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WiMAX-UMTS Converging Architecture with IMS Signalling analysis to achieve QoS

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Abstract

The third-generation partnership project (3GPP) and 3GPP2 have standardized the IP multimedia subsystem (IMS) to provide ubiquitous and access network-independent IP-based services for next-generation networks via merging cellular networks and the Internet. The IEEE 802.16 worldwide interoperability for microwave access (WiMAX) promises to provide high data rate broadband wireless access services. The IP Multimedia Subsystem (IMS) seems to be the technology that will prevail in Next Generation Networks (NGN s), 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. In this paper we propose a heterogeneous network model based on the IMS that integrates the Worldwide Interoperability for Microwave Access (WiMAX), Universal Mobile Telecommunications System (UMTS) and provides guaranteed QoS. In this paper, hybrid interworking architecture to integrate 3G (UMTS) and WiMAX networks with QoS is proposed. Moreover, IMS based signaling along with QoS algorithm was analyzed for UMTS and WiMAX interworking Architectures. QoS parameters such as Ethernet load and delay, IP Packet end to end delay, TCP delay, Active TCP connection count and TCP retransmission count, Email download response and upload response, Voice jitter, Voice packet delay variations and voice traffic received were analyzed

Keywords: QoS; WiMAX; 3G ; UMTS; Interworking ;IP multimedia subsystem

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1.   INTRODUCTION

The evolving demand for mobile Internet and wireless multimedia applications has motivated the development of broadband wireless access technologies in recent years. The broadband wireless industry has recently focused on IEEE 802.16 Worldwide Interoperability for Microwave Access (WiMAX) networks because WiMAX provides simultaneous support for high mobility and high data-rates, and provides a greater coverage area compared to Wireless Local Area Networks (WLANs). However, WiMax coverage area is limited when compared with 3G cellular networks, and 3G networks provide the added benefit of ubiquitous connectivity although at lower data rates than WiMAX networks. The complementary coverage area and data rate characteristics of WiMAX and 3G networks motivate further exploration of their interworking with the intent of providing ubiquitous high-speed wireless data access, and consequently, attracting a wider user base. Interworking architectures have been studied in literature. Ahmedi, 2009 did not analyze the IMS registration procedure and the effects of different interworking architectures on the IMS signalling delay. Anzaloni et al., 2011 discussed about the performance study on the impact of authentication security levels for IMS in 3G networks. Kim and Ganz, 2005 presented the Architecture for 3G and 802.16 Wireless Networks Integration with QoS Support. An Integrated WiMAX/WiFi Architecture with QoS Consistency over Broadband Wireless Networks is presented by Lin et al., 2009. Liu and Zhou, 2005a presented Improved Interworking Architecture for UMTS-WLAN Tight Coupling. Liu and Zhou 2005 b. presented HCRAS: A Novel Hybrid Internetworking Architecture between WLAN and UMTS Cellular Networks.

Mahmood and Gage, 2003 characterized the Architecture for Integrating CDMA2000 and 802.11 WLAN Networks. Performance Analysis of a Novel Architecture to Integrate Heterogeneous Wireless Systems is discussed by Mohanty and Xie, 2007. Munir and Wong, 2007 presented Interworking Architectures for IP Multimedia Subsystems. Munir, 2008 discussed about Analysis of SIP-Based IMS Session Establishment Signaling for WiMAX- 3G   Networks. Architecture for UMTS-WIMAX Interworking was discussed by Nguyen Vuong et al., 2006. Psimogiannos et al., 2010 presented IMS-based network architecture for WiMAX-UMTS and WiMAX- WLAN interworking. Modeling and Optimization for the Design of IMS Networks was discussed by Rajagopal and Devetsikiotis, 2006. Ruggeri et al., 2005 discussed about 802.11-Based Wireless LAN and UMTS Interworking: Requirements, Proposed Solutions and Open Issues. Taaghol et al., 2008 presented about Seamless Integration of Mobile WiMAX in 3GPP Networks, SIP-Based Vertical Handoff between WWANs and WLANs discussed by Wu et al., 2005.

The rest of the paper is organized as follows. In Section 2 Proposed architecture of hybrid coupled WiMAX-3G interworking is discussed. Performance evaluation of the proposed architecture is discussed in section 3. Section 4 concludes the paper.

