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A Novel Resource Provisioning Algorithm for the Integrated UMB-WiMAX -WLAN Overlay Networks

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***Abstract*—**The next-generation heterogeneous networks aim to offer ubiquitous high quality IP-based multimedia services to the users anywhere at any time. The different radio networks such as Long Term Evolution (LTE), Universal Mobile Telecommunication Systems (UMTS), Ultra Mobile Broadband (UMB), Worldwide interoperability for Microwave Access (WiMAX), Wireless Local Area Network (WLAN), etc. are co-located in the same geographical area to provide different services are called overlay networks. The advantages of integration of these networks include increased efficient utilization of overall network bandwidth; enhanced QoS of the users and the increased support for the mobility. There are more challenges in integrating these different networks like terminal mobility, session establishment, session management, session negotiation and charging etc. The IP Multimedia Subsystem (IMS) is the solution for above mentioned issues. This paper proposes an architecture framework for interworking of the overlaid Ultra Mobile Broadband (UMB), Worldwide Interoperability for Microwave Access (WiMAX) and Wireless Local Area Network (WLAN) technologies using advanced IMS. IMS acts as a promising overlay service that provides a platform through which various networks are integrated to provide seamless multimedia services. A novel Resource Provisioning Algorithm (RPA) is proposed in this paper to enhance QoS.

***Keywords*—**Heterogeneous, IMS, NGN,Resource allocation, UMB, WiMAX, WLAN

I. INTRODUCTION

The next generation of telecommunications industry is undergoing a fundamental change and they are progressively migrating to new infrastructures that promise to revolutionize the services offered as peer-to-peer entities, which facilitate sharing. In order to establish a peer-to-peer connection with seamless access 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 establish peer-to-peer and peer-to-content connections easily and securely [1].

The IMS will take communication to the next level by offering enriched communication means, since it is designed to provide robust multimedia services across roaming boundaries and over diverse access technologies. As the IMS networks use the Session Initiation Protocol (SIP) for session establishment, management and transformation, they are able to mix and match a variety of IP-based services in any way they choose during a single communication session and can add or drop services as and when they choose [2].

The Ultra Mobile Broadband (UMB) is a next generation MIMO-OFDMA based Wireless WAN (WWAN) standard being developed by the 3rd Generation Partnership Project 2 (3GPP2), to enable ultra-high data rate mobile wireless connectivity. It is designed for robust mobile broadband access and is optimized for high spectral efficiency and short latency using advanced modulation, link adaptation and multi-antenna transmission techniques. In addition, fast handoff, fast power control, and inter-sector interference management are embedded in the design to facilitate communication in highly mobile environments. The UMB system uses Orthogonal Frequency Division Multiplexing (OFDM) as the main modulation technique. It employs sophisticated channelization techniques to facilitate high throughput and high reliability. It incorporates adaptive coding and modulation with synchronous Hybrid ARQ (HARQ) and turbo coding with variable retransmission latency. The UMB forward link supports MIMO (both single codeword with closed loop rate and rank adaptation and multi-codeword (layered) with per-layer rate adaptation) with closed loop pre-coding and space division multiple access (SDMA). The peak rate reaches 300 Mbps on forward link in a 20MHz system. The reverse link supports quasi-orthogonal transmission: orthogonal transmission based on OFDMA technique and non-orthogonal across multiple receives antennas. IEEE802.11/WLANs and IEEE 802.11/WLAN is the standard to provide moderate- to high-speed data communication in a short range. The IEEE 802.16/WiMAX is the standard to provide broadband wireless services requiring high-rate transmission and strict QoS requirements in both indoor and outdoor environments [4].

The rest of this paper is organized as follows. Section II discusses recent work related to IMS networks and the next generation heterogeneous networks. In Section III, IMS subsystem is discussed in detail. Section IV presents the architecture of the network UMB. Section V discusses Resource Provisioning Algorithm used in the hybrid coupled UMB-WiMAX-WLAN interworking architecture using advanced IMS. Section VI presents simulation and results. The conclusion is present in Section VII.

