QoS guarantee for real-time applications in heterogeneous IPv6-based wireless environments. HPIN performs fast handoff, localized mobility management, context transfer and access network discovery. The aim of HPIN is to allow seamless roaming and services continuity across various access networks. The work for explained that mobility management enables systems to locate roaming terminals in order to deliver data packets (i.e., location management) and maintain connections with them when moving into new subnet (i.e., handoff management) and observes that With the coexistence of various wireless access technologies, two kinds of handoffs are possible viz: horizontal and vertical handoffs. Horizontal or intra-system handoff occurs when an MN moves between the access points (APs) or base stations (BSs) of a same network technology. When AP/BSs belong to different networks (e.g., IEEE802.11 and UMTS), such movement refers to vertical or intersystem handoff. 4G or next-generation wireless networks (4G/NGWN) characteristics make the implementation of vertical handoff more challenging than horizontal handoff

The problem currently faced by emerging mobile communications is to design architecture of the network model to support real-time media applications such as Voice over IP VoIP, data as well as video applications. One of the key issues in context is to provide the Quality of Service (QoS) consistent with the user expectations. This is recognized as the single biggest challenge in providing high-quality mobile IP based networks. In mobile networks, one of the principal additional factors affecting QoS is minimizing service disruption during handoffs of the mobile nodes. It is shown that packet loss or packet error over wireless links can cause significant throughput degradation in TCP applications, owing to the TCP flow control algorithm. A macro mobility approach that will address throughput, delays, utilization, and packet losses at the event of handoff will be widely accepted. As such this work proposes a Macro Mobility Mobile IPv6 (3MIPv6) to solve this challenge.

2. Overview of Handoff

Handoff (handover) refers to the mechanism by which an ongoing session is transferred from one BS to another as seen in Fig.1. It could also be defined as the process of transferring an ongoing call or data session from one channel connected to the core network to another [8]. In mobile networking, with cellular deployment crossing multiple cells, on the move is inevitable. Hence, the serving base station (BS) changes with mobility. A serving BS might change depending on the load conditions as well in which MS is involuntarily shifted to another BS in order to balance the network load.

Therefore, a handoff decision mechanism is an indispensable function of a cellular network. The decision for handoff could be based on several parameters: signal strength, signal to interference ratio, distance to the base station, velocity, load, etc. The performance of the handover mechanism is extremely important in mobile cellular networks, in maintaining the desired quality of service (QoS). For instance, Fig.2 illustrates a typical signal strength reading as mobile station traverses to another cell.

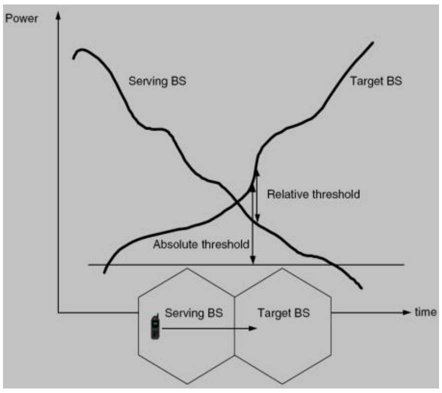

Figure 1: Handoff

A handover decision may be triggered either when the target signal strength is higher than serving signal strength or when serving signal strength falls below a threshold. One can see that former may induce handover early but sustain better quality connection; however, the latter induces robust but poor quality connection since wireless channel introduces random large-scale variation in the received signal strength and handover decision mechanism based on measurements of signal strength induces the “ping-pong” effect, frequent handovers due to false triggers. Frequent handovers influence the QoS, increase the signaling overhead on the network, and degrade throughput in data communications.

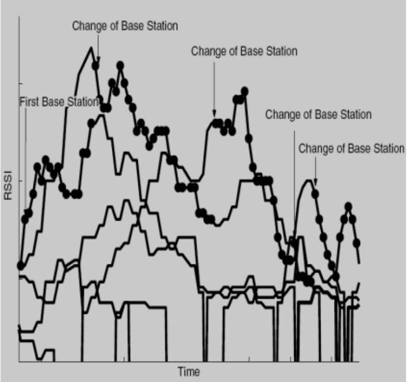

Figure 2: RSSI readings and handover decision

Thus, this work recommends that network operators should consider smart deployment strategies along with intelligent handover decision algorithms to efficiently use the network bandwidth while providing QoS.