2. The Proposed Hybrid coupled WiMAX-UMTS Architecture

Two network models were created. 1. Hybrid Coupled WiMAX-UMTS Interworking Architecture without QoS provisioning 2. Hybrid Coupled WiMAX-UMTS Interworking Architecture with QoS provisioning. In the hybrid WiMAX-3G Interworking Architecture without QoS shown in Fig. 1, Wireless Access Gateway of WiMAX is directly interconnected to 3G (UMTS) through IP Multimedia Subsystem and also indirectly interconnected through IMS via Internet backbone. In hybrid coupling scheme traffic paths are differentiated according to the type of the traffic. For the real-time traffic, tightly coupled network architecture is chosen, and for the non-real time and bulky traffic, loosely coupled network architecture is chosen. Fig.1 shows hybrid coupled WiMAX-UMTS interworking architecture without QoS configuration. QoS algorithm is not configured for this hybrid architecture. This network model consists of only one mobile node user to be supported. IP multimedia subsystem is configured for this architecture. Simulation time period taken for this
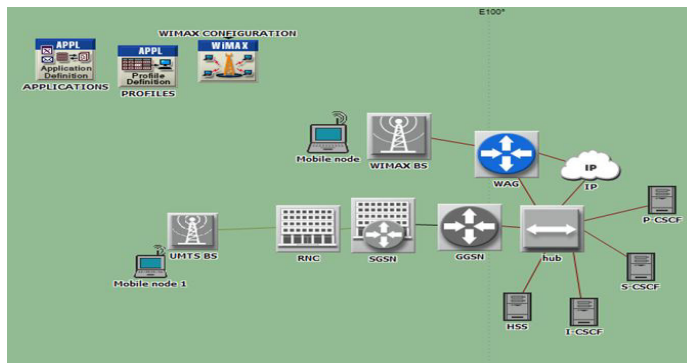
network model is 400 sec.

Fig . 1 Hybrid Coupled WiMAX-UMTS Interworking Architecture without QoS

   In WiMAX configuration framing mode is enabled for this network model. Email and voice traffic is given as application profiles in this model. IMS (IP multimedia subsystem) module is configured in the WiMAX-UMTS architecture. SIP (session initiation protocol) is one of the protocols of IMS which will provide efficient session management. SIP signalling also provides better resource allocation and mobility. Here in the proposed work Hybrid Coupled WiMAX-UMTS Interworking Architecture without QoS provisioning and Hybrid Coupled WiMAX-UMTS Interworking Architecture with QoS provisioning are compared and different performance metrices were formulated. This Architecture consists of only one mobile user for each base station. If the number of users increased then the QoS performance metrices are also decreased because of no proper QoS provisioning in the network model.

2.1   QOS Guarantee in proposed hybrid WiMAX-UMTS Architecture

    Due to the differences in the network band width, providing users with a constant level of service is not feasible. The goal of QoS guarantee is to offer suitable quality of service in the given network, in accordance with users' QoS profiles and application requirements. The QoS guarantee involves the task of mapping the QoS parameters from P-CSCF, GGSN, PDF, QoS negotiation, and the resource reservation mechanism.UMTS defines four classes of QoS services based on different application requirements: conversational, streaming, interactive, and background. WiMAX also defines four classes of QoS: UGS (unsolicited grant service), realtime polling service (rt-PS), non-real-time. Polling service (nrt-PS) and BE (best effort). According to the application scenario, QoS class mapping can be implemented according to the mapping relation. The conversational and streaming services of UMTS correspond to the UGS and rt-PS services in WiMAX. The interactive service can be mapped to nrt-PS and BE services in WiMAX in different application scenarios. However, the background service in UMTS has the same requirement and application scenario as the BE service in WiMAX. QoS negotiation between session peers (to determine the particular codec to use for each medium) is performed using the SIP offer/answer model, in which each session peer offers its QoS capabilities using Session Description Protocol (SDP) descriptions in the message body. Note that SIP session signaling and effective QoS resource allocation (e.g., GPRS Packet Data Protocol (PDP) or DiffServ) is independent. Fig. 2 shows the Proposed Hybrid coupled WiMAX-3G Interworking Architecture with QoS. In this proposed model hybrid coupled WiMAX-UMTS interworking architecture with QoS provisioning architecture number of users is increased by 10 when compared to previous model which has only single user. Though the users are more, the performance of Hybrid coupled WiMAX-UMTS architecture with QoS outperforms the hybrid coupled WiMAX-UMTS architecture with QoS because of proper QoS provisioning algorithm.
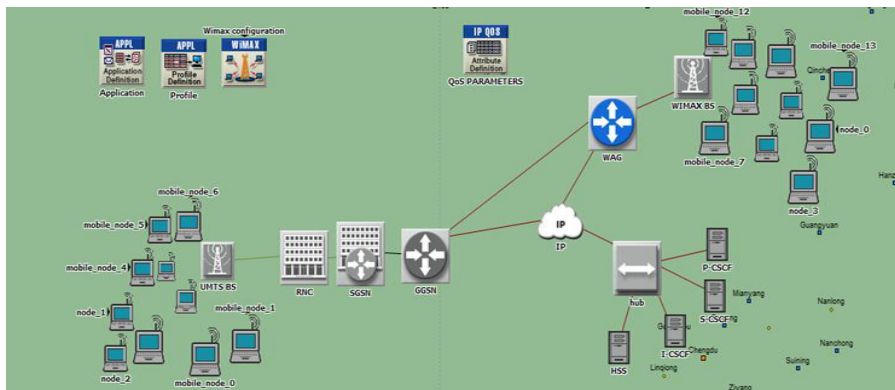
Fig. 2 Hybrid coupled WiMAX-3G Interworking Architecture with QoS