II. RELATEDWORKS

Since the IMS networks are still in an ongoing activity, the industry and the research community constantly try to face open issues and extend IMS beyond 3G, by proposing

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interworking architectures that aim on seamless service provisioning. An overview of IMS infrastructure along with its services, applications, and future potential is discussed by Esguevillas et al. in [5]. Nikolaos et al. [6] presented a complete signaling flow concerning the authorization, registration, session set up and vertical handoff processes, as well as, an analytic model for cost analysis of the proposed architecture. Munasinghe and Jamalipour [7] proposed architecture for interworking heterogeneous all-IP networks with an in-depth analysis of its performance. Vijayalakshmy and Sivaradje [8] presented QoS provisioning Interworking model that integrates a WiMAX network, a UMTS network and a WLAN in an IMS compatible architecture and it is compared with WiMAX-UMTS interworking along with IMS. Chowdhury and Gregory [9] provided the results of a performance analysis of two potential 3G/WLAN integration schemes: tight and loose coupling. Mobile IP is used as a mobility management scheme and EAP-AKA for common authentication. Sharma and Leung[10] presented a lightweight, robust, and architecture compatible IMS authentication protocol that implements a one pass IMS procedure by promoting efficient key re-use for a mobile user. They derived an analytical model of the proposed scheme, and conduct numerical analysis that reveal a user authentication delay decrease of more than 50 percent. Then in [11], they presented a lightweight, robust, and architecture-compatible IMS authentication protocol that implements a one-pass IMS procedure by promoting efficient key reuse for a mobile user for LTE-femtocell heterogeneous access networks.

III. IP MULTIMEDIA SUBSYSTEM(IMS)

IMS is a global, access-independent and standard-based IP connectivity and service control architecture that enables various types of multimedia services to end-users using common Internet-based protocols. It seems to be the technology that will prevail in Next Generation Networks (NGNs), since the interworking environment and the service flexibility that this technology offers to the currently deployed wireless broadband technologies makes it appealing to users, service developers and network operators. IMS has been adopted by 3GPP (3rd Generation Partnership Project) and it is the leading contender as the base of the ITU work on Next Generation Networks [6].

3GPP is the body that took Session Initiation Protocol (SIP) as the control protocol for multimedia communication and has built finite architecture for SIP-based IP multimedia service machinery (the IMS). SIP is a rendezvous protocol that is, a signaling protocol designed to establish, manage, and tear down multimedia sessions on the Internet. Additionally, SIP can provide asynchronous notifications and announcements of events. It also allows endpoints on the Internet to discover one another and negotiate the characteristics of a session they would like to share. The fact that SIP makes it easy to create new services carried great weight in this decision, so it was chosen as the session control protocol for the IMS. Since the IMS uses the Session Initiation Protocol (SIP) for session establishment, management, and transformation, its offerings include functions, such as authentication, addressing, routing capability negotiation, service invocation, provisioning, charging, session establishment, etc. In addition to the session control protocol there are a number of other protocols that play important roles in the IMS as Diameter, HTTP, etc. [6].

The IMS is a system architecture designed for supporting multimedia services for transmission over different access technologies. The IMS architecture is a collection of functions linked by standardized interfaces. Some of the IMS SIP entities are responsible for interfacing non-SIP IMS network nodes using different protocols designed for AAA. The IMS is a 3-layer architecture, as shown in Fig. 1.

