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Enhanced Mobility Management Technique for Unified Broadband Interworking Architecture

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Abstract - The complementary characteristics of the existing active wireless networks provide the potential to meet the ever increasing demands of the interactive multimedia services through internetworking. Efficient Mobility Management protocols implemented in the interworking network, allows the mobile users to be continuously connected to the best available access network depending on their requirements. With the existing MIPV6, PMIPV6, and HMIPV6, etc., protocols having their own disadvantages of triangular routing, convergence latency, signalling overhead, scalability and reliability, a proficient solution is required to increase the efficiency of mobile users working with broadband services. In this paper, an EH-MIP (Enhanced Hybrid-Mobile IP) mobility management protocol for Ultra Mobile Broadband (UMB), World Wide Interoperability for Microwave Access (WIMAX) and Wireless Local Area Network (WLAN) interworking network is proposed. The EHMIP is obtained through modifying the functional elements of existing PMIV6, such as to reduce the delays involved in repeated binding catch messages in signaling. The interworking UMB-WiMAX-WLAN-EHMIP architecture is implemented with a service based mobility management algorithm, to allow users to select the suitable channel by analyzing the service type and mobility conditions of the user. The QoS parameters in terms traffic sent- received, response times, for Email and HTTP, and packet end-to-end delay, packet delay variation for VoIP and Video applications are simulated and its performances are compared using OPNET.

Keywords - *Heterogeneous networks, service type, mobility, interworking, hybrid coupling, Mobility management, Quality of Service*
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1. Introduction

Heterogeneous wireless networks (HWNs) offer a potential solution to handle the exponential increase of the voice and data services. The existing Heterogeneous networks such as, UMTS (Universal Mobile Telecommunication Networks), WiMAX (Worldwide Interoperability for Microwave Access), LTE (Long Term Evolution), WLAN (Wireless Local Area Network), etc., offers a wide range of service capabilities and suitability for various multimedia applications. Nevertheless, the present existing wireless technologies has to be further enhanced to satisfy the exponentially increasing needs and requirements of the mobile users [1]. Integration of these contrary extant technologies with different specifications lead to better performance of users, and offers network with challenges of seamless mobility, security, service differentiation, access control, QoS (Quality of Service) and resource management.

In this paper, wireless technologies such as UMB (Ultra Mobile Broadband), an evolution of CDMA (Code Division Multiple Access) 2000, WLAN and WiMAX are integrated to fit the requirements of the multimedia and interactive services. These technologies developed independently, have complementary characteristics to allow the network to provide users with suitable data rates, coverage area, mobility and QoS support for both VoIP and data services. UMB a part of 3GPP2 (Third Generation Partnership Project), is a robust and efficient technology which offers a wide coverage with high data rate compared with WiMAX and WLAN networks. It offers a huge improvement of its forerunners through AMC (Adaptive Modulation and Coding) OFDMA (Orthogonal Frequency Division Multiple Access) and MIMO (Multiple Input Multiple Output) antenna techniques, which can be made as a choice to LTE network. IEEE 802.16e/WiMAX a strong contender of IEEE802.11e/WLANs, as both technologies are designed to provide low cost, high speed data rates, QoS provisioning and broadband wireless Internet access [2].

WiMAX can bring the underlying Internet connection needed for interactive services with enhanced QoS as it provides an ubiquitous broadband, while WLAN does not. Through integration of these technologies with unique and contrary features, the network on whole can provide users with enhanced QoS and capacity, to meet the request of the multimedia and interactive applications required for the broadband era.

With all the specific ability of the interworking networks, the main challenge for the wireless communication deal with the ability to maintain session continuity to provide a seamless connection to the user. The factor of maintaining session continuity itself consists of several concerns which question regarding the performance of handoff latency and mobility management . Mobility management issue breaks the existing mobility protocols into two types of approaches which are host based and network based. The former requires a modification in the mobile node stack to support mobility and the later involves changes in the serving network layers to handle mobility issues. The most significant and challenging issues of next-generation mobility management includes, optimal selection of the access network, provide seamless mobility between access technologies and adaptation of multimedia transmission with support for QoS and security. To meet these challenges an efficient mobility management scheme to allow the serving networks to locate a MN's point of attachment for seamless delivery of data packets, without increasing the latency and signalling overhead is needed. The advantages and the limitations of each network in interworking environment influence the services provided to the user even if they are roaming and when they are far away by their home network.