In Communications, there may be different reasons why a handover might be conducted, these might include:

- When the phone is moving away from the area covered by one cell and entering the area covered by another cell the call is transferred to the second cell in order to avoid call termination when the phone gets outside the range of the first cell;
- when the capacity for connecting new calls of a given cell is used up and an existing or new call from a phone, which is located in an area overlapped by another cell, is transferred to that cell in order to free-up some capacity in the first cell for other users, who can only be connected to that cell;
- in non-CDMA networks when the channel used by the phone becomes interfered by another phone using the same channel in a different cell, the call is transferred to a different channel in the same cell or to a different channel in another cell in order to avoid the interference;
- Again in non-CDMA networks when the user behaviour changes, e.g. when a fast-travelling user, connected to a large, umbrella-type of cell, stops then the call may be transferred to a smaller macro cell or even to a micro cell in order to free capacity on the umbrella cell for other fast-traveling users and to reduce the potential interference to other cells or users (this works in reverse too, when a user is detected to be moving faster than a certain threshold, the call can be transferred to a larger umbrella-type of cell in order to minimize the frequency of the handovers due to this movement);
- In CDMA networks a handover (see further down) may be induced in order to reduce the interference to a smaller neighboring cell due to the "near-far" effect even when the phone still has an excellent connection to its current cell, etc.

The most basic form of handover is when a phone call in progress is redirected from its current cell (called source) to a new cell (called target). In terrestrial networks the source and the target cells may be served from two different cell sites or from one and the same cell site (in the latter case the two cells are usually referred to as two sectors on that cell site). Such a handover, in which the source and the target are in different cells (even if they are on the same cell site), is called inter-cell handover. The purpose of inter-cell handover is to maintain the call as the subscriber is moving out of the area covered by the source cell and entering the area of the target cell. A special case is possible, in which the source and the target are one and the same cell and only the used channel is changed during the handover. Such a handover, in which the cell is not changed, is called intra-cell handover. The purpose of intra-cell handover is to change one channel, which may be interfered, or fading with a new clearer or less fading channel.

2.1 Types of Handover

In addition to the above classification of inter-cell and intra-cell classification of handovers, they also can be divided into hard and soft handovers:

- A hard handover is one in which the channel in the source cell is released and only then the channel in the target cell is engaged. Thus the connection to the source is broken before or 'as' the connection to the target is made—for this reason such handovers are also known as break-before-make. Hard handovers are intended to be instantaneous in order to minimize the disruption to the call. A hard handover is perceived by network engineers as an event during the call. It requires the least processing by the network providing service. When the mobile is between base stations, then the mobile can switch with any of the base stations, so the base stations bounce the link with the mobile back and forth. . This work leverages on this type of handover model to achieve macro-mobility switching with zero latency, handoff delay and good QoS
- A soft handover is one in which the channel in the source cell is retained and used for a while in parallel with the channel in the target cell. In this case the connection to the target is established before the connection to the source is broken, hence this handover is called make-before-break. The interval, during which the two connections are used in parallel, may be brief or substantial. For this reason the soft handover is perceived by network engineers as a state of the call, rather than a brief event. Soft handovers may involve using connections to more than two cells: connections to three, four or more cells can be maintained by one phone at the same time. When a call is in a state of soft handover, the signal of the best of all used channels can be used for the call at a given moment or all the signals can be combined to produce a clearer copy of the signal. The latter is more advantageous, and when such combining is performed both in the downlink (forward link) and the uplink (reverse link) the handover is termed as softer. Softer handovers are possible when the cells involved in the handovers have a single cell site.

In mobile communications, the advantage of the hard handover is that at any moment in time one call uses only one channel. The hard handover event is indeed very short and usually is not perceptible by the user. In the old analog systems, it could be heard as a click or a very short beep, in digital systems it is unnoticeable. Another advantage of the hard handoff is that the phone's hardware does not need to be capable of receiving two or more channels in parallel, which makes it cheaper and simpler. A disadvantage is that if a handover fails the call may be temporarily disrupted or even terminated abnormally. Technologies, which use hard handovers, usually have procedures which can re-establish the connection to the source cell if the connection to the target cell cannot be made. However re-establishing this connection may not always be possible (in which case the call will be terminated) and even when possible the procedure may cause a temporary interruption to the call.