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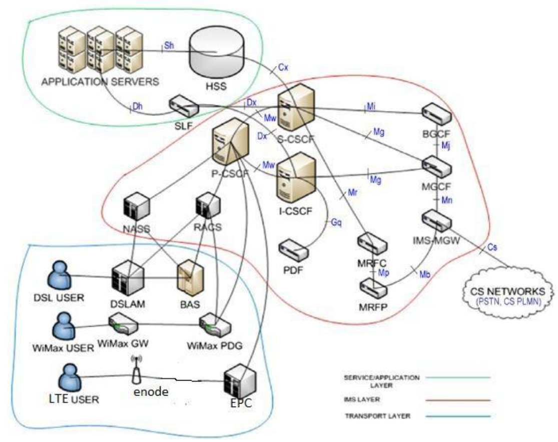

Fig. 1 IMS 3-Layer architecture

It consists of the Transport Layer, which includes all the entities for the supported access networks; the Control Layer where the core IMS network resides; whereas at the top exists the Service Layer which includes the application servers hosting the IMS services [6].

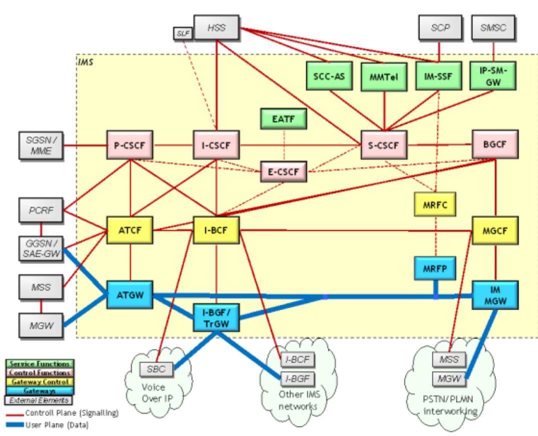

Fig. 2 The architecture of the advanced IMS

The advanced IMS core network, as shown in Fig. 2, predominantly consists of many nodes such as HSS (Home Subscriber Server), SLF (Subscriber Location Function), CSCF (Call Session Control Function), etc. In order to be able to support the IMS, an evolution of the HLR (Home Location Register), which is a GSM node, was further developed for creating the HSS. HSS is the master database for all subscribers and service-related data of the IMS as identities, registration information, access parameters, service-triggering

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information, location information and security information. The presence of the Subscription Location Function (SLF) is dictated by the existence of more than one HSS in a network and its main role is to map users' addresses to HSSs. The CSCF, which is a SIP server, is an essential node in the IMS that processes the SIP signaling. The CSCF processes all the call requests received from the other VoIP call control servers or terminals in IP-based multimedia networks.

There are four different kinds of Call Session Control Functions (CSCF). Each CSCF has its own special tasks and namely depending on their particular function. They are:

- Proxy-CSCF (P-CSCF).
- Serving-CSCF (S-CSCF).
- Interrogating-CSCF (I-CSCF).
- Emergency-CSCF (E-CSCF).

The P-CSCF server is the first point of contact for a User Equipment (UE) entering the IMS subsystem where the UE discovers its address. P-CSCF is also responsible for maintaining Security Associations (SAs) and applying integrity and confidential protection for SIP signaling. The S-CSCF server is the focal point of the IMS, which is considered the central node of the signaling plane. It handles registration processes, making routing decisions, maintaining session states and storing the service profile between the UE's SIP addresses. The I-CSCF is the contact point for the home network of the destination UE, which may be used for concealing the configuration, capacity, and topology of the home network from the outside world. E-CSCF is a dedicated functionality to handle routing user-originated emergency calls such as sessions towards police, fire brigade and ambulance.

To complete the IMS interworking environment, additional servers have been standardized in addition to the above IMS core entities. The IMS-Media Gateway (IMS-MG) provides gateway between the IMS and circuit-switched networks. The Media Gateway Controller Function (MGCF) interacts with the Media Gateway Function (MGW) to support flexible connection handling. The Breakout Gateway Control Function (BGCF) plays an important role in providing routing functionality based on telephone numbers. The Multimedia Resource Function (MRF) provides the home network with the ability to support multiparty calls, multimedia conferencing, tones, and diverse announcement functionalities [6].

