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Research paper



Performance analysis of integrated WLAN-WiMAX-UMTS networks for multimedia applications

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Abstract

Next Generation Wireless networks (NGWN) are the integration of different types of available wireless networks. These integrated networks will provide seamless connectivity for multimedia user applications. Among various wireless networks, the networks such as Wireless Local Area network (WLAN), Worldwide Interoperability for Microwave Access (WiMAX) and Universal Mobile Telecommunications System (UMTS) have their own unique characteristics and support for wide range of multimedia user applications. So, the integration of these networks and their performance analysis in respect of Quality of Service (QoS) is a major concern nowadays. Hence, this paper deals with the integration of WLAN, WiMAX and UMTS networks by considering QoS parameter. Further, the integration of these networks are analyzed with loose coupling and tight coupling architecture along with and without QoS. Furthermore, the performance analysis of the above mentioned integrated network for multimedia applications is also done. The simulation is performed through Opnet simulator.

Keywords: *HetNets; IP QoS; WLAN; WiMAX; UMTS.*

1. Introduction

Wireless technology has transformed our lives in many ways. There are different wireless technologies available for both fixed and mobile users which provide various multimedia services with their unique features. The most widely known networks are WLAN, WiMAX and UMTS. Each and every network is different from the other in respect of service area, data rate, bandwidth, traffic classes, cost and network operators. UMTS network has wide range of coverage area, high mobility support but provides low data rate [1]. Because of the low data transfer rate, UMTS network is not able to provide service for large number of multimedia user applications. Whereas WiMAX provides higher data rate, while WLAN supports larger bandwidth with high speed data transfer rate ranges up to 54Mbps. Based on these different features, the integration of these networks will enable the users to have the advantages of wider coverage area, higher data rate, larger bandwidth which permits seamless connectivity anywhere at any time. The combination of these coexisting interworking networks is known as Heterogeneous Networks (HetNets). In heterogeneous network environment, the users must be provided with fast access to the network with reduced packet loss rate. In order to offer ubiquitous service to the end users, it brings the necessity of analysing the QoS performance for differentiated services across the networks. Hence this work mainly focuses on proposing the better interworking architecture of WLAN-WiMAX-UMTS networks. Further, the overall QoS performance analysis of proposed integrated framework is done with IP QoS implementation for multimedia user traffic.

The rest of this paper is organized as follows. The next section deals with the related works. Section III discusses about interworking architecture of heterogeneous networks.

Section IV provides an overview of Internet Protocol (IP) QoS schemes and scheduling algorithms which will be implemented in heterogeneous network environment. Section V presents the simulation and comparison of QoS performance analysis of proposed interworking architectures with the implementation of various IP QoS schemes. Section VI provides the conclusion of the work.

2. Related works

Lot of works has been carried out so far to analyze the QoS performance of interworking architectures of heterogeneous networks. Sheetal Jadhav et. al [2] have studied the QoS performance of WiMAX and UMTS networks supporting Voice over Internet protocol (VoIP) traffic alone and evaluated that the WiMAX outperforms UMTS in case of VoIP applications. The authors in the survey paper [3] have analyzed the QoS performance of WiMAX-UMTS converging network architecture with IP Multimedia Subsystem [IMS] signaling for various traffics such as Voice, Email, Ethernet load etc. The same architecture is evaluated and related with interworking architecture of WLAN-WiMAX-UMTS in [4] and concluded that it performs better than the former integrated network. But this work is failed to focus on real time video traffic analysis. Vijay Verma and Silki Baghla have carried out the QoS performance analysis of integrated WLAN and UMTS networks for File transfer protocol (FTP) and video applications [5]. The simulation results show that the FTP application performance is better in terms of delay than the video conferencing application in the integrated network environment.

Instead of analyzing the performance of integrated network architectures alone, Mina [6] has proposed a framework to compare and analyse the Qos metrics of integrated Hetnets along with pure WiMAX and UMTS models for VoIP application. This work concludes that the pure UMTS model performs better for voice call services having lesser delay than WiMAX model and hetnets. Prerna Mehta et. al have presented the QoS performance analysis of the

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integrated WLAN-WiMAX-UMTS network architecture for voice, video and FTP applications [7]. From the simulations results it is observed that the FTP application achieves the least delay and better response time than the video applications. However, the analysis is done without the IP QoS implementation.