2.2 Overview Mobile IPv6

Mobile IP was designed by IETF in two versions Mobile IPv4 [9] and Mobile IPv6 (MIPv6) [10]. The main goal of the protocol is to allow mobile nodes to change its point of attachment to the Internet while maintaining its network connections. This is accomplished by keeping a fixed IP address on the mobile node (Home Address or HAd). This address is unique, and, when the mobile node is connected to a foreign network (not its usual network) it uses a temporal address (Care-of Address or CoA) to communicate, however, it is still reachable through it’s HAd (using tunnels or with special options in the IPv6 header). Essentially, MIPv6 has three functional entities, the Mobile Node (MN), a mobile device with a wireless interface, the Home Agent (HA), a router of the home network that manages localization of the MN, and, finally the Correspondent Node (CN), a fixed or mobile node that communicates with the MN.
The protocol has four phases:

1. Agent Discovery: The MN has to discover if it is connected to the home network or to a foreign one. In this case, router advertisements are used to propagate the discovery phase. That is, those messages are sent periodically by all IPv6 routers and include information for client auto configuration. Using this information, the MN obtains a CoA.
2. Registration: The MN must register its CoA to the HA and to CN’s. This way, they know”who” is the MN (HAd) and”where” it is (CoA). Some messages related to this phase are”Binding Update” (BU) and”Binding Acknowledgment” (BA).
3. Routing and Tunneling: MN establishes a tunnel with the HAd (if it is necessary), and it is able to receive and send data packets (using the tunnel, or directly).

4. Handover: MN changes its point of attachment. It must discover in which network it is connected (phase 1) and register its new CoA (phase 2). During this phase, some data packets (sent or received by the MN) can be lost or delayed due to incorrect MN location.

Limitations

The Mobile IP has the following shortcomings:

1. The packets sent from a CN to an MN are received by the HA before being tunneled to the MN. However, packets from the MN are sent directly to the CN. This inefficient mechanism of non-optimized Mobile IP is called triangular routing. It results in longer routes and more delay in packet delivery.
2. When an MN moves across two different subnets, the new CoA cannot inform theold CoA about MN’s current location. Packets tunneled to the old CoA are lost.

2.3 Mobility in IEEE 802.11

The Wireless LAN protocol [10] is based on a cellular architecture, where each cell is managed by a Base Station (BS, commonly known as Access Point or AP). Such a cell with the BS and the stations (STA) is called a Basic Service Set (BSS) and can be connected via a backbone (called Distribution System or DS) to other cells, forming an Extended Service Set (ESS). All these elements together are one single layer 2 entity from the upper OSI layers’ point of view. APs announce their presence using periodic “Beacon Frames” containing synchronization information. If a STA desires to join a cell, it can use passive scanning, where it waits to receive a “Beacon Frame” or active scanning, when it sends “Probe Request” frames and receives a “Probe Response” frame from all available APs. Scanning is followed by the Authentication Process and if that is successful, the Association Process. Only after this phase is complete the STA capable of sending and receiving data frames. STAs are capable of roaming, i.e. moving from one cell to another without losing connectivity but the standard does not define how it should be performed, it only provides the basic tools for that: active/passive scanning, re-authentication and re-association [11].

From [11], the most critical part of this technology (WLAN + Mobile IP) is the handoff as discussed above. During this phase, the mobile node (MN) is not able to send or receive data, and some packets may be lost or delayed due to intermediate buffers. This is often unacceptable for real-time or streaming applications (i.e. VoIP) as case. According to the measurements performed in [12], the WLAN/IPv6/Mobile IPv6 handoff takes about 2 seconds. This time is unacceptable for VoIP traffic and other real time traffics. The IETF “MIPv6 Signaling and Handoff Optimization” working group has designed Fast Handovers for Mobile IPv6 (FMIPv6) in order to speed it up. This project argues that an optimal fast handover major goal is to reduce both the handover latency (the duration of the handover) and the packet losses to zero as explained.