The rest of the paper includes, the existing mobility management protocols and schemes, discussed in Section-II. The proposed Enhance Hybrid - Mobile Internet Protocol (EH-MIP), to reduce the latency and signalling overhead due to triangular routing problem in existing PMIPV6 is detailed in Section- III. Service based Mobility management protocol to allocate users to the best serving network channel depending on the traffic type and mobility of the user is given in Section - IV. The QoS performance metrics such as traffic sent and received, response time, packet end-to-end delay, packet delay variation for Voice, video, Email and HTTP applications are obtained in section-V. The significance of the Service based mobility management algorithm implemented in the UMB-WiMAX-WLAN interworking network with the proposed EH-MIP is validated through comparison with the scenario without mobility management algorithm. Section- IV draws the conclusion and future scope of work.

2. Related Works

The adoption of a centralized and distributed mobility management approaches were the existing solutions for mobility management for HWNs. The distributed mobility management is the main existing method so far developed as a valid framework to design future mobile network architectures, to meet the requirements of large traffic in the core and the rise of extremely dense wireless access networks. Future wireless networks are expected to be more flexible, relaxing and allowing Internet services to be located closer to the users, to solve the challenges of seamless terminal mobility, session management, negotiation, and establishment with reduced latency and signalling overhead, etc., of the interworking networks. In [3] a novel distributed mobility management (DMM) scheme was introduced which acts as a new architectural model for evolving mobile IP networks. The technology developments that are dynamic and moving towards the distributed mobility management and the work of related standards development organizations (IETF and 3GPP) to report these new needs are discussed. DMM method provide a better experience to mobile users, and also act as an impulsive to the satisfy the increase in the traffic demand to make easier for mobile devices to access content. [4,5] gives the architecture of heterogeneous interworking network which provides a substantial ability in increasing network data rate and coverage area provides more suitable for mobile end users. The combination of wireless networks provides better service to end users, it also has its own issues. The types of networks that are integrated into a heterogeneous architecture, each have been developed separately with their own specific characteristics. These special requirements of these networks make the interworking between them a challenging task particularly for QoS sensitive real time data. In [6], the essential improvements in mobility management for current and future communication networks and the integration of these heterogeneous networks for a even handoff and better QoS in the framework of next evolutionary step for wireless communication network is discussed. The current changes for handoff management and location registration are considered and an outline of the problem regarding the handoffs and QoS to be solved by the next generation of wireless networks is discussed in [7].

The heterogeneous networks become larger and users demand for higher data traffic with sustained QoS increases. The mobility management solutions has increasingly become an important part of awareness to provide unified handover mechanisms not only for simple mobile data, but also for real-time and multimedia applications such as voice over IP (VoIP), video conferencing, IPTV, and internet gaming. The challenges and issues to integrate PMIPv6 with MIH framework to improve the handover performance is discussed in [8]. A survey of the existing PMIPv6 handover procedures and proposed approaches including the predictive and reactive Fast PMIPv6 and PMIPv6 with IEEE802.21 framework accompanied with discussion about points of weaknesses, but the authors focused only on fast PMIPv6 with MIH scheme of integration in detail [9]. A survey on techniques, strategies, and protocol categories involved in mobility management protocols and their challenges are discussed in [10]. [11] Explains the main desirable features and the key strengths of PMIPv6 through qualitative and quantitative analyzed soft he host-based and the network-based mobility management protocols. However, this study limited of wireless delay and handover latency and did not consider the signaling cost and packet loss. The interworking of SIP with IPv6 mobility management protocol with hybrid mechanism, which aims to reduce the handover latency, is given in [12].

A number of researches are being carried out with the aim to provide better services to the wireless Internet users. The reason is because disconnection may occur during the handover process and this forms the more crucial problem if the wireless network is transmitting real-time multimedia applications. In order to begin a peer-to-peer connection with seamless admission to any service, anytime, anywhere, and with any device, we need a new global system the IP Multimedia Subsystem (IMS) that allows applications in IP-enabled devices to create peer-to-peer and peer-to-content connections easily and securely. [13] Discuss the features and the benefits of IMS, an active architecture that provides the industry and the research community to face the open issues by proposing interworking architectures that aim on seamless service provisioning. Though several existing host based and network mobility management protocols, each as its own challenges in terms of increased latency due to triangular routing, signaling overhead and seamless connectivity. To reduce the latency in order to increase the QoS, from the user perspective, an Enhanced Hybrid Mobile Internet Protocol (EHMIP) is proposed to reduce the signaling overheads required to perform seamless connectivity in an interworking HWN.