Here QoS provisioning Algorithm is added along with hybrid coupled WiMAX-3G Interworking architecture. QoS negotiations, Resource Reservation, Session Convergence and Session Mobility are controlled by IP multimedia subsystem where Session Initiation Protocol as the main key element. Additionally IP QoS algorithm is added to this Hybrid coupled WiMAX-3G interworking architecture for scheduling mechanism. Here Class based Weighted Fair Queuing (CB-WFQ) algorithm is used. It is the combination of Priority Queuing and Weighted Fair Queuing. Here All Types of traffics such as low, medium, normal and high are serviced. No Queues are starved. All Queues are serviced by allowing Low traffic to be fairly distributed. Number of users supported here is more than hybrid coupled WiMAX-UMTS without QoS. Efficiency is more here even though numbers of users are increased because of IP QoS provisioning architecture. Simulation time period taken for this test bed is also 400 sec. Here in this network model also only email and voice traffic are sent and analysed. Email upload response time and download response time of this network model, TCP delay and retransmission count, Ethernet delay, IP packet end to end delay, Voice Jitter and voice packet delay variations were considered for analysis.

2.2 WiMAX-UMTS session setup

The following sections give an overview of the signalling flow involved in the session setup [1] between the ANs. WiMAX-UMTS session setup When the INVITE message arrives at the P-CSCF 1 (messages 1-5), it is verified for the correctness of its Route header field and is inspected if the Session Description Protocol (SDP) [35] offer is valid with QoS values that are applied to the Home Network. If it passes the previous check, then it is forwarded to the S-CSCF 1 which has become known during the registration procedure presented in previous section. The S-CSCF1, when it receives the INVITE message, (message 6) identifies the caller's identity from the relevant header field and tries to route the SIP request based on the originating user in the Request-URI. Following, with the DNS procedures, it tries to locate a SIP Server, which is actually an I-CSCF, in the terminating network to forward the INVITE message. The I-CSCF receives the INVITE message and has to forward it to the S-CSCF2 which is allocated to the caller (message 7). In order to discover the address of the S-CSCF2, which is the next node that the message has to pass, the I-CSCF has to query the HSS with a Diameter LIR request (message 8). The HSS receives the Diameter request, and searches for data associated with the user of the Public-Identity AVP header field, one of which is the S-CSCF2 address which inserts into a Server-Name AVP in a Diameter Location-Information-Answer (LIA) message. The I-CSCF receives the LIA (message 9) and routes the INVITE request (S-CSCF2). Eventually, the INVITE message reaches the terminal of USER2 (messages 10–16). The USER2 responds with a 183 Session Progress to the SDP offer and may start its resource reservation due to the knowledge of all the required parameters (messages 17–30). In messages 31–43, the USER1 terminal examines the SDP answer which