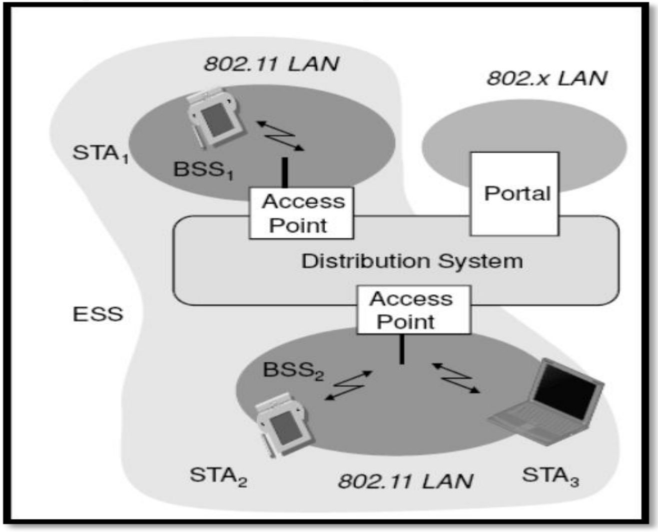

Figure 3: IEEE 802.11 Architecture

3. Methodology

An analytical approach as well as the use of discrete event simulation, was found suitable for this work. In this work, it was hard to find a tractable analytical approach that can be used to obtain practical results. However, conceptual models alongside with discrete event simulation methodologies helped to develop an experimental test-bed by predictive and reactive provisioning.

3.1 The Test-bed

Our test-bed is composed of three access routers, two APs, one MC, one MN and one correspondent node (CN). The test-bed contains three IPv6 subnets. The top access router provides IPv6 Internet connectivity to the rest of the test-bed and is also configured as a HA. Each AP is connected to a different IPv6 subnet and access router. Figure 4 illustrates the test-bed.

3.2 Selection of Wireless Devices

It is now well known that the time required by a layer 2 handover strongly varies according to the wireless devices. In a first (production) evaluation of the mobile Handover in the test-bed, this work used a CISCO AP (Linksys), and 3Dlink 802.11 a/b/g PCMCIA wireless card managed by the Dlink-WiFi driver that fits the Mobile Handover specifications.

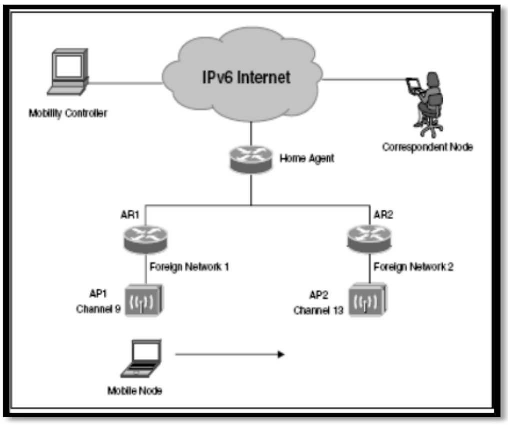

Figure 4: 3MIPV6 test-bed.

Therefore, this was adapted via the AP in the simulation model also. Due to the nature of the IPv6 protocol, the 3MIPv6 implementation requires fine grained control over the behaviour of the wireless card (nodes) so that it could be efficient. Hence, this work assumed and retained the 3Dlink card and its driver for the mobility study.

3.3 Implementation of 3MIPv6

For a good analysis of the hard handover scheme proposed using 3MIPV6, this work deemed it necessary to build up a good set of tests in the Simulation environment comprising of active voice/VoIP traffic and ran a set of 10 tests each in the scenarios for 5 minutes long, from where a set of 40 valid handovers was extracted.

In order to evaluate the 3MIPv6 protocol and the test-bed implementation, this work used two different packet rates and sizes for the mobile nodes and other mobility components in the test-bed. Half of the tests had 64kbps traffic, now this flow simulates with UDP the properties of VoIP traffic under IPv6. It sends 34 packets per second with 252 bytes of payload as stated in. Due to the low rate needed for voice/VoIP, the other tests are done on a higher packet rate, so the impact of a different bandwidth can be studied. This flow (Data) sends 84 packets per second with a payload size of 762 bytes per packet. As part of the main goal, this work seeks to analyze the 3MIPV6 implementation, check if it works as expected and provide performance results from stated QoS metrics, especially regarding its handover latency and the QoS parameters during macro-mobility.

To test the implementation under stress conditions requires having multiple MNs and APs which is very difficult to deploy in a real test-bed. These kinds of test are left as future work but implemented in this work using the simulation platform. All the tests are from the CN to the MN. With 3MIPv6, when the packets flow in this direction, the access routers must tunnel and buffer packets showing an interesting behavior. However, when the traffic source is the MN, there is no need to tunnel packets, just to buffer them on the MN (the 3MIPv6 handover latency remains constant for both directions), hence this research focused on the CN–>MN direction.