3. Enhanced Hybrid Mobile Internet Protocol

The novel Enhanced Hybrid –Mobile Internet protocol (EH-MIP) protocol architecture shown in Fig.1, is proposed to reduce the signaling overhead for mobility involved between the interworking networks. The Convergence – Mobile Anchor Point (C-MAP) is the heart of the architecture, which act as a converging point, to exchange signaling information for the interworking networks. The main function of C-MAP includes, random searching for available spectrum of network and automatic update of the channel information to the Mobile Access Gateways (MAGWs) to the host network. The Local Mobility Anchor (LMA), present in the existing PMIPV6 mobility protocol, which is the core point of attachment to route the packet between the CN and the MAG [14], is replaced by the C-MAP in the proposed EH-MIP, to reduce network signals.

The modified C- MAP is relieved from the data forwarding role and only the Binding Cache and its management operations are maintained. Hence the signaling delay involved in LMA, is reduced. The C-MAP is also enabled to send and parse both Proxy Binding Update (PBU) and Proxy Binding Acknowledgment (PBA) messages, to the host network. It is the node that updates the Binding Cache Entry (BCE) allocated for the MNs in the mobility domain. The BCE is obtained from the Corresponding Node (CN) from the database of the Mobility Management Database (MMD) unit, which maintains the information of the MN and acts as a memory for the C-MAP. It broadcast the MNs ID to the MAGWs of the interworking network, to initiate route between the home network and the handoff network. If the binding is lost or the binding update message was not received, the mobile node will be unreachable from home agent, and the CN could not locate the MN for handover.

The MAGW in EHMIP, is enriched with functions to maintain a local Binding Cache for the MNs that are attached to it and it analyses the PBU and sends an PBA to the C-MAP, to inform the current attachment of the MN. The binding cache has to be extended to include information regarding previous MAGWs where the mobile node was anchored and still retains active data sessions. The MAGW tracks the movement of the MN and initiates the mobility related signals through the Base station attached to it. The MAGW establishes a secure route for the MN to handoff and it also encapsulate and decapsulate the packet from and to the MN before forwarding.

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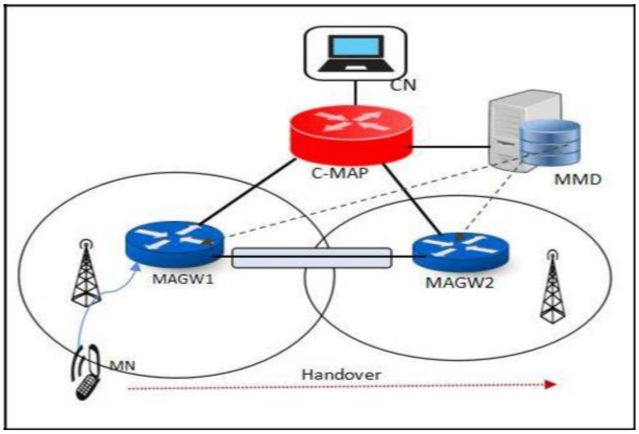

Fig. 1 Enhanced Hybrid Mobile Internet Protocol

The signaling and handoff procedure for the MN between MAGW1 and MAGW2 in an interworking network architecture using EHMIP is given in Fig. 2. The C-MAP, the central point of attachment holds the information of the MN, via the MMD, which acts as the memory for the C- MAP. The MAGWs rely on the C-MAP and the MMD associated to it, to access and update information related to the MNs, stored as mobility sessions in the memory of MMD. Hence this centralized node maintains and act as a global view for the status of the MN in interworking network. The MAGWs in the proposed EH-MIP, is chart-less of the past information related to mobility of the MNs in the network, and all the mobility oriented information are stored in the MMD. Whenever there occurs a attachment or detachment of the MN, the C- MAP is queried regarding the mobility status in the domain.