Mahdi H. Miraz et. al have presented the QoS analysis of WiFi, WiMAX, and WiFi-WiMAX networks for VoIP application [8]. This work mainly evaluated the QoS metrics such as jitter, Mean Opinion Score (MOS) and packet end to end delay. Omar Arafat et. al [9] have designed and developed a mobile user device with three radio access network interface to provide seamless connectivity over WiMAX, UMTS and Mobile IP networks by performing intersystem handover.

Even though lot of works is done on QoS performance analysis of homogeneous network and integrated heterogeneous network model for various applications, yet, there is no work focused in analyzing the overall performance of interworking network architecture with IP QoS implementation for multimedia traffic. Hence, this paper evaluates the overall QoS performance metrics of WLAN-WiMAX-UMTS interworking network architecture implemented with two queuing scheme for various kinds of real time traffic.

3. WLAN-WIMAX-UMTS interworking architecture

The evolution of data over the cellular networks is increased rapidly because the users demand multimedia traffic at same time to download more video, transfer more data and making interactive chat. Mobile phone users are allowed to make a voice or video call via the Internet anytime with enhanced quality as the network provides better QoS performance. The necessity of providing seamless connectivity to the users anywhere at any time, introduces the concept of interworking of different radio access technologies.

The interworking of several networks makes the users to avail the advantage of increased coverage area, higher data rate and bandwidth. The future technology is the combination of different wireless networks known as hetnets which coexists and interoperates with each other to provide better QoS performance to the multimedia users. This made us to deal with the interworking of WiMAX-UMTS-WLAN networks to analyse its overall QoS performance. Several works reported the interworking of these networks as mentioned in the literature review [10-13]. From that, integration of WLAN-WiMAX-UMTS networks can be mainly classified into loosely coupled interworking architecture and tightly coupled interworking architecture as shown in Fig.1.

a) Loosely coupled interworking architecture

In this type of architecture, the different radio access networks are combined individually through IP backbone as shown in Fig.1. In this architecture, the congestion can be reduced due to traffic flow through IP network.

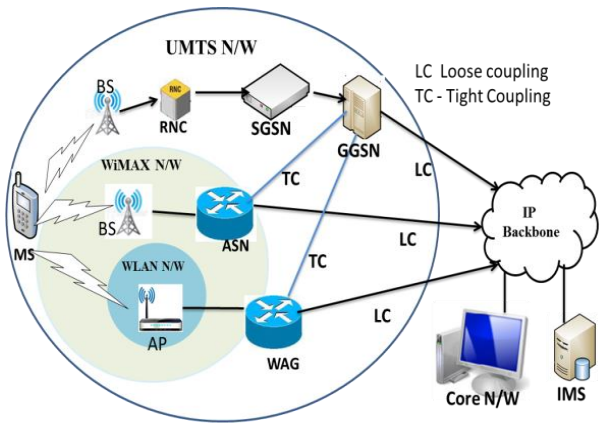


Fig. 1: Interworking Heterogeneous Networks.

b) Tightly coupled interworking architecture

In tightly coupled architecture, the WiMAX and WLAN networks are directly attached to UMTS network either at Gateway GPRS Support Node (GGSN) level or at Serving GPRS support Node (SGSN) level. In this way, the WiMAX and WLAN networks is considered as another Radio access network (RAN) of UMTS network.

HetNets are in need to offer best services to each and every user anytime by making connection to the best available radio access network. In that context, mapping the different QoS classes among these different radio access networks becomes a big task. The following section briefly describes about the various QoS schemes and scheduling algorithms.