4. Simulation and Result

The object representation in OPNET tool shows the actual physical location and movements of the mobile nodes. Also, for mobility flow explanations, packet tracer was used to create an animation model. The network test-bed is square shaped, and contains sub-networks that are also circular. The size of the subnets is 10x10m, and there is *n*x*n* sub-networks in our network, where "*n*" is a global parameter. Therefore there are *n*x*n* access points. The global parameter "server_number" determines the number of servers, "homeAgent_number"determines the number of home agents, and "mobile_number" determines the number of mobile nodes. At the beginning of the simulation, the mobile nodes are placed on a random location, with a random speed (*x*, *y*) of movement. This speed changes periodically and randomly during the simulation. If a mobile leaves the simulation area, it enters on the "other side" again. Other parameters used are shown in table 1. This scenario can be seen on Figure 5. The parameters were selected based on the expectations of 3MIPV6, HMIPV6 and FHMIPV6. Hence, these are optimal values for the Macro-mobility analysis in this work To validate the reliability of the simulation environment some experimental measurements were carried out to ascertain QoS metrics for the 3MIPv6 as well as FMIPV6 and HMIPV6 .The major statistical parameters or metrics investigated in this work includes: Throughput, latency, Packet losses, and Utilization and stability responses. The responses were compared against FMIPV6 and HMIPV6. This is shown in the plots below; the results presented showed that the 3MIPV6 had better performance from the plots compared with FMIPV6 and HMIPV6 in the context of the adopted metrics

Table 1 parameters used and their property

RTS Threshold(Bytes)	1024
Fragmentation Threshold	2048
Data rate	54Mbps
PHY Characteristics	DSSS/OFDM
Packet Reception Power Threshold(W)	7.33E-14
Short retry Limit	3
Triangled&Direct Sending	Enable
Mobile Nodes	30per subnets
Subnets	3
Servers(Mobile controller)	3
Home Agents(HA)	3