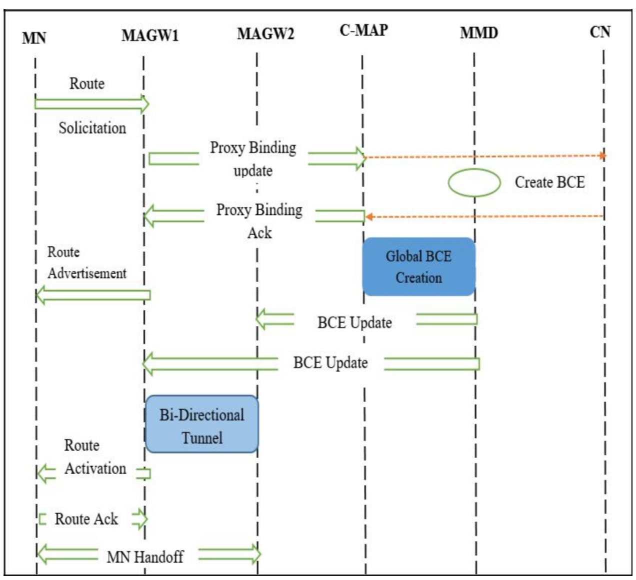

Fig. 2 EHMIP- Signaling Procedure

The message exchange procedure between the MAGW1 and MAGW2 related to the interworking networks involves, Signal message flow between HN and C-MAP, Binding creation and update, route activation, establishing secure connection to the suited network, and MN handoff. The MAGW1, the current home network of MN, quires the mobility status of the MN to the C-MAP, through the PBU messages. The C- MAP, on the information stored in MMD, created the BCE and replies to the MAGW1 with PBA. Then a Global BCE update is sent to all the MAGWs connected to the CN, and the MAGW with suitable channel condition (here MAGW2) to accept the handoff of MN, connects to the C-MAP, and the route advertisement is sent to the HN. Upon receiving the route advertisement, a secure path for transfer is developed between MAGW1 And MAGW2, and the encapsulated message is transferred to the MAGW2, which forwards the decapsulated data packets to the MN, via the corresponding access router.

4. Service Based Mobility Management Algorithm

The proposed EH-MIP is implemented with a Service Based mobility management algorithm, as given in Fig.3, which classify the user based on type of service and speed, to provided user with the service under the suitable coverage area of UMB- WIMAX - WLAN hybrid interworking network as shown in the Fig.4. The users are classified first depending on the type of service as Dynamic and Static users, which corresponds to the Real time and Non Real Time applications respectively. Dynamic users, involving Real Time Voice and Video services are sorted to be served by the UMB, and the UMB- WiMAX coverage area, as they need to supply with a high data rate and uninterrupted services. After the selection of the suitable coverage area, the users are then again classified and admitted based on the speed of the MN. The MN with high mobility speed (nearly 150 km) are allocated the channel of UMB network. And the users with medium speed (100 km and less) are allotted with the channels in the UMB- WiMAX coverage area. The static users to serve Non Real time applications such as

Email, FTP and HTTP, are preferably admitted to WLAN- UMB -WiMAX coverage area. Again the user with less speed (less the 100 Km) are served by the WLAN network, as it can support only a low level of mobility, and the users with medium and high speed are served by the UMB or the WiMAX Access routes of the interworking network. The mobility management algorithm based of two step categorization, can reduce the call blocking and dropping measures and hence increases the capacity and QoS of the network.