4. IP QOS scheduling schemes

Nowadays the internet users demands various kinds of application traffic such as Email, Web browsing, FTP, VoIP and Video conferencing etc. But these diverse applications require different treatments, to know the difference between real time traffics to provide better QoS services to the users. QoS in a network offers transport for several applications comprising delay-sensitive, bandwidth-intensive applications and so on [14]. QoS can offer protected, determinate, and assured services to these applications by dealing end to end delay, bandwidth, delay variation which is also known as jitter and packet loss rate in a network. Numerous queuing and scheduling algorithms have been introduced to offer the differential and required QoS to heterogeneous network applications to satisfy multimedia user requirements. Some of the well-known and widely applied queuing schemes are

- First in First out (FIFO)
- Custom Queuing (CQ)
- Priority Queuing (PQ)
- Weighted Fair Queuing (WFQ)
- Class Based Weighted Fair Queuing (CBWFQ)
- Flow Based Weighted Fair Queuing (FBWFQ)
- Low Latency Queuing (LLQ)

In order to offer Qos guaranteed services to internet multimedia users, the Internet Engineering Task Force (IETF) has established two types of QoS models known as Integrated Services (IntServ) and Differentiated Services (DiffServ). Integrated Services (IntServ) is a framework which offers the required network resources at every router based on per flow basis for every incoming flow. This model uses Resource Reservation Protocol (RSVP) to provide guaranteed QoS based on the concept of per flow traffic handling. In addition to this, the QoS guarantee to the incoming new traffic flow is done based upon the Call Admission control (CAC) without interrupting the current process.

Differentiated Services works on the principle of classification and management of incoming traffic flows [15]. Instead of allocating network resources based upon per flow basis as in IntServ, the DiffServ uses Differentiated Services Code Point (DSCP) to classify the incoming traffic flow. Depending upon the value of DSCP, this model provides differential services to multimedia user applications in heterogeneous network environment. Since this model allocates resources based on current flow analysis using DSCP point, this paper is mainly focused on DiffServ domains.

The most widely used queuing schemes are Priority Queuing (PQ) and Weighted Fair Queuing (WFQ). The WFQ is classified into sub classes such as Class Based Weighted Fair Queuing (CBWFQ), Flow Based Weighted Fair Queuing (CBWFQ) and Low Latency Queuing (LLQ) [16]. Let's see an overview of these queuing schemes below.

In Priority Queuing (PQ) scheme, the traffic flows are divided into four queues at the router's output port. These queues are classified as high, medium, normal and low. The scheduler follows the working principle in which the high priority packets are served first before the lowest priority queues. After serving the highest priority queue, the scheduler starts to serve the second level priority queue. While serving this queue the scheduler checks for the presence of

any highest priority queue, if yes, it will start to serve them immediately and after finishing that it will moves on to serve second queue and so on. This process continues till the end which may results in not offering service to lowest priority queue to the very end. So this scheme may result in greatest delay in offering service to lowest priority queue packets. Sometimes low level packets may not be offered service and can be dropped out. Hence voice packets will dominate the network resources and starve the data packets.

The next most important queuing scheme is CBWFQ, the extended version of WFQ. CBWFQ offers provision for user defined traffic classes. CBWFQ makes the user to specify the exact amount of bandwidth to be allotted for a particular class of traffic. Based upon the available bandwidth on the interface, user can divide it up to 64 classes and control the traffic delivery among them, which is not possible with flow-based WFQ. In FBWFQ, the traffics are classified based upon the weights. Based upon the weights, it determines the amount of bandwidth to be allotted for classified traffics in relative with the other. This makes the FBWFQ scheme more effective than CBWFQ. For flow-based WFQ, the classification of traffics and weights are rely on and restricted to the seven IP Precedence levels. Here, in this paper, the IP QoS performance evaluation of heterogeneous network environment is done using the queuing schemes namely CBWFQ and FBWFQ. Each queuing schemes have its own advantages and disadvantages in providing differentiated services for multimedia traffic, which is discussed detail in results section.

5. Simulation results and discussions

The simulation models and their corresponding QoS performance analysis are done using Opnet Modeler 14.5 simulator. The real time and non-real time traffic such as Video conferencing, VoIP and FTP are considered to analyse the performance metrics such as Jitter, MOS value, Packet end to end delay, traffic sent and received, download response time etc., of the proposed integrated network environment.

a) WLAN- WiMAX-UMTS interworking architecture without IP QoS

In order to choose the better interworking architecture, the performance metrics comparison between loosely coupled and tightly coupled interworking architecture is made in this section. The loosely coupled and tightly coupled interworking architecture of WLAN-Wimax-UMTS networks which are discussed earlier is created using Opnet Modeler 14.5 and they are shown in the Fig. 2 and 3 respectively.