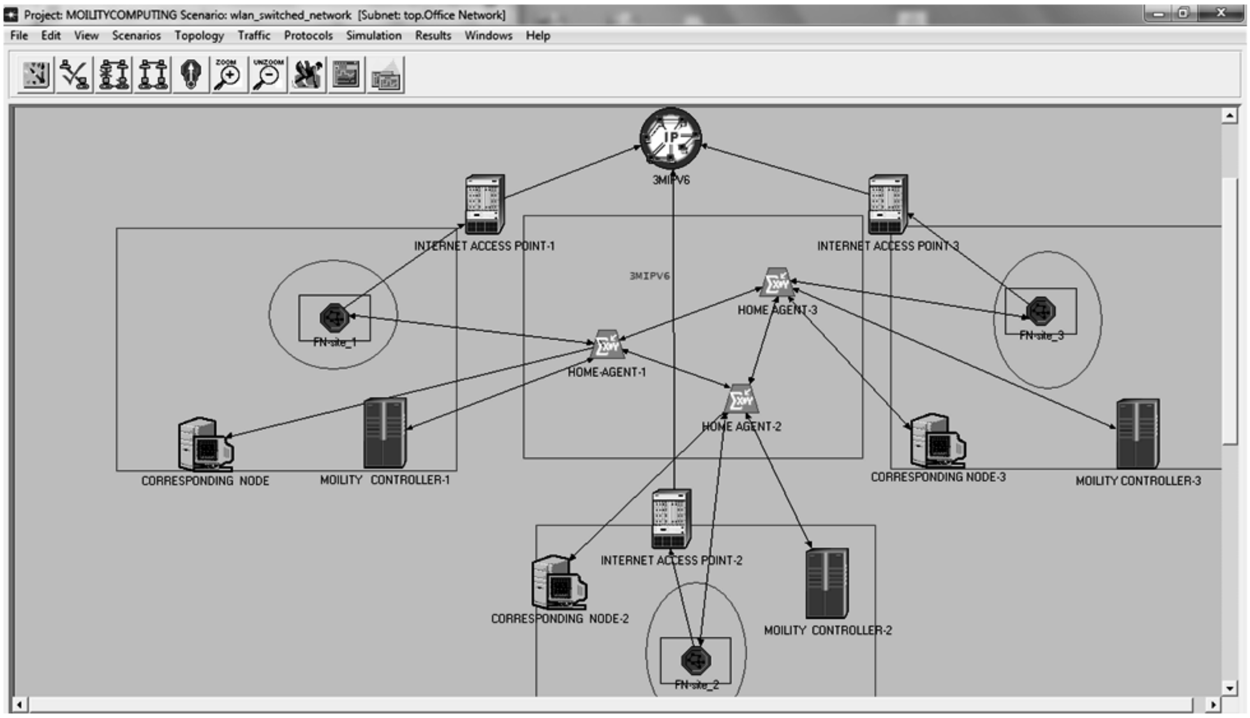

Figure 5. **OPNET Screenshot 3MIPV6 simulation environment Analysis**

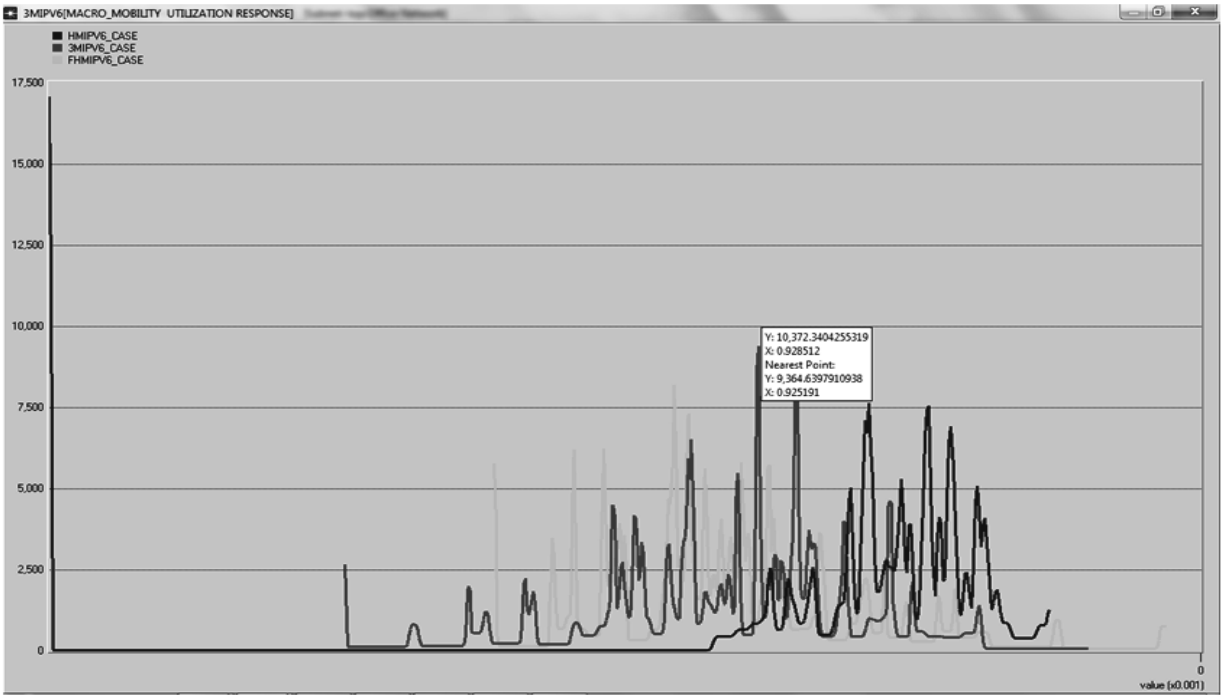

Figure 6: **Macro-mobility Utilization responses in the context of user access to location remote resources.**