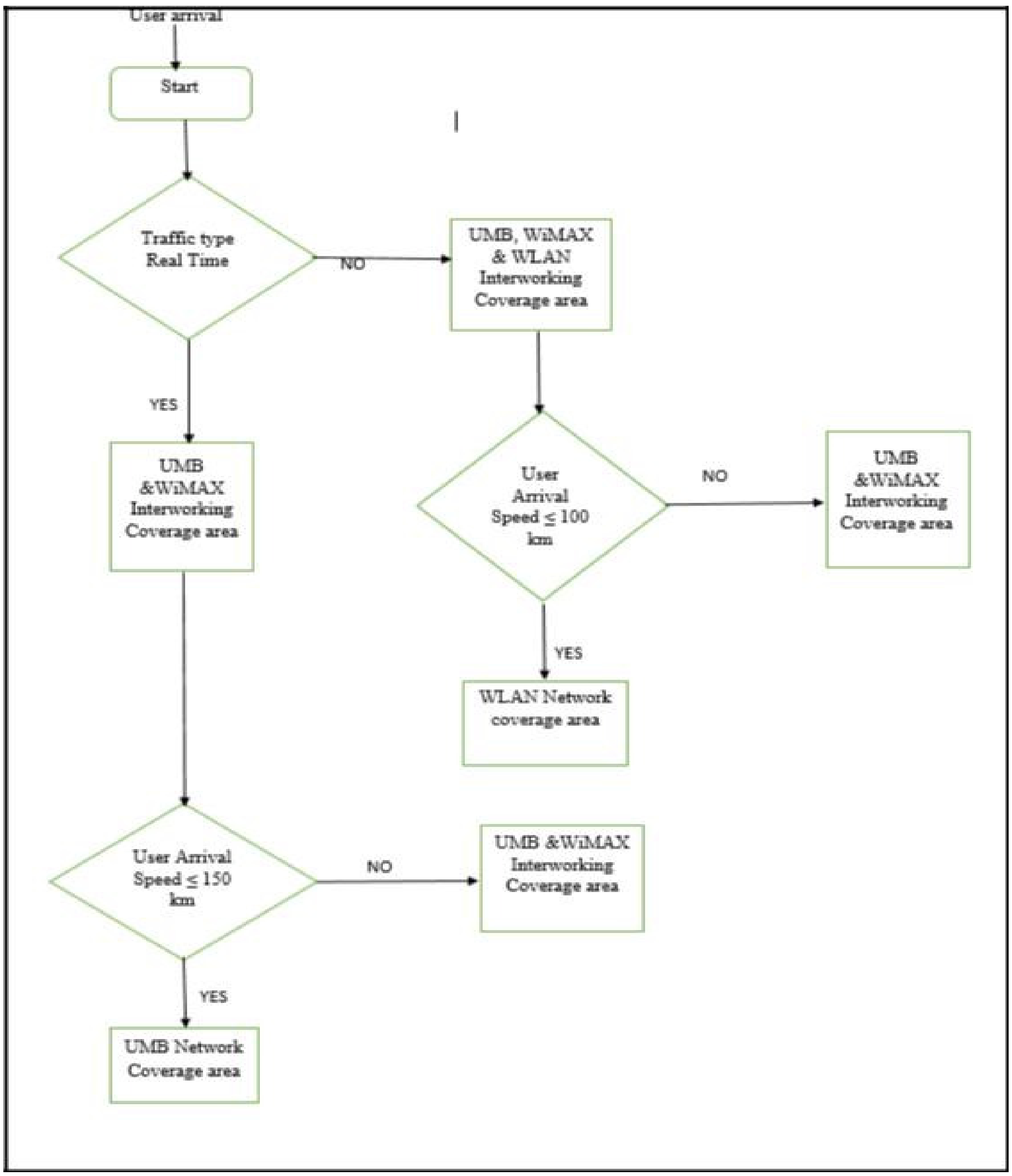

Fig. 3 Service based Mobility Management Algorithm

5. Simulation Results

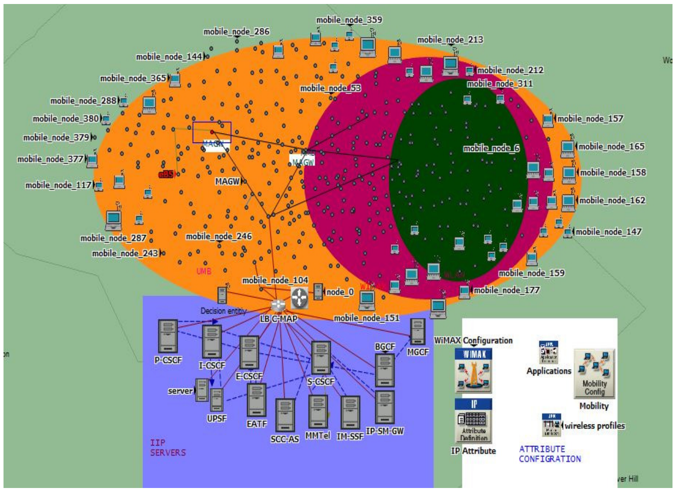

Fig. 4 Interworking UMB-WIMAX-WLAN- EHMIP Architecture

In this section, the performance metrics such as packet end to-end delay, jitter for voice, upload and download response time for email, object response time and page response time for HTTP were simulated using OPNET 14.5. The performance of the service based mobility management algorithm and the proposed EH-MIP is validated by obtaining their comparison results for the UMB-WIMAX-WLAN hybrid interworking network shown in Fig.4. The hybrid interworking architecture of the UMB-WIMAX-WLAN, enables high flexibility and scalability to traffic flow through the tightly coupled interworking between the gateways of the connected networks. The hybrid mating between the routers of the network and the core IP, reduces the delay involved and enhances the quality of the applications served by the networks.