IMS-level registration is the procedure which is used to authorize the user to access the IMS network and use the IMS services. It is done after IP connectivity for the signaling that has been gained from the access network and the application level registration can be initiated after the registration to the access is performed. IMS-level registration is accomplished by a SIP REGISTER request and the user is considered to be always roaming [6].

As shown in Fig. 3, The Mobile Station (MS) initiate the registration process by sending SIP Register information flow to P-CSCF. Upon message reception, the P-CSCF examines the "home domain name" to discover the entry point to the home network as it might not reside to MS' home network. So the SIP ''REGISTER" attaches to the information needed and sends the register information flow to the I-CSCF. To indicate whether the user is already registered and allowed, The Cx-Query/Cx-Select-Pull information flow should be sent to the HSS by the I-CSCF. A Response is sent from the HSS to the I-CSCF and it will contain the S-CSCF name or a list of the qualifications of the available S-CSCFs. Using the name of the most appropriate S-CSCF; I-CSCF sends the register SIP ''REGISTER" to S-CSCF. The S-CSCF contacts HSS to authenticate the MS. The HSS stores the S-CSCF name and the S-CSCF stores the information for the indicated user. A user invitation ("401 UNAUTHORIZED") is sent by the I-CSCF to the P-CSCF. The P-CSCF repeats the above presented messages exchange, with exception of the new ''UAA" which this time contains routing information. The S-CSCF returns the 200 OK information flows. The I-CSCF shall release all registration information and The P-CSCF shall store the home network contact information, and shall send information flow to the MS.

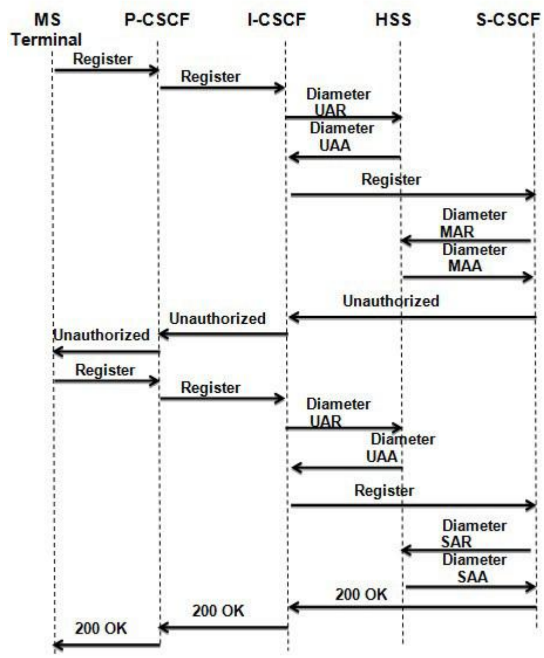


Fig. 3 Registration at the IMS level

IV. ARCHITECTURE OF UMB

UMB supports a flat all IP architecture where all packets, voice, or data go through the same path. Flat networks provide faster responses, and therefore more applications can be offered. UMB architecture consists of Access Terminals (ATs) and Access Networks (ANs) as shown in Fig. 4. An Access Terminal has a radio interface to communicate with the Access Networks. An Access Network is a network entity that contains an Access Network Route Instance (ANRI) for the purpose of logically communicating with the AT. The Access Network consists of Access Gateway (AGW),evolved Base Station (eBS) and Session Reference Network Controller (SRNC).