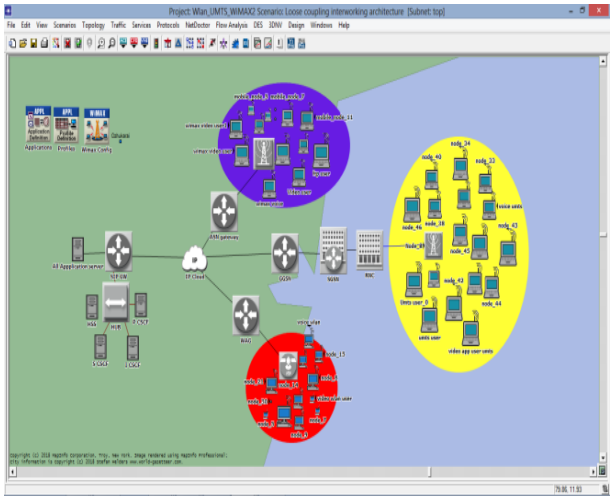


Fig. 2: WLAN-Wimax-UMTS Interworking Architecture – Loose Coupling Scenario.

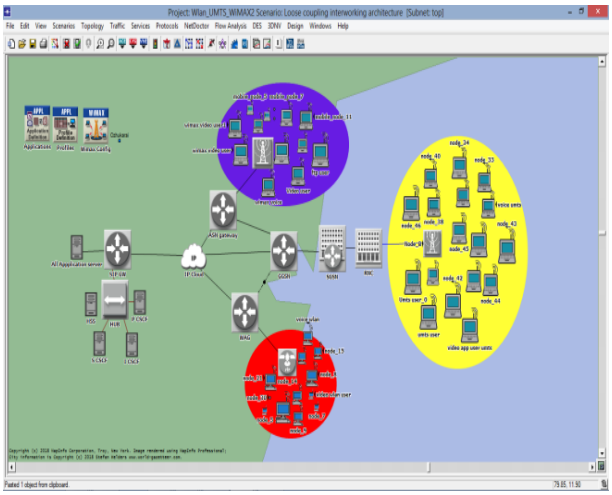


Fig. 3: WLAN-Wimax-UMTS Interworking Architecture – Tight Coupling Scenario.

b) Performance analysis of WLAN- WiMAX-UMTS Interworking architecture without IP QoS

These two scenarios with multimedia traffic users are made to run for the simulation time of 30 minutes. From the simulation of two scenarios, the following results are observed which is shown from the fig. 4 to fig.6. Fig. 4, 5 and 6 illustrate the service activation delay, context activation delay and uplink & downlink tunnel delay comparison of UMTS network respectively for both interworking architecture scenario.

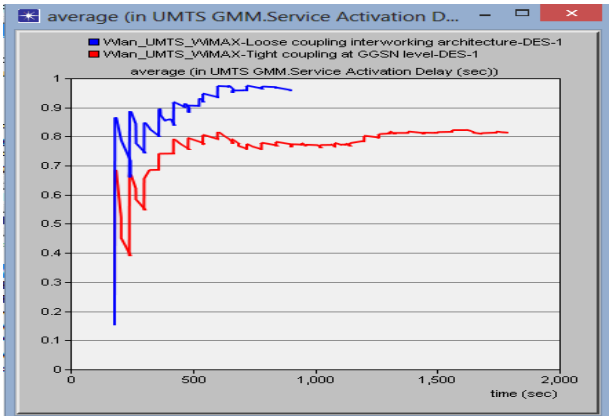


Fig. 4: UMTS Service Activation Delay.

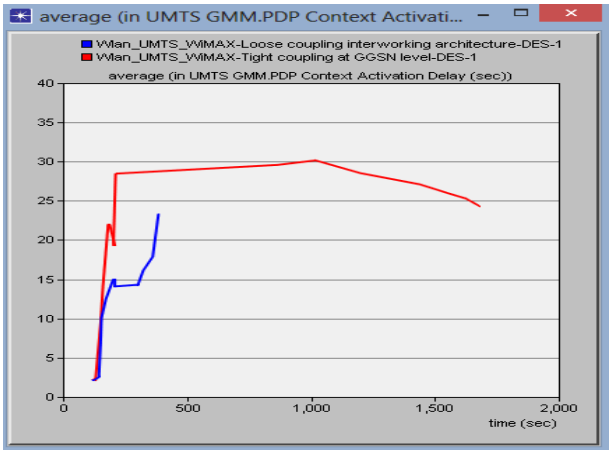


Fig. 5: UMTS Context Activation Delay.

