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Performance Enhancement of Quality of Service of IP Mobility for Real-Time Traffic

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***Abstract*– Future Internet traffic will be huge both for real time and non-real time traffic in an IP mobility environment due to proliferation of mobile nodes. MIPv4 is one of IETF defined IP mobility protocols but with QoS issues like end-to-end delay due to triangular routing, jitter and throughput. OPNET Modeler 14.5 was used in this research to simulate MIPv4 based WiMax network combining MPLS and Diffserv to improve upon the service quality of the network. The end-to-end delay for 20 mobile nodes (MN) was reduced considerably to less than 0.09 second for VoIP traffic and 0.7 second for video conferencing. Jitter was virtually eliminated and good improvement on service throughput. With this improvement in MIPv4 network performance, it can be integrated with MIPv6 network for better future Internet service delivery.**

***Index Terms*– Diffserv, Mobile IP, MPLS, VoIP, Video Conference and WiMax**

I. INTRODUCTION

INTERNET connectivity has evolved overtime. Connection to the Internet could only be achieved formerly until fixed access points are linked either at homes, offices, or business places but of recent devices like PDAs, iPhones, iPods, Androids, other handhelds can be connected to the Internet anytime and anywhere. The users of these mobile devices enjoy connections to the Internet service provided by the cellular operators as they roam from one cell to another without noticing the effects of transition from one base station (BS) to another [1], [2]. This seamless ubiquitous experience through cellular technology is being extended to IP nodes and this informs the Internet Engineering Task Force (IETF) request for comments (RFC) on mobile version of the Internet Protocol called Mobile Internet Protocol (MIP). MIP is an IETF standard communications protocol designed to allow mobile device users to move from one network to another while maintaining a permanent IP address. There are two versions of MIP which are MIPv4 and MIPv6, they are the IP mobility implementation for the next generation of Internet Protocol [3], [4], [5].

Having said that the internet was originally designed as a location dependent network, but with the recent advancements in wireless technologies such as worldwide interoperability for microwave access (WiMax), it has become increasingly necessary to introduce more efficient mobility into the internet. Management protocols were created to handle this mobility by watching over Mobile Nodes (MN) and ensuring reliable delivery of packets as the Mobile Node moves from place to place. These protocols can either be node based depending on which entity handles mobility signaling [3]. Mobile IP, a network based mobility management protocol, handles its mobility with the aid of two network entries, the Mobility Access Gateways and the Local Mobility Anchor (LMA). The invention of MIPv6 has led to a shift from the use of MIPv4.

However, MIPv4 is not completely cast out as it can be improved on by utilizing various QoS approaches. The need for a protocol to support mobile nodes devices movement from one cell/subnet to another led to researches on IP mobility. The existing protocol then was the IPv4 which was basically designed for fixed nodes. Hence, the quest to make IPv4 become mobile gave birth to the Mobile IPv4 (MIPv4). According to IETF [6], [7], a mobile node has two addresses which are Home Agent Address and the Care-of Address (CoA). The former is permanent while the latter changes and is associated with the network the MN is visiting.

In this section, the reasons for IP mobility have been unveiled with particular reference to the protocol supporting IP mobility. Section II gives better explanation of the problems associated with them and how researchers have attempted to solve some of the problems. The network design and implementation of this research work are presented in section III followed by the results and discussions in section IV while the conclusion of this article is available in section V.

II. LITERATURE REVIEW

The two major issues of concern in this 4G network are IP mobility and quality of service (QoS) supports [8]. QoS provisioning will include prioritization of traffic, controlled jitter and latency, bandwidth optimization for real time and interactive traffic and improved loss characteristics. However, IP mobility support will be very crucial because mobile computers will account for a majority of Internet population in the next generation converged network. Hence, the IETF

Mobile IP Working Group designed mobile IPv6 (MIPv6) to achieve IP mobility that will enable IP nodes to move from one subnet to another.