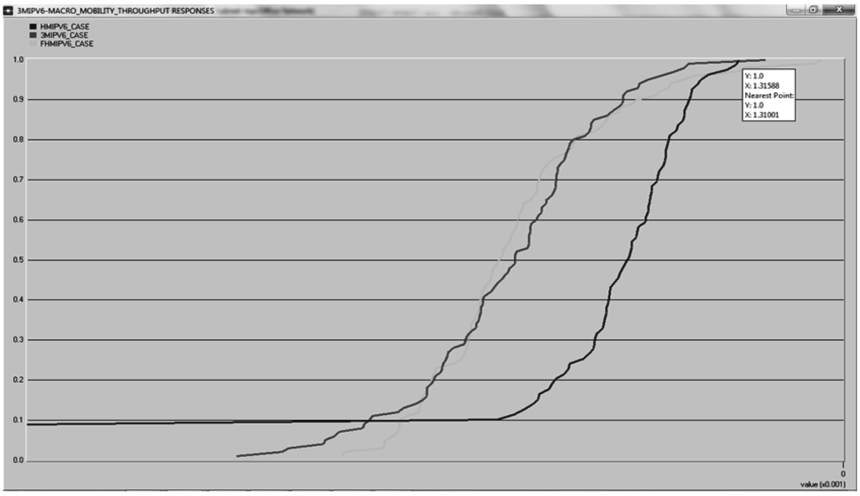

Figure 7: Macro-mobility throughput responses

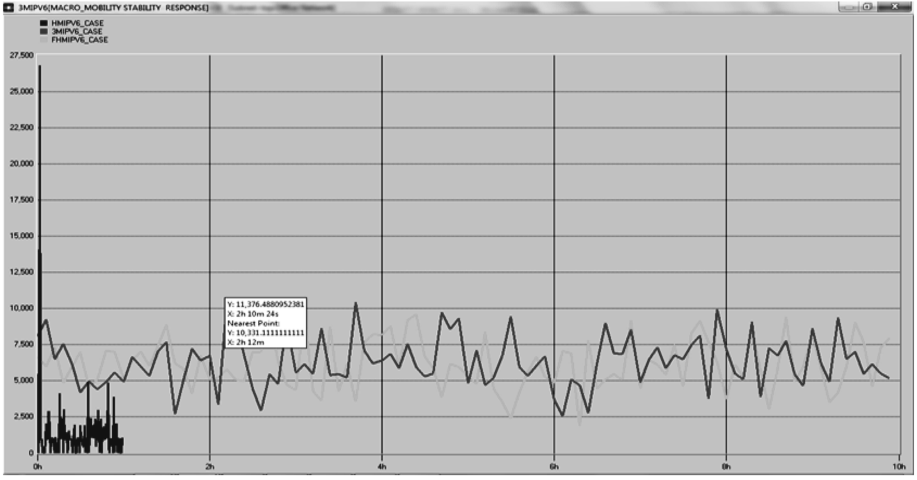

Figure 8: Macro-mobility stability responses

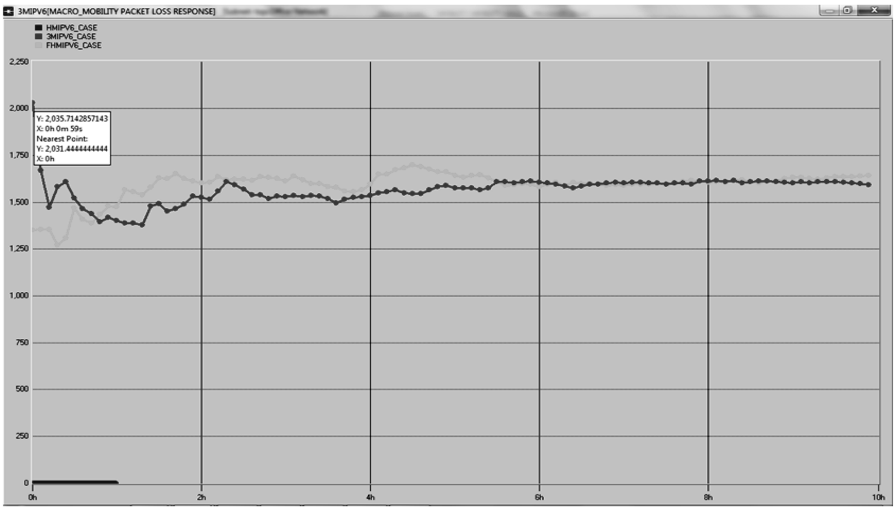

Figure 9. Macro-mobility Packet loss responses

5. Conclusion

With wide deployment of wireless technologies which allows users to move while communicating, macro-mobility has emerged with its challenges. The Hierarchical Mobile IPv6 protocol (HMIPv6) and the Fast Handoff (FHMIPV6) enables transparent movement across separate IPv6 subnets. However, the procedures accompanying such terminal mobility vis-à-vis HMIPV6 and FHMIPV6 are often a cause of delays in ongoing communication in the context of macro-mobility. This work has presented a3MIPV6 as a scheme that can efficiently address the macro-mobility problems in mobile communication networks. It presented a steady-state probability model within a MAP domain for improved performance in mobility communication. Through a 3MIPV6 test bed, this work experimented, evaluated and compared performance of the 3MIPv6, and the Fast Handovers for Mobile IPv6 (FMIPv6) when the mobile node (MN) receives a video/voice stream or participates in a data conversation.The results presented have shown that the 3MIPv6 protocol achieve seamless handovers in the context of quality of service. It took approximately 22.4*ms* in the experiments to complete the simulation runs due to the selected wireless device and took about 2minutes in the evaluation test-bed and when configuring the sending frequency of Router Advertisements at the highest possible rate, the MN stopped losing data packets whenever the voice/VoIP traffic or video stream or video conference scenarios is executed .