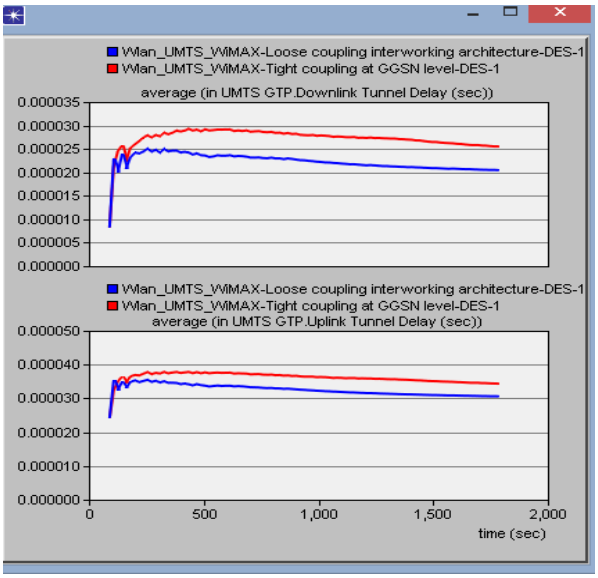


Fig. 6: UMTS Network Uplink and Downlink Tunnel Delay.

Fig. 7 and 8 portray the comparison of FTP download response time and FTP traffic received in case of both loose and tight coupled scenarios.

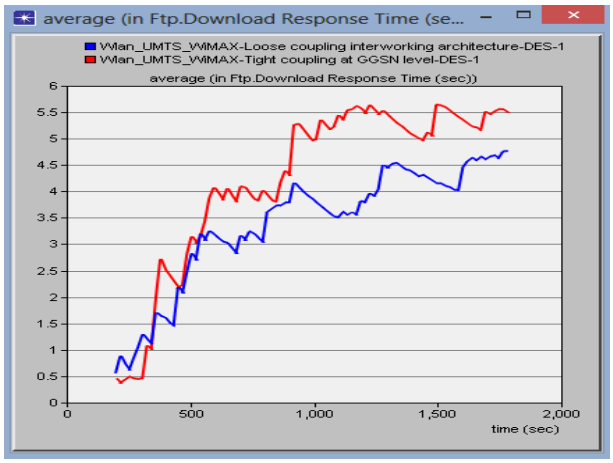


Fig. 7: FTP Download Response Time.

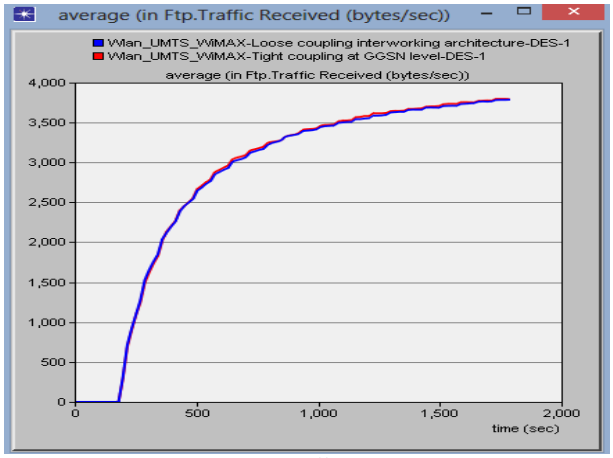


Fig. 8: FTP Traffic Received.

From the graphs, it is inferred that in respect of delay and response time, loosely coupled interworking architecture performs better than the other. But the throughput efficiency is good for both architectures regardless of delay which can be inferred from Fig. 8. However delay constraints are much important in heterogeneous network environment. Hence, the loosely coupled interworking proposed architecture is considered for further Qos performance analysis with IP QoS implementation.

c) Performance analysis of proposed framework with IP QoS implementation

As discussed in earlier section, the loosely coupled interworking architecture of WLAN-WiMAX-UMTS networks shown in Fig.9 are chosen for further performance metrics analysis with implementation of different types of IP QoS schemes. The IP QoS queuing profiles considered for evaluation are CBWFQ, FBWFQ and PQ. Totally three scenarios are created for the analysis. First scenario is created for the loosely coupled WiMAX-WLAN-UMTS interworking architecture without IP Qos as shown in the Fig.2. The remaining scenarios are implemented with IP QoS queuing schemes namely CBWFQ and FBWFQ separately for the architecture shown in Fig. 9.