Some of the changes in IPv6 towards achieving mobility are a set of mobility options to include in mobility messages; a new home address option for the destination options header; new type 2 routing header; new Internet Control Message Protocol for IPv6 (ICMPv6) messages to discover the set of home agents and to obtain the prefix of the home link; changes to router discovery messages and options; and additional neighbour discovery options. The MIPv6 called the Next Generation Protocol ('IPng') in itself has a lot of challenges yet unsolved ranging from handover delay, switching delay, multicasting, load balancing, security and so on [9]. Switching performance has to be improved upon to achieve seamless roaming between different subnets [10], [11]. This is necessary because during handover process from one subnet to another, MN goes through mobile testing, new address configuration, neighbour router detection, duplicate address detection, binding update and all these are normally characterized with switching delays [4].

The routing of packets is such that packets from the Correspondent Nodes (CN) destined for the MN are routed through its home agent address which then redirects the packet in an IP tunnel by encapsulating the datagram with a new IP header using the MN's CoA address because the foreign agent has become the MN's default router. However, when the MN is communicating, it sends packets directly to the CN without the knowledge of the Home Agent but uses its permanent home address as the source address for the IP packets. This triangular routing process is peculiar to MIPv4 [11] and it is not good for real time communication especially for delay sensitive applications like video and voice traffics. Though a route optimization approach of binding cache entry at the correspondence node (CN) has been proposed as the solution to triangular routing problem of mobile IP but not fully exhausted [13].

As a result of the characteristic delays associated with MIPv4, researchers began to make contributions on how to optimize this mobile protocol. Some of the later improved versions of MIPv6 that gave birth to Fast MIPv6 (FMIPv6) introduced the link layer mobility prediction or link layer trigger mechanisms. In this IETF proposal, the MN issues Fast Neighbour Advertisement (F-NA) messages, then data exchange is possible between new Access Router (nAR) and MN. It reduces handover latency and data loss rate while increasing a new signal load [14], [15].

To provide QoS over dynamic mobile environment, it has been said that MIP can be integrated with Multiprotocol Label Switching (MPLS) [16]. MPLS is an IETF specified framework which allows for efficient designation, routing, forwarding and switching of traffic flows through the network. It maps IP addresses to simple, fixed length labels used by different packets forwarding and switching technologies. A label is an identifier which denotes a forwarding equivalence class (FEC) [17], [18]. A FEC is a group of IP packets given the same treatment and forwarded over the same path [16], [15]. Since the labels are short and of fixed length, MPLS can achieve high efficiency compared with conventional IP routing where longest prefix matching is normally used [19].

In the IP routing, packet forwarding is done on hop-by-hop basis using any of the Interior Gateway Routing Protocol (IGRP) and Exterior Gateway Routing Protocol (EGRP) depending on the administration. This process can be repetitive and characterized with a lot of delays at each hop (switch or router) especially in the core network. MPLS brings in QoS and overcomes these challenges by forwarding packets based on their class of service (CoS) requirements. Also, MPLS is very versatile in that it supports IP, frame-relay and remains independent of layer 2 and 3 protocols. It specifies mechanisms to manage traffic flows of various granularities that is flows between hardware, machines and between different applications. Data transmission is done by making use of established label switch paths (LSPs) between the ingress and the egress routers (Label Edge Routers) in an MPLS domain **[9],** [17], [18].

III. DESIGN AND IMPLEMENTATION

The study was aimed at applying improvement mechanism to MIPv4 and compare the performance of the improved with MIPv4 and MIPv6 without any improvement mechanism. QoS investigated include packets sent and received, end-to-end delay, jitter and throughput. Improvement mechanism employed was a combination of the IP mobility protocol with MPLS in a differentiated service. The simulation was carried out using Optimized Network Engineering Tool (OPNET) Modeler version 14.5 for MIPv4 and MIPv6 network. The scenarios without MPLS are provided in Fig. 1 and Fig. 2 respectively, while the network setup for QoS improvement can be seen in Fig. 3 and Fig. 4, respectively.