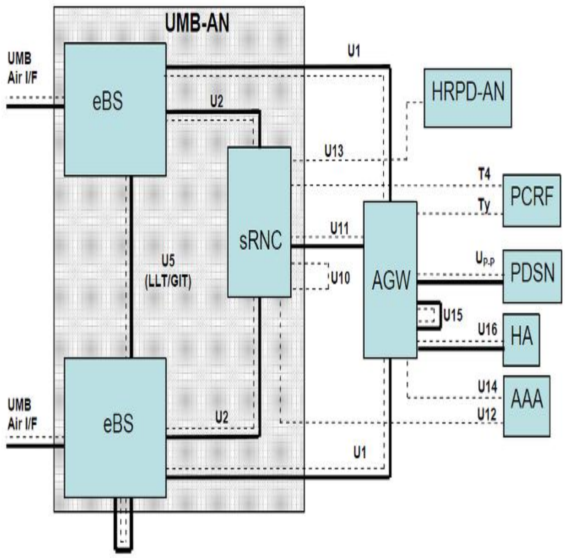


Fig.4 UMB Architecture

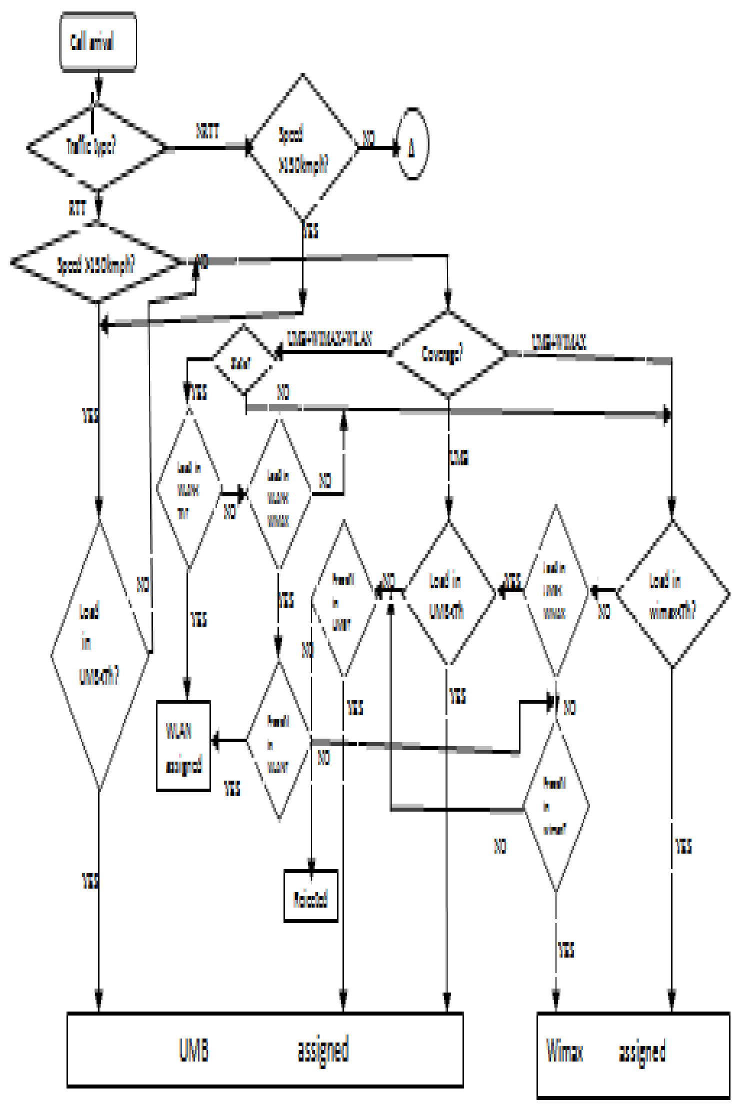
The Access Gateway (AGW) is an entity that provides the user's "point of IP connectivity" to the network. That is, the AGW is in effect the first-hop router for the mobile terminal. The AGW performs layer 3 services including hot-lining, accounting, policy enforcement, etc. The Evolved Base Station (eBS) provides the over-the-air signaling and user data transport that is used by the Access Terminal (AT) for connectivity to the radio access network. The functions of the eBS include over-the-air transmission of packets, encryption/decryption of packets, scheduling for over-the-air transmission, policy enforcement for over-the-air transport, header Compression. Session Reference Network Controller (SRNC) is responsible for maintaining radio access specific information for the AT in the UMB radio converged access network, the session reference idle state management, and providing paging control functions when the AT is idle. The SRNC is an authenticator also responsible for access authentication of the AT.