contains the IP address of the callee where the media streams are sent. Answers with a PRACK which includes a new SDP offer due to the changes WiMAX GW that might be occurred at the SDP negotiation. Furthermore, the USER1's terminal starts its resource reservation. USER 2 responds to the PRACK with the 200 OK (messages 44– 56), and starts its resource reservation. Within this 200 OK, there is a notification in the SDP field, which informs the caller's terminal that the resource reservation has not been completed at the caller's. The USER1's terminal sends an UPDATE request (messages 57–69), which contains another SDP offer, in which indicates that the resources has been reserved at his local segment. The flow sequence diagram of the WiMAX-UMTS session setup signalling process is depicted in Fig. 3)
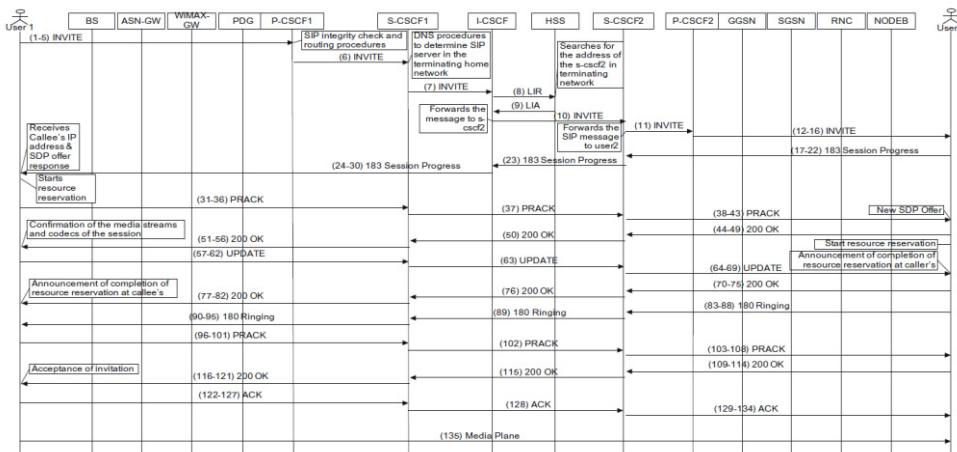

Fig. 3 The WiMAX -UMTS session setup process signalling

The caller's IMS terminal sends as an answer a 200 OK message according to the SDP offer/answer model (messages 70–82). It is likely at this point, that the USER 2's terminal has also completed its resource reservation according to the time the procedure takes to be completed. The IMS terminal rings and generates a 180 ringing response which travels far to the caller's terminal (messages 83– 95). When the USER1's IMS terminal receives the 180 Ringing responses, it will likely generate a ring-back tone to indicate at the other side that the terminal is ringing. It, also, sends a PRACK as a response to the previous 180 ringing response (messages 96– 108). The USER2's IMS terminal responds with a 200 OK, which completes the INVITE transaction (messages 109–121). Then, the USER1's IMS terminal sends an ACK request (messages 122–134), to conform the receipt of the 200 OK response and starts generating a media-plane traffic across the USER2's terminal (message 135).

3. Performance evaluation

3.1   Simulation results and discussion

A network model with two Access network namely UMTS and Wimax are ineterconnected with IP Multimedia Subsystem using OPNET Modeler 14.5. For purpose of simulation attributes of each entity in the network model was set to default . Performance Metrics considered are Active TCP connection count and TCP retransmission count, TCP delay and IP End to End Delay variations, Ethernet Load and delay, Email Upload Response and Email Download Response, Voice Jitter and Voice packet delay variations, voice traffic received.
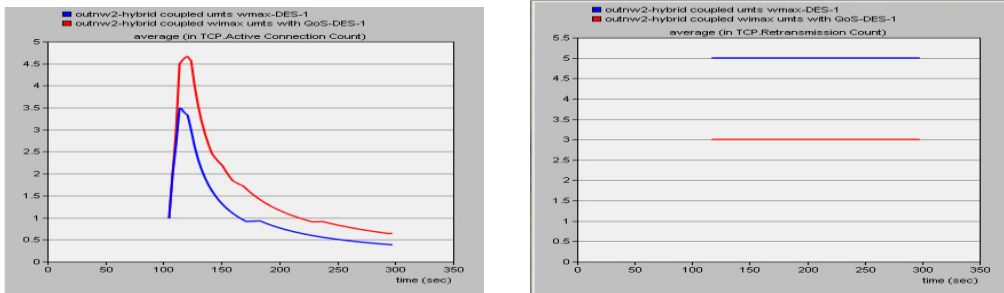
Fig. 4. a) Comparison of TCP Active connection count in sec for Hybrid coupled WiMAX and UMTS architecture without QoS and with QoS.   Fig 4. b) Comparison of TCP retransmission count in sec for Hybrid coupled WiMAX and UMTS architecture without QoS and with QoS.