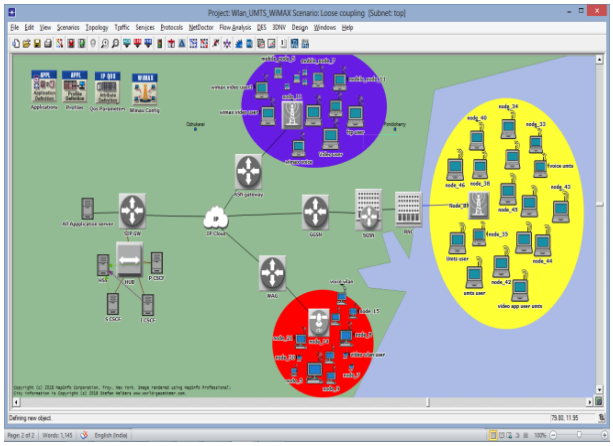


Fig. 9: WLAN-WIMAX-UMTS Interworking Architecture – Loose Coupling with IP QoS Scenario.

The above mentioned scenarios are made to run for the simulation time of 10 minutes. The following results are obtained from the simulation which is shown from the Fig. 10 to 13. Fig.10 portrays the comparison of voice jitter and MOS value of the integrated architecture framework. From Fig. 10, it is observed that FBWFQ results in less jitter compared to that of CBWFQ. In case of MOS value, the FBWFQ scheme provides acceptable value than the other scheme.

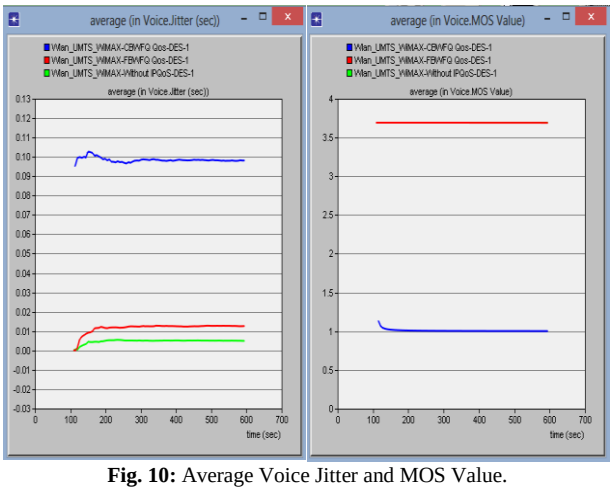


Fig. 10: Average Voice Jitter and MOS Value.

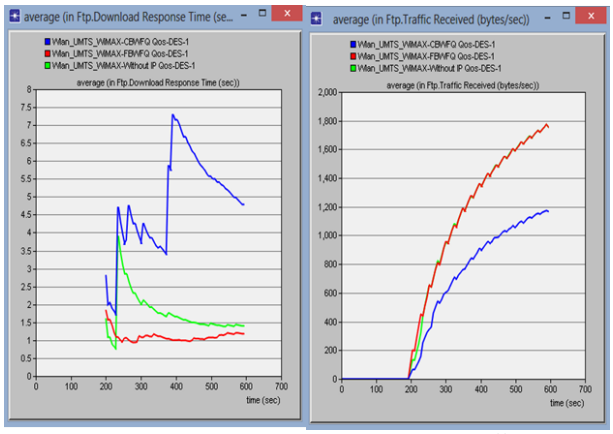


Fig. 11: Average FTP Download Response Time and Traffic Received.

Fig. 11 represents the comparison of FTP download response time and traffic received in the integrated network architecture of WLAN, UMTS and WiMAX networks. From the graph, it is shown that CBWFQ results in more delay and reduced throughput compared to other. So, for FTP traffic, the CBWFQ IP QoS serves poor performance. Fig.12 shows the comparison of Packet delay variation and Packet end to end delay for video and voice traffic of integrated network environment. Similarly, the average traffic received for video and voice traffic in WLAN, UMTS and WiMAX networks for three different scenarios is shown in the Fig.13.