V. PROPOSED RESOURCE PROVISIONING ALGORITHM

In Heterogeneous Wireless Networks (HWNs), Radio Resource Management (RRM) is a key to jointly manage the resources from multiple access networks. The operators are viewed as global optimizers to jointly manage the resources among the networks for maximization of the network utility,and the users with multiple interfaces have the flexibility to select its association to improve the capacity of the system. To provide users with satisfactory quality of service (QoS) and to improve the utilization of resources in HWNs, RPA should select a suitable network for the users.

The author in the paper [13] considered only speed of the user to allocate the resource.The author in the paper [4] considered both speed of the user and traffic type to allocate the resource. In integrated UMB-WiMAX-WLAN networks the proposed RPA admits incoming calls to a specific network based on type of service, velocity of user ,the location where user present in the three coverage areas and allocates dynamic bandwidth reservation for handoff calls. The proposed scheme preferably admits high velocity (more than 150kmph) users to high coverage networkUMB because it can support the mobility up to 350 kmph [3] and the static users are preferably admitted to WLAN except voice service. The moving users up to the speed 150 kmph are admitted to the WiMAX network. High velocity users are also preferably allocated to WiMAX or UMTS based on service type. High velocity voice users are referably admitted to UMB and bandwidth sensitive real time applications like video conferencing, multimedia applications are connected to WiMAX network. Similarly low velocity voice users are preferably connected to UMTS instead of WLAN since WLAN provides less QoS (delay, jitter) for voice calls. Bandwidth reservation for handoff calls increases QoS but reduces the network utilization. The Proposed RPA dynamically varies the bandwidth reservation for handoff calls by predicting traffic using Markov model proposed in [14]. It increases QoS with enhanced network utility.

The flow chart for the proposed RPA is shown in Fig. 5. This algorithm reduces the call rejection rate and it increases capacity of the network and enhances QoS.



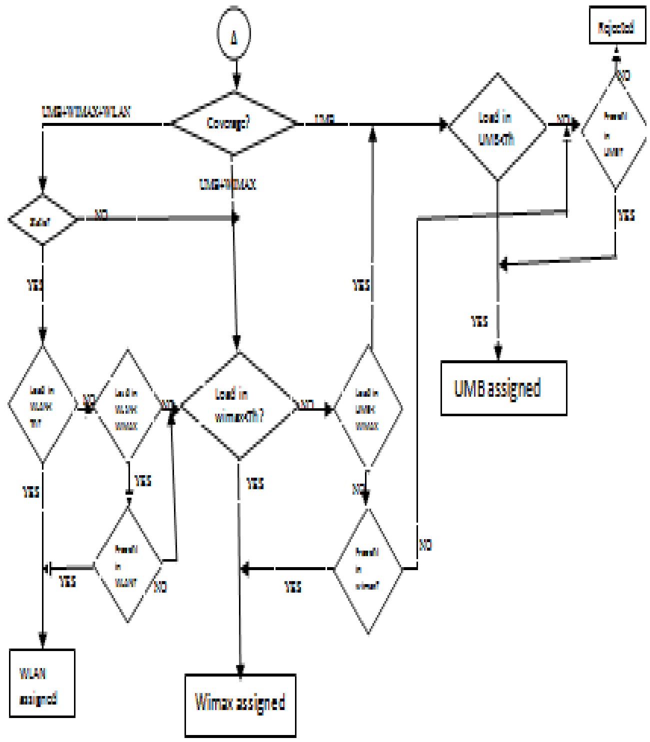


Fig.5 Flow chart of Resource Provisioning Algorithm (RPA)

VI. SIMULATION AND RESULTS

In this section, the performance metrics such as acket end-to-end delay, voice jitter, email upload and download response time, HTTP object response time and page response time were simulated and compared with and without RPA.Opnet14.5 is used for simulation.