Fig.4 a) depicts the number of Active TCP connection made by Hybrid Coupled WiMAX and UMTS Interworking Architecture for without QoS and with QoS. It is observed that number of connection made by Hybrid Coupled Interworking Architecture without QoS is less and a connection made by Hybrid Coupled Interworking Architecture with QoS is greater. Thus more Connection are made in Hybrid Coupled than the other coupling Architectures. Fig.4 b) shows TCP retransmission count for Hybrid coupled WiMax and UMTS interworking architecture without QoS and with QoS. Here TCP retransmission count is very less for Hybrid coupled interworking architecture with QoS when compared to Hybrid coupled interworking architecture without QoS. This shows that Hybrid coupled interworking architecture with QoS is having higher speed and lower packet delay
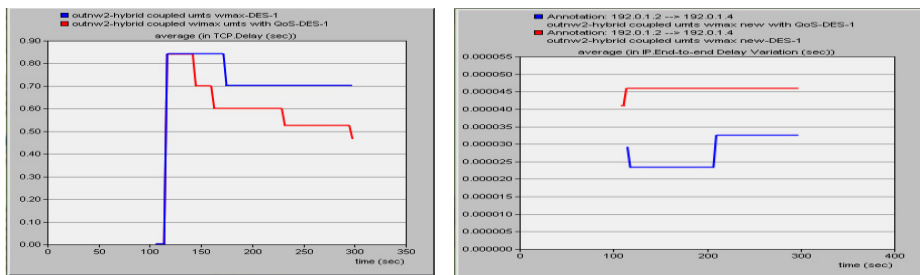

Fig. 5   a)Comparison of TCP delay in sec for Hybrid coupled WiMAX and UMTS architecture without QoS and with QoS.   Fig. 5 b) Comparison of IP end to end Delay variation in sec for Hybrid coupled WiMAX and UMTS without Qos and with QoS

Fig. 5 a) shows theTCP delay for Hybrid coupled WiMax and UMTS interworkin architecture without QoS and with QoS. TCP delay is defined as the time it takes for the application to get a packet from source to destination through a TCP connection. Transmission control protocol delay for Hybrid coupled interworking architecture with Qos is very less than for Hybrid coupled interworking architecture without Qos. IP end to end Delay is defined as time taken for the packet to reach its destination, in seconds. It is measured as the difference between the time a packet arrives at its destination and the creation time of the packet. Fig.5 b) shows the comparison of delay taken by Hybrid Coupled Interworking Architectures with QoS and without QoS. It is observed that delay incurred by Hybrid Coupled Architecture with QoS is less than Hybrid Coupled Architecture without QoS.
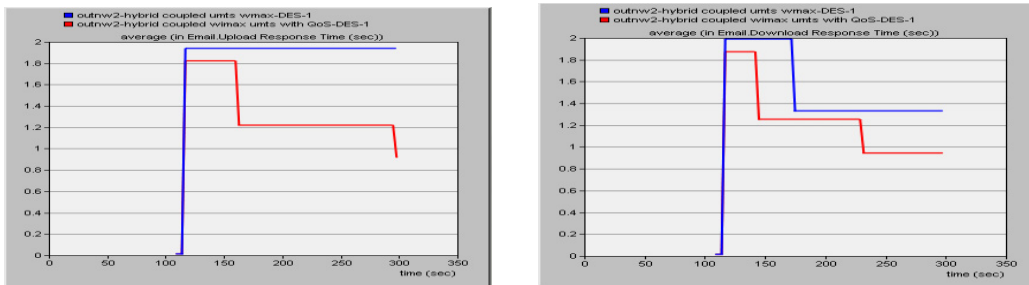
Fig.6 a) Comparison Email Upload Response in sec for Hybrid coupled WiMAX and UMTS without Qos and with QoS   Fig.6 b) Comparison of Email Download Response time in sec for Hybrid coupled WiMAX and UMTS without Qos and with QoS