Voice Jitter is defined as a variation in the delay of received VoIP packets. Fig. 5 shows the global delayed variation between the transmission of packets and its reception between the Core IP and the network. The proposed EH-MIP with service based mobility management algorithm reduced the latency of the network, by classifying the dynamic user to be served by the UMB- WiMAX network. The UMB/ WiMAX network with Adaptive modulation and Coding techniques, could reduce the noise involved in the transmission and hence, the jitter is having smooth curve when compared to the architecture without algorithm.

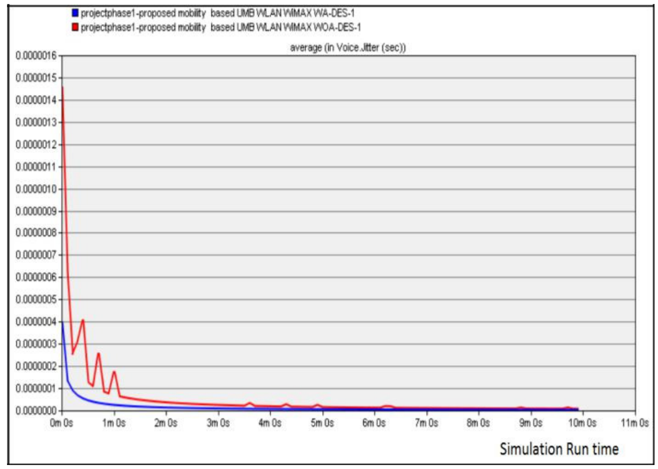

Fig. 5 Voice Jitter (sec)

Voice packet delay variation, in Fig. 6 represents the variance among the end to end delay for the time taken for the VoIP packets to be created to be received. The simulated result below compares the packet delay variation for the EH-MIP with service based mobility management algorithm and without algorithm. The variation values for both the scenarios are minimum, but the architecture with the service based mobility management algorithm has a reduced variance by 20%, since a dedicated set of network is allocated for the dynamic users.

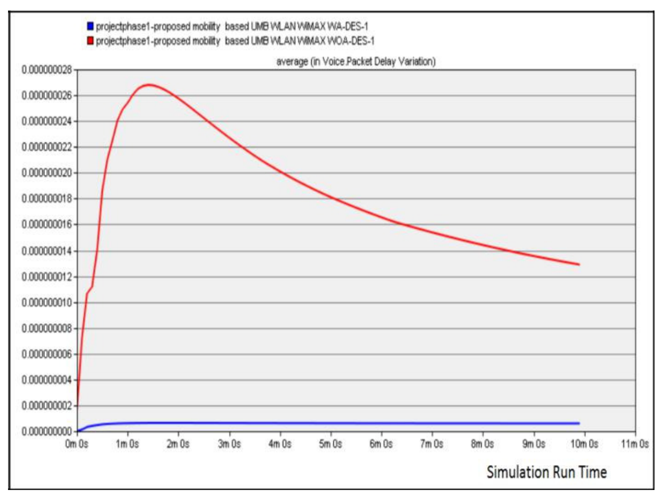

Fig. 6 Voice Packet Delay Variation

Users serving video application are also categorized under dynamic users. The Voice Packet Delay variation representing the variance in the time taken for creation and the reception of a video packet and the end to end delay involved in transmitting and receiving a video are

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considered as the performance metrics. Fig.7 shows the video Packet delay variation of EH-MIP interworking architecture with service based mobility management algorithm is probably less when compared to without algorithm, after a period of simulation run time. The dynamic video application with variable traffic characteristics shows a increased variance till 3 min of the simulation and after stability of the traffic flow, the packet flow is stabilized and hence the variation decreases gradually.