Each scenario above has the following network elements; four Wimax Base stations, two routers, a label switching router (LSR), two label edge routers (LER), two switches, three servers as the corresponding node and WiMAX subscriber stations as mobile nodes (MN). The Base_station_1 was configured as the home agent (HA) of the mobile node while the other three base stations were configured as the Foreign Agents (FA). The Mobile_node was also configured to recognize the Base_station_1 as its HA. The number of MN was varied from 10 to 30 in step of 10 to increase the network congestion.

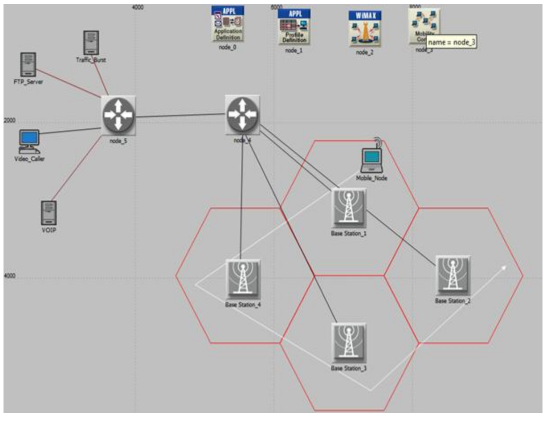


Fig. 1: MIPv4 Network without MPLS

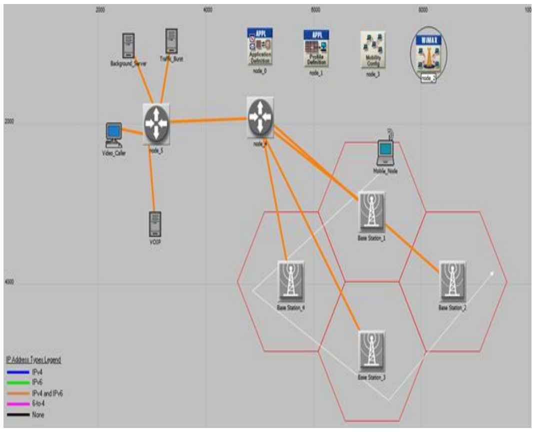


Fig. 2: WiMax Network MIPv6 without MPLS

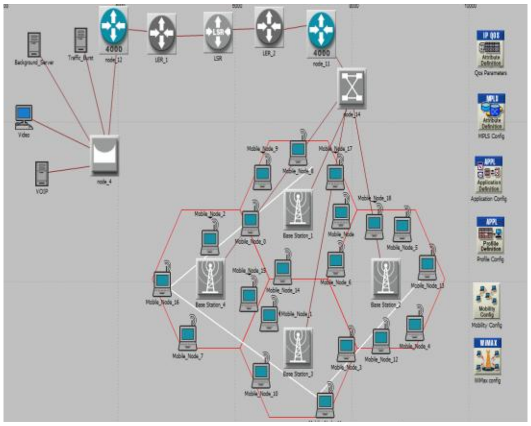


Fig. 3: WiMax Network MIPv4 with MPLS and Differentiated Service

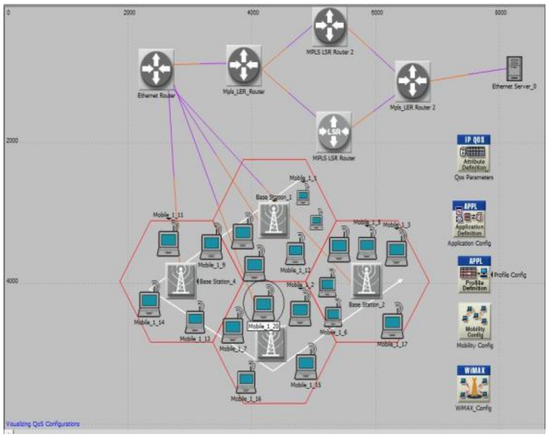
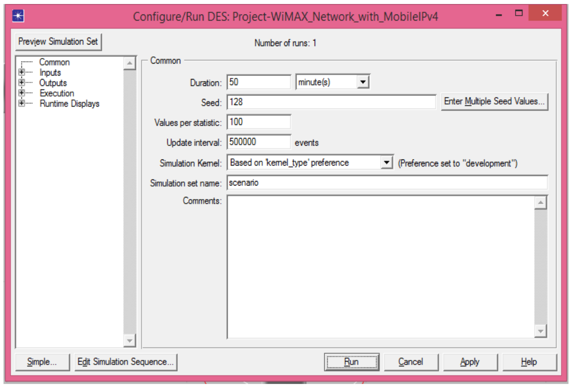