Email Upload Response time is time elapsed between sending emails to the email server and receiving acknowledgments from the email server. This time includes signaling delay for the connection setup. Fig. 6 a) shows the comparison of upload response time in sec taken by Hybrid Coupled WiMAX and UMTS Interworking Architectures for with QoS and without QoS. It is observed that upload response time taken by Hybrid Coupled Architecture with Qos is very less than Hybrid coupled Architecture without QoS. Email Download Response time is time elapsed between sending request for emails and receiving emails from email server in the network. Fig.6 b) shows the comparison of download response time taken by Hybrid Coupled WiMAX and UMTS Interworking Architectures with Qos and without QoS. It is observed that Email download response time taken by Hybrid coupled Interworking Architecture with QoS is also very less than Hybrid coupled interworking architecture without QoS.
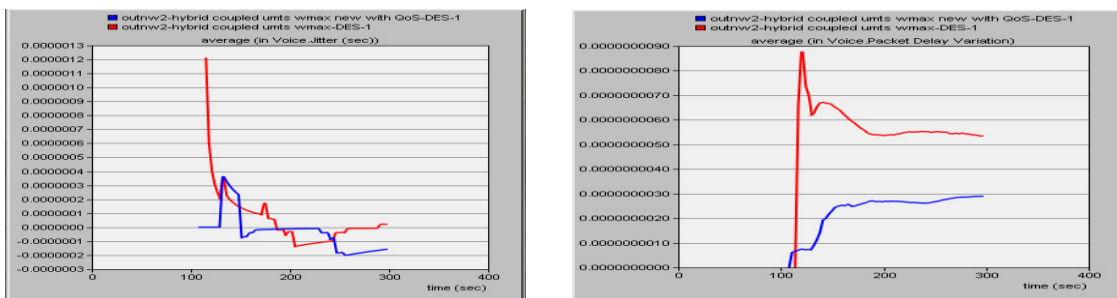

Fig. 7 a) Voice jitter in sec for Hybrid coupled WiMAX and UMTS without Qos and with QoS   Fig. 7 b) Voice packet delay variations in sec for Hybrid coupled WiMAX and UMTS without Qos and with QoS

Voice Jitter is defined as a variation in the delay of received voice packets. At the sending side, packets are sent in a continuous stream with the packets spaced evenly apart. Due to network congestion, improper queuing, or configuration errors, this steady stream can become lumpy, or the delay between each packet can vary instead of remaining constant. Fig. 7 a) shows the voice jitter for Hybrid coupled WiMAX and UMTS without Qos and with QoS. Voice Jitter for Hybrid coupled architecture with QoS is very low   i.e 0.00000002 sec when compared to hybrid architecture without QoS. Fig. 7 b) shows Voice packet delay variations for Hybrid coupled WiMAX and UMTS without Qos and with QoS. A voice packet delay variation is very less for hybrid coupled WiMAX and UMTS architecture with Qos than without QoS. The value is nearing 0.000000000.30 sec. This shows the proposed hybrid architecture with QoS architecture is better than without QoS.

4. Conclusion

WiMAX enhancements may include global roaming support to compete with the 3G cellular network market, it is important to consider that the existing 3G network customer base and infrastructure is much larger than that of WiMAX; thus, maximum revenue may only be achieved through the integration of these networks. Hence, in order to provide a uniform service experience and rich IP-based multimedia services to users, IMS is of particular importance with studying 3G and WiMax interworking. The 3G and WiMAX interworking with IMS support would provide users with access to heterogeneous wireless networks from any UE, and common billing and session management. In this work, the proposed Hybrid WiMAX-3G interworking architecture with QoS outperforms existing tightly coupled interworking architecture, loosely coupled interworking architecture and Hybrid coupled architecture. In case of Hybrid WiMAX-3G interworking Architecture with QoS, it inculcates the functions of both the tightly coupled and the loosely coupled interworking architecture and hybrid coupled, hence providing rich services to ubiquitous users. IP multimedia subsystem along with QoS provisioning attributes provides QoS negotiation, Session mobility, Session convergence and Resource management in the proposed hybrid WiMAX-3G interworking Architectures.

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