The hyprid coupled interworking architecture of UMB-WIMAX-WLAN using advanced IMS is shown in Fig. 6. Hybrid coupling uses both tight coupling and loose coupling connection that is WiMAX BS and WLAN AP are connected to both AGW (Access Gateway) and IP core network.

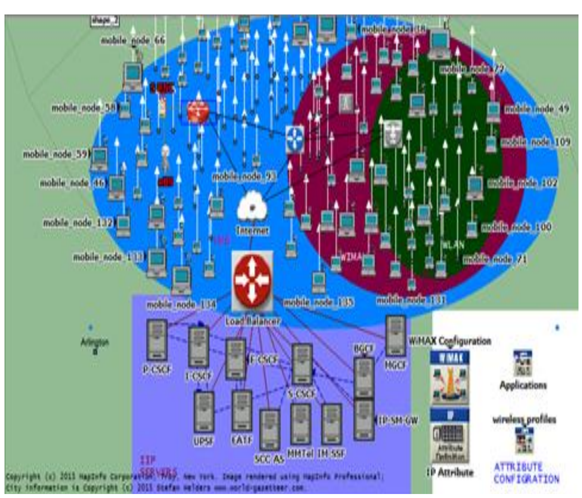
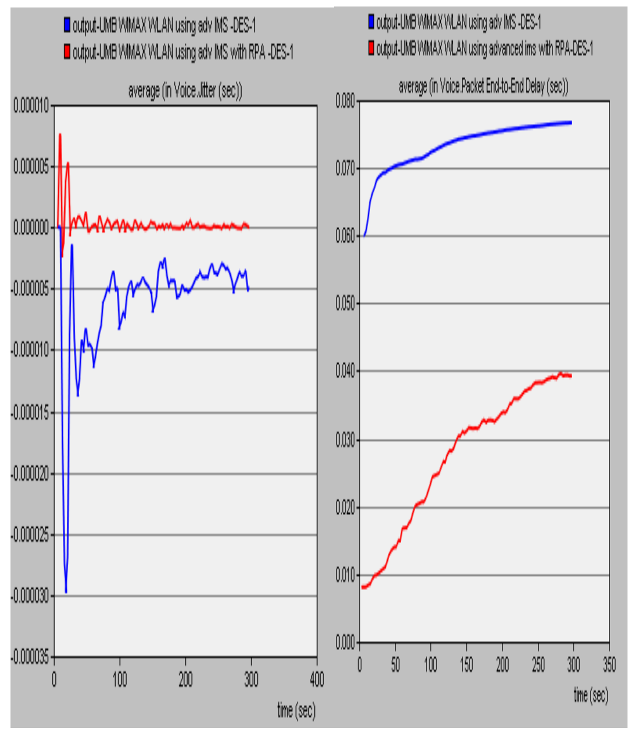


Fig. 6Hybrid coupled interworking architecture of UMB-WIMAX-WLAN using advanced IMS

A. *Voice jitter and voice packet end-to-end delay*

Voice Jitter is defined as a variation in the delay of received VoIP packets. As shown in Fig. 7(a), our proposed algorithm has approximately no delay in the received VoIP packet. Voice packet end-to-end delay represents the time taken by the VoIP packets to travel from sender to the receiver. From Fig. 7(b), it is clear that Voice packet end-to-end delay is reduced by the proposed algorithm.