Fig. 4: WiMax network MIPv6 with MPLS differentiated service with 20 users

However, the trajectories of the nodes were assumed the same. In the design, a cluster of 4 base stations with mobile nodes (MN) to represent users, were connected to a router that was linked to a server. The interfaces from both the VoIP and video caller servers were configured to carry out Weighted Fair Queuing (WFQ) as opposed to the default First in First out (FIFO). The traffic was also Differentiated Services Code Point (DSCP) based. Then the VOIP and video traffic profiles were configured to carry out expedited forwarding (EF).

There are 3 ways of converting an IPv4 network to IPv6 which are by dual stack that is running IPv6 and IPv4 concurrently on the same interface. The tunneling approach involves encapsulation of IPv6 traffic inside IPv4 packets and the third is by Network Address Translation (NAT) protocol translation (NAT-PT) between IPv4 and IPv6 addresses. The tunneling method was used in this research that is IPv6 to IPv4 tunneling.

In Application Configuration, the type of background applications that were running in the network for the mobile node were real-time networks traffics that is VoIP and video conferencing applications were configured. In both scenarios VoIP calls are added at fixed time interval that is for every two seconds and simulation time was 50 minutes as can be seen in Fig. 5. The implementation was done to the effect of combination of MPLS and Diffserv on the performance of MIPv4 and MIPv6 for a single user voice and video traffic and later as number of MN was increased.



Number of runs: 1

Common

Duration: 50 minute(s)
Seed: 128
Values per statistic: 100
Update interval: 500000 events
Simulation Kernel: Based on 'kernel_type' preference (Preference set to "development")
Simulation set name: scenario
Comments:

Fig. 5: Configuration for Traffic Simulation

IV. RESULTS AND DISCUSSIONS

In voice communication, jitter is undesirable for the simple fact that it causes breaks in voice calls and such time difference in arrival of voice traffics can be boring in VoIP. Therefore for a quality network for VoIP calls, jitter has to be minimized or completely eliminated if possible. The simulation results shown in Fig. 6, the jitter for the VoIP traffic remained at a constant stable value of zero when MPLS was used with Diffserv to improve on the QoS of the WiMax network while the other two scenarios (when MIPv4 and MIPv6 without MPLS and Diffserv used as network layer protocol), voice traffic experienced a bit of jitter at the beginning until they eventually became stable.

It was observed from the resulting graphs Fig. 7 and Fig. 8 that the performance when the real time traffics were transmitted using the hybrid QoS improvement mechanism was much better than when MIPv4 and MIPv6 were used alone.