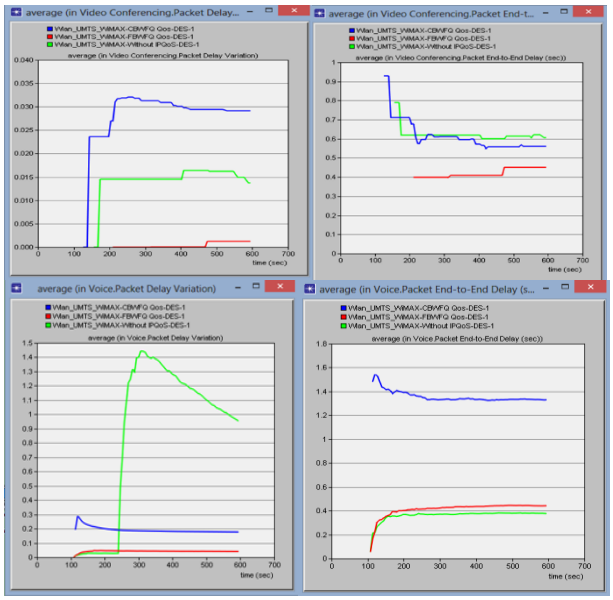


Fig. 12: Packet Delay Variation and Packet End to End Delay for Video and Voice Traffic.

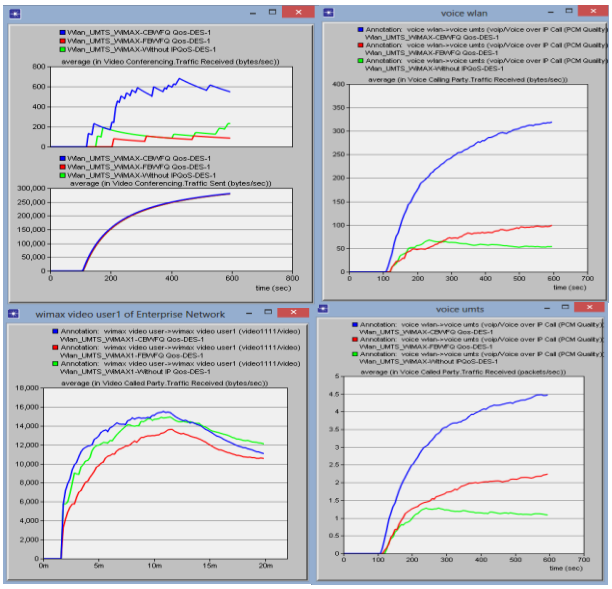


Fig. 13: Average Traffic Received for Video and Voice Traffic in WLAN, UMTS and WIMAX Networks.

From the comparison results, it is observed that the FBWFQ queuing scheme implemented scenario performs better in terms of delay when compared to that of CBWFQ implemented scenario and without IP QOS scenario. Hence, it can be concluded that the FBWFQ scheme is suitable for delay sensitive networks since it has lesser delay in all cases as shown in Fig.12. Whereas the networks based upon the throughput efficiency can go for CBWFQ regardless of the delay because CBWFQ scheme performs better in case of throughput efficiency which can be observed from the Fig.13.

6. Conclusion

The simulation models of proposed loose coupling interworking architecture of WLAN-WiMAX-UMTS networks are created and simulated using Opnet. The simulated results portrays the overall performance evaluation of QoS metrics such as delay, jitter, packet end to end delay, traffic sent and received etc., for multimedia user traffic. Two types of QoS schemes such as CBWFQ and FBWFQ are implemented in interworking architecture to analyse its performance metrics. From the performance comparison results, it is concluded that CBWFQ technique provides throughput efficiency in trade off with delay for video and voice traffic except for FTP traffic. Whereas FBWFQ provides lesser delay for all kind of traffics but fails to provide throughput efficiency in integrated network environment. Hence, depending upon the user and network requirements, the appropriate IP QoS schemes can be appended to provide best service.