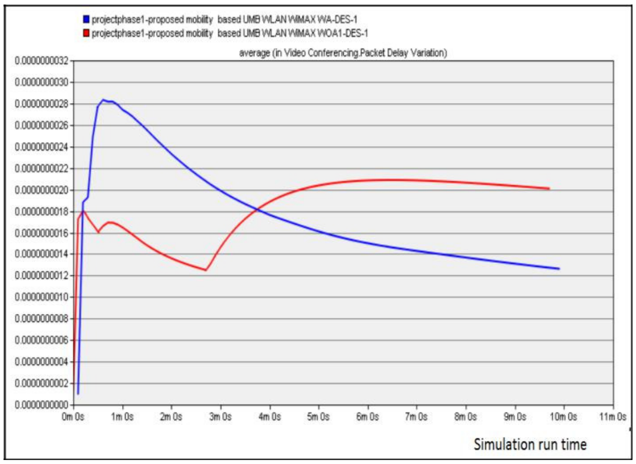

Fig. 7 Video Conferencing- Packet Delay Variation

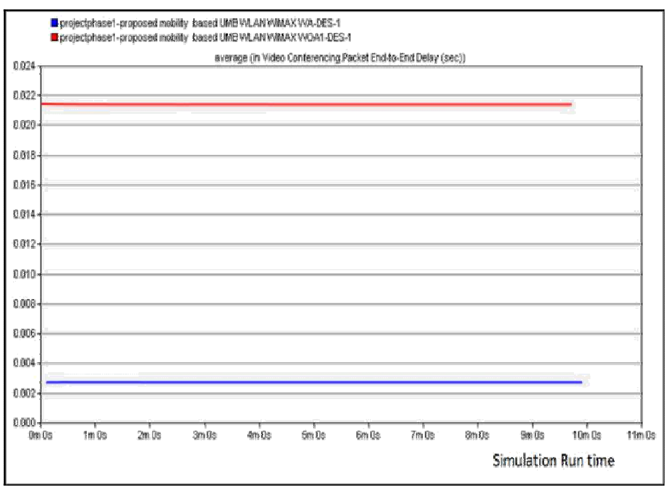

Fig. 8 Video Conferencing- Packet End to End Delay (sec)

The video end to end delay includes propagation delay, compression delay, packetization delay and packet switching delay. The time taken to send a video packet from application layer of sender to the destination node's application layer. In Fig.8, the video Packet end to end delay of EH-MIP Interworking Architecture with service based mobility management algorithm is less when compared to without algorithm. As service based mobility management algorithm prioritize the dynamic applications to the UMB and WiMAX coverage area, which can support high data rate applications, the delay incurred for packet transfer is reduced and hence increases the QoS.

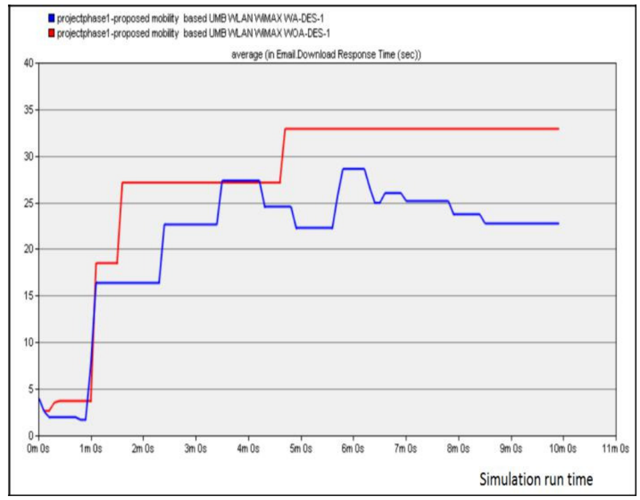

Fig. 9 Email- Download Response Time (sec)

The Download and Upload Response time of Email and the Object and Page response time of HTTP applications are considered to the static services for the proposed mobility management network. The download response time of Email represents the time elapsed between sending requests for emails and receiving emails from email server in the network. It is the time taken for the mobile node to access the requested data from the E-Mail server which should be relatively low.

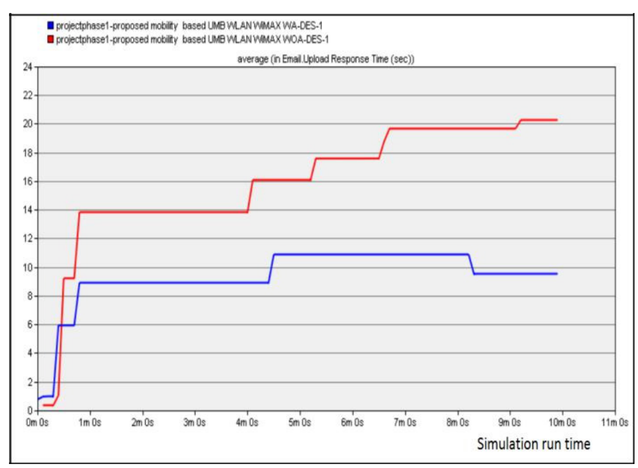

Fig. 10 Email- Upload Response Time (sec)