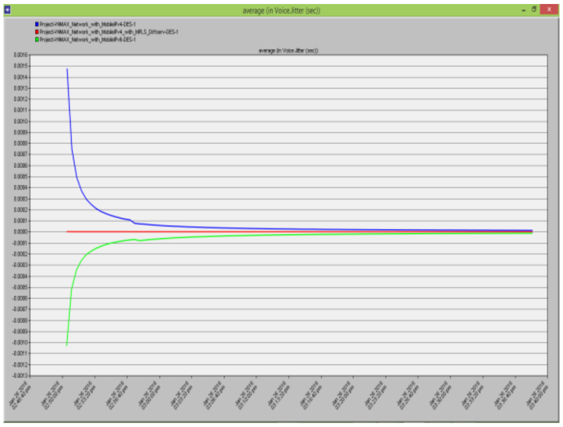


Fig. 6: VoIP traffic Jitter for single MN

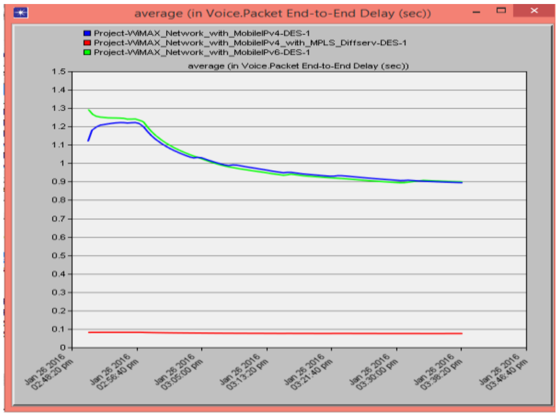


Fig. 7: VoIP traffic end-to-end packet delay for single MN

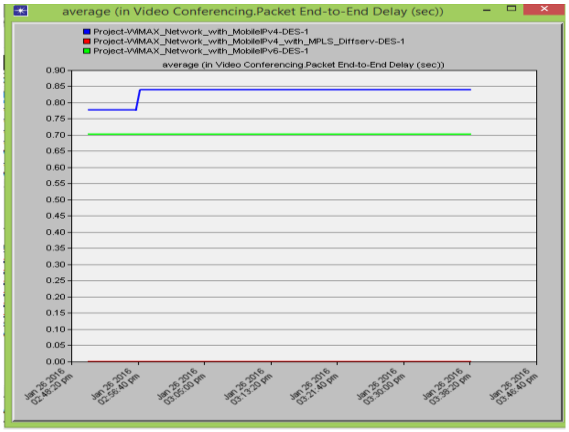


Fig. 8: Video conference traffic end-to-end packet delay for single mobile node

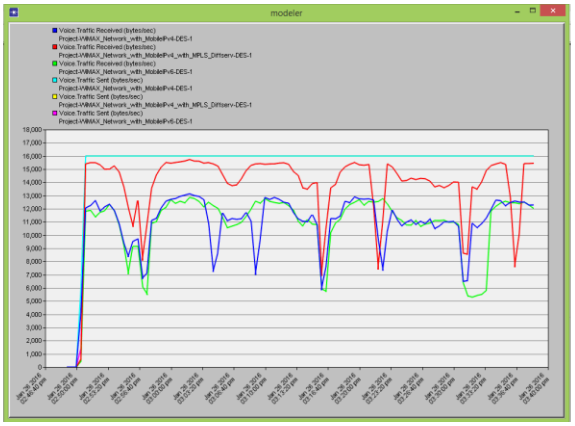


Fig. 9: Network Throughput for single mobile node

The graph above shows the end-to-end packet delay of the three protocols a mobile node. MIPv4+MPLS and Diffserv experienced the least end-to-end delay and the delay is constant, less than 0.09 second all through the simulation time. This kind of delay will be unnoticeable by the users. The end-to-end delay due to both the MIPv4 and MIPv6 alone was above 1.0 seconds and later dropped to 0.9 second, will constitute a disturbance to the VoIP callers even as number of callers increases. This view also holds for video conference traffic as video callers had delay virtually eliminated while the average end-to-end delay of 0.7 for the MIPv6 and that of MIPv4 was 0.84 seconds.

A constant traffic of 16 KB (16,000 bytes) was sent to the MN. The throughput was simulated for each of the individual traffic profiles based on the traffic sent against the traffic received. It is evident from the simulation result in Fig. 9 that averagely up to 15KB of traffic was received successfully when MIPv4 was combined with MPLS+Diffserv while averagely about 13KB of traffic was received when MIPv4 and MIPv6 were used alone.

It is imperative to assess the effect of increase in the number of MNs on the performance of MIP when combined with MPLS+Diffserv as improvement mechanism having shown by simulation study that this hybrid QoS improvement mechanism gives performance than when the two mobile IP protocols are used alone. Simulation study in Fig. 10 for VoIP traffic showed an increase in end-to-end delay as number of MN was increased but was still less than 0.09second showing that service quality can be guaranteed for many more users if admitted into the WiMax network since congestion was not in view. However, the video traffic simulation study presented in Fig. 11, showed an end-to-end delay slightly greater than

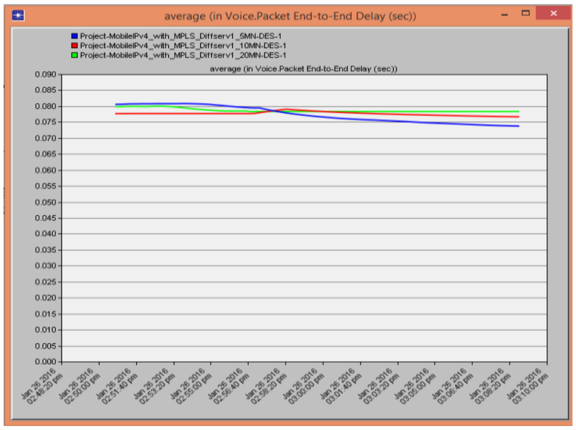


Fig. 10: Delay for VoIP traffic for multiple mobile nodes

0.7second meaning that any further increase in the number of video callers will further degrade the network and make a nuisance of video calls. So, it obvious from the results that more voice callers will be supported more than video callers.

Fig. 12 is the throughput for VoIP traffic for multiple MN for the hybrid QoS implementation for MIPv4. It showed the MIPv4 combined with MPLS+Diffserv received more traffic than using MIPv4 and MIPv6 alone and it can also be seen that throughput decreases with increase in the number of MNs on the WiMax network.

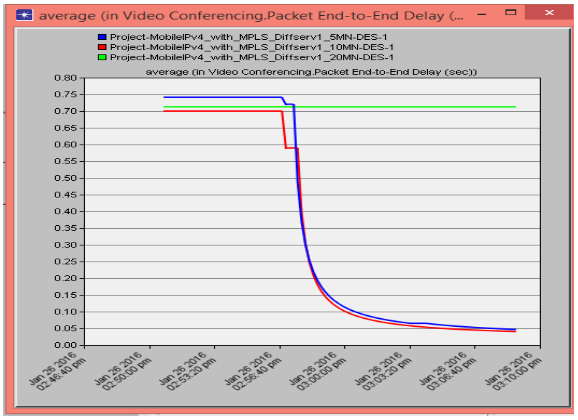


Fig. 11: Delay for video traffic for multiple mobile nodes

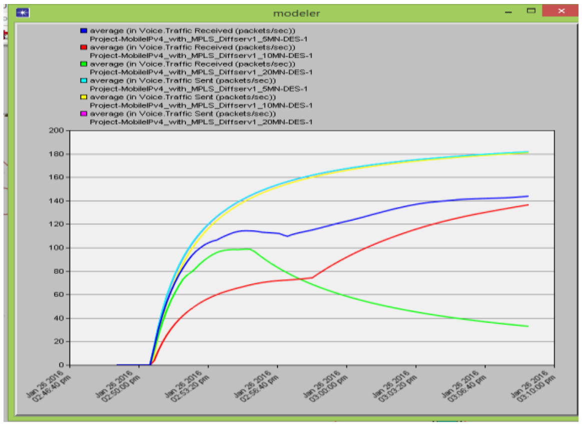


Fig. 12: Throughput for VoIP traffic for multiple mobile nodes

V. CONCLUSION

It has been shown in this research that MIPv4 and MIPv6 will support IP mobility for the future internet networks but not without QoS deficiencies that needs to be improved upon for better quality service delivery. The hybrid combination of MPLS and differentiated service have been used to improve upon end-to-end delay, jitter and throughput experienced by real time applications (VoIP and Video) in a MIPv4 supported WiMax network. This improvement mechanism helps to overcome some of the problems associated with the MIPv4 by improving speed of packets forwarding and giving preferential treatment to real time traffics in a differentiated service.

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