References

[1] K. S. Munasinghe and A. Jamalipour, "Interworking of WLAN-UMTS Networks: An IMS-based Platform for Session Mobility," IEEE Communications, Vol. 46, No. 9, pp. 184-191, 2008.

[2] SheetalJadhav, Haibo Zhang and Zhiyi Huang, "Performance Evaluation of Quality of VoIP in WiMAX and UMTS", in proceedings of 12th International Conference on Parallel and Distributed Computing, Applications and Technologies, South Korea, pp. 375-380, January 2012.

[3] G. Vijayalakshmy and G. Sivaradje, "WiMAX-UMTS Converging Architecture with IMS Signaling analysis to achieve QoS", Elsevier 2nd International Conference on Communication, Computing & Security (CCCS-2012), NIT Rourkela, India, 2012.

[4] G. Vijayalakshmy and G. Sivaradje, " A QoS guaranteed Tight coupled WiMAX-3G-WLAN Convergence using IMS signaling analysis", International Conference on Computer Communication and Informatics (ICCCI -2013), Coimbatore, India, January 04 – 6, 2013.

[5] Vijay Verma and SilkiBaghla, "Performance evaluation of QoS in WLAN-UMTS network using OPNET modeler, International Journal of Science and Research (IJSR), Vol.3, No. 8, pp.857-860, 2014.
[6] Mina Malekzadeh, "Heterogeneous Cellular Interworking of WIMAX and UMTS for Sensitive Real-Time Services", International Journal of Information Engineering and Electronic Business, vol. 6, pp. 1-8, 2016.
[7] Prerna Mehta, Silki Baghla. "Performance Evaluation of Heterogeneous Networks for Various Applications Using OPNET Modeler", International Journal on Recent and Innovation Trends in Computing and Communication, Vol. 3, No. 6, pp. 4003-4006, 2015.
[8] Mahdi H. Miraz et. al., "Simulation and Analysis of Quality of Service (QoS) Parameters of Voice over IP (VoIP) Traffic through Heterogeneous Networks", International Journal of Advanced Computer Science and Applications, Vol. 8, No. 7, pp. 242-248, 2017.
[9] Omar Arafat, Mark A Gregory, M. M. A. Khan, "Interworking Architecture between 3GPP IMS, Mobile IP and WiMAX in OPNET", in Proceedings of IEEE International Conference on Electrical, Electronics and System Engineering, Kuala Lumpur, Malaysia, pp. 48-53, 2014.
[10] A.A. Atayero and E.I. Adegoke, "Interworking Architectures in Heterogeneous Wireless Networks: An Algorithmic Overview", International Journal of Computer Applications, Vol. 48, No .9, pp. 38-44, 2012.
[11] Haji, A., Ben Letaifa, A. and Tabbane, S., "Integration of WLAN, UMTS and WiMAX in 4G", in 16th IEEE International Conference on Electronics, Circuits, and Systems, Yasmine Hammamet, pp. 307-310, 13-16 Dec 2009.
[12] Quoc-Thinh Nguyen-Vuong, Fiat, L. and Agoulmine, N., "An Architecture for UMTS-WIMAX Interworking", in the 1st International Workshop on Broadband Convergence Networks, Vancouver,.BcN 2006, pp. 1-10,7 April 2006.
[13] FangminXu, Luyong Zhang and Zheng Zhou, "Interworking of Wimax and 3GPP networks based on IMS [IP Multimedia Systems (IMS) Infrastructure and Services]", Communications Magazine, IEEE, Vol. 45, Issue 3 , pp. 144-150, March 2007.
[14] Mohsin Iftikhar, "Performance Analysis of DiffServ Domain with Heterogeneous Queuing and Scheduling Schemes", Journal of Emerging Trends in Computing and Information Sciences, Vol. 4, No. 6, pp. 591-595, June 2013.
[15] A.Kos and B. Klepec, "Performance of VoIP applications in a simple Differentiated Services network architecture", IEEE EUROCON, vol. 1, pp. 214-217 , 4-7 July, 2001
[16] Charles Sarraf, Firas Ousta, Nidal Kamel, Mohd Zuki, "Mapping of QoS between UMTS and WiMAX in Tight Coupling Heterogeneous Wireless Network", International Journal of Soft