REFERENCES

[1] D. Johnson, C. Perkins and J. Arkko, “Mobility Support in IPv6”, IETF draft, work in progress, 2003.

[2] C. Castelluccia, “HMIPv6: A Hierarchical Mobile IPv6 Proposal” ACM Mobile Computing and Communications Review, vol.4, no.1, pp. 48-59, January 2000.

[3] A. Cabellos-Aparicio, R. Serral-Graci`a, L. Jakab, J. Domingo-Pascual: Measurement based analysis of the handover in a WLAN MIPv6 scenario Passive and Active Measurements 2005, Springer, LNCS 3431, pp 203-214.

[4] C. Castelluccia, “A Hierarchical Mobility Management Scheme for IPv6”, Proceedings of the Third IEEE Symposium on Computers and Communications 1998 (ISCC ’98), 30 June-2 July 1998, Page(s): 305-309

[5] T. Ernst, C. Castelluccia and H.-Y. Lach, “Extending Mobile-IPv6 with Multicast to Support Mobile Networks in IPv6”, 1st European Conference on Universal Multiservice Networks 2000 (ECUMN 2000), 2-4 Oct. 2000, Page(s): 114-121.

[6] P. Harini, “A Novel Approach to Improve Handoff Performance in Hierarchical Mobile IPv6 using an Enhanced Architecture” International Journal of Computer Science and Technology, IJCST Vol. 2, Issue 1, March 2011.

[7] Christian Makaya *, Samuel Pierre, “Adaptive handoff scheme for heterogeneous IP wireless Networks” Computer Communications 31 (2008) 2094–2108.

[8] Mohanty, S. “A new architecture for 3G and WLAN integration and inter-systemhandover management”. Wireless Networks, Vol 12, No 6, November 2006, pp. 733-745.

[9] D. Johnson, C. Perkins and J. Arkko: IP Mobility Support for IPv6 *RFC 3775* (2004)

[10] Albert Cabellos-Aparicio et al , “Evaluation of the Fast Handover Implementation for Mobile IPv6 in a Real Testbed” ,(unpublished).

[11] Misra, A., Das, S., Dutta, A., and McAuley, A., and Das, S.K “ IDMP-based fast handoffs and paging in IP-based 4G mobile networks”. IEEE Communications Magazine, Vol 4, No 3, March 2002, pp. 138-145.

[12] Hiussi, F.M., Khotimsky, D.A., and Krishnan, S. (2002). Mobility management in third generation all-IP networks. IEEE Communications Magazine, Vol 40, No 9, Sep 2000, pp. 124-135.

[13] Akyildiz, I.F., Xie, J., and Mohanty, S. “A survey of mobility management in next generation all-IP-based wireless systems”. IEEE Wireless Communications Magazine, Vol. 11,No 4, Aug 2004, pp. 16-28.

[14] Perkins, C.E. (2008). IP mobility support for IPv4, IETF RFC 3344, draft-ietf-mip4 rfc3344bis-07, October 2008.

[15] Y. Zhang and D.liu, “Adaptive algorithm for call Admission control in wireless Networks,”

IEEE Global Telecom conference (GLOBECOM' 01), Vol 6,2011, pp.3628-3632.

[16] Perkins, C.E., and Johnson, D.B. (2001). Route optimization in Mobile IP. Internet draft, IETF, draft-ietf-mobileip-optim-11.txt,September 2001.

[17] Salsano, S., Polidoro, A., Mingardi, C., Niccolini, S., and Veltri, L. (2008). SIP- basedmobility management in next- generation networks. *IEEE Wireless Communications*, Vol 15, No 2, April 2008, pp. 92-99.

[18] A Jera, A. Molinaro and S. Marano," Handoff management with mobility Estimation in Hierarchical systems," IEEE Transaction on vehicular Technology vol.51, Sept 2012, p.915-934.