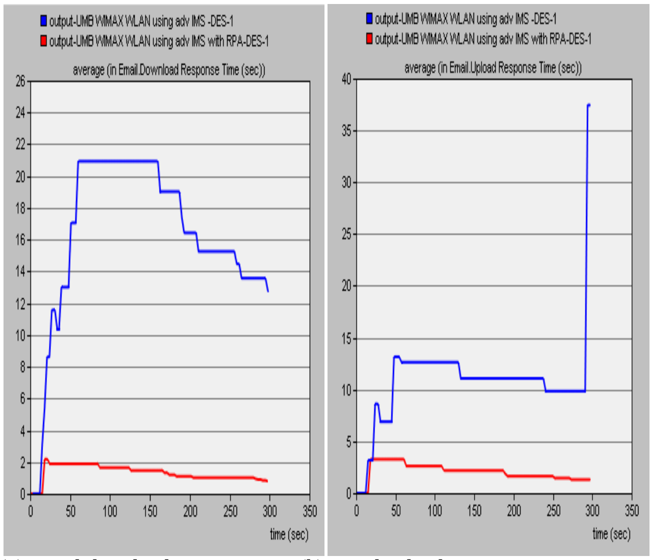


(a) Voice jitter (b) Voice packet end-to-end delay

Fig. 7 Comparison of delay time in sec

B. *Email download and upload response time*

Download response time represents the time elapsed between sending requests for emails and receiving emails from email server in the network. Email upload response time represents the time elapsed between sending emails to the email server and receiving acknowledgments from the server and it includes signalling delay for the connection setup.Fig. 8 shows the comparison of upload response time and download response time in sec taken by UMB-WiMAX-WLAN hybrid coupled architecture with and without RPA. It is observed that both response times taken by our proposed algorithm are less than integrated networks without the algorithm. Fig. 8(a) compares the Email download response time and Fig. 8(b) compares the Email upload response time. From the figures, it is clear that the Email response times are reduced when proposed algorithm is used.

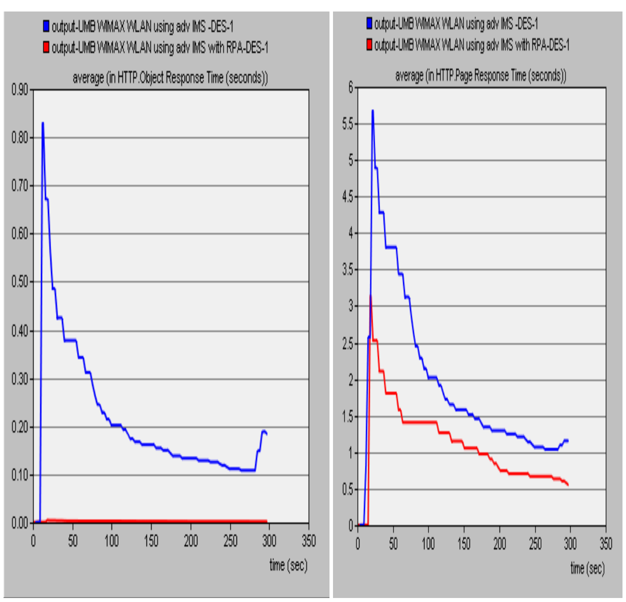


(a) Email download response time (b) Email upload response time

Fig. 8 Comparison of Email response time in sec

C. *HTTP Object response time and page response time*

Object response time specifies response time for each received object from the HTML page. Page response time specifies time required to retrieve the entire page with all the contained objects. Fig. 9 shows the comparison of HTTP object response and page response time in sec taken by UMB-WiMAX-WLAN hybrid coupled architecture with and without RPA. It is observed that both response times taken by our proposed algorithm are less than integrated networks without using the algorithm.



(a) HTTP Object response time (b) HTTP Page response time

Fig. 9. Comparison of HTTP response time in sec

VII. CONCLUSION

In this paper, a novel Resource Provisioning Algorithm have been proposed for the next generation heterogeneous networks that merges UMB, WiMAX and WLAN using advanced version of IP Multimedia Subsystem (IMS).Advanced IMS is very useful in session control, authorization,authentication, Quality of Service (QoS), charging, personalmobility, etc. Various QoS metrics like jitter, end-to-end delay and response time for voice, Email and HTTP are simulated and compared.The performance evaluation shows the proposedalgorithm reduces delay, response times and thus it enhances QoS.

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