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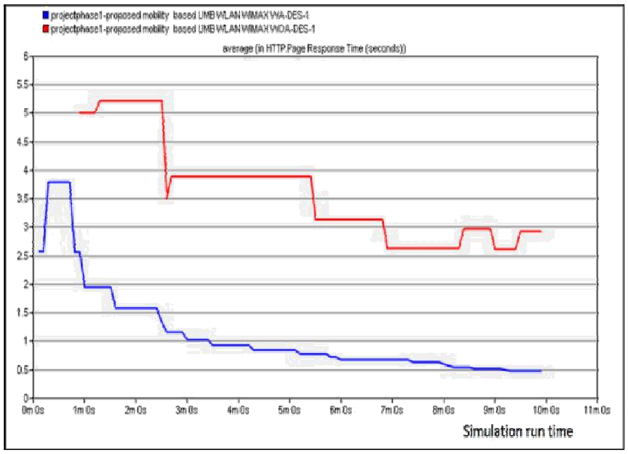

Fig. 11 HTTP- Object Response Time (sec)

Similarly the email upload response time represents the time elapsed between sending emails to the email server and receiving acknowledgments from the server. It also includes the signaling delay for the connection setup, the time taken for the MN to upload the data in the E-Mail server. Fig. 9 and 10 shows the Email Download and Upload response time respectively obtained for the UMB- WiMAX- WLAN interworking network, with Mobility management protocol. In both the results, the network with EH-MIP with the Service based mobility management protocol is shows comparatively lesser response time than the network without algorithm. This can be validated through the service differentiation involved in the proposed mobility management algorithm.

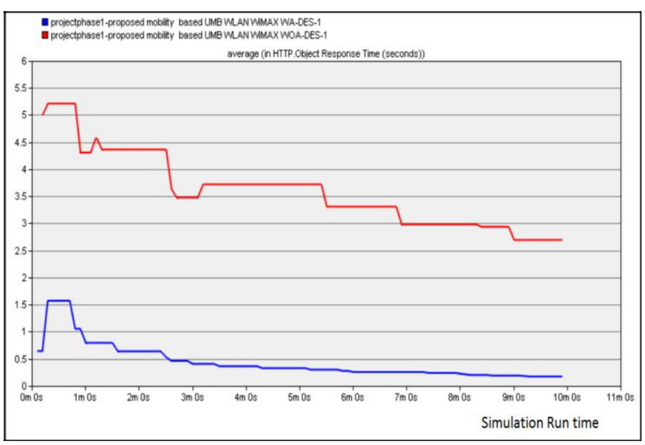

Fig. 12 HTTP- Page Response Time (sec)

The HTTP object and page response time are the metrics representing the performance of the HTTP applications. The response time is the round trip delay i.e. time taken for request and response between application server of network and HTTP server. The HTTP Object response time is the duration for each inlined object to retrieve entire inline objects of the HTML page. Fig. 11 shows the object response time for the network with service based mobility management algorithm is much reduced compared to the EH-MIP without algorithm. The Page response time, shown in Fig. 12, is the time taken for the HTTP server to respond for the MN's request to access data. It is the time period taken for the completely downloading the elements of an web page. With service categorization and dedicated network to serve the static applications, the EH-MIP Interworking Architecture with service based mobility management algorithm reduces the latency involved in the network and hence the response time is reduced compared to the network without algorithm.

The above simulated results, shows that the performance for the proposed EH-MIP, and it is observed that with the service based mobility management algorithm of the network, the users are allocated with the suitable network channel to serve both dynamic and static users with varied speed of mobility. The EH-MIP with service differentiation and prioritization is efficient to the users among the interworking network, in reducing the delay, jitter and response times for VoIP, Video, Email and HTTP of the networks considered for the simulation.

6. Conclusions

In this paper, a Novel Enhanced Hybrid- Mobile Internet Protocol (EH-MIP) is proposed for the UMB- WiMAX WLAN interworking architecture. The EH-MIP network is implemented with a service Based mobility management algorithm to increase the capacity and QoS of the interworking network. The EH- MIP, obtained as a modification of the existing PMIPV6, can reduce the signaling overhead and latency, by reducing the messages transferred for handoff and route optimization. The service based mobility management still reduced the latency and increased the QoS of the network, by allocating users based on type of service and the speed of user. QoS metrics like jitter, end-to-end delay and response time for voice, Email and HTTP are simulated and compared for the architecture with EH-MIP with and without the proposed algorithm. The performance evaluation shows that differentiating users based on service type and mobility of user, provide better channel and network selection to suite the required QoS of the Real time and Non real time services. The performance can be further investigated by including additional dynamic and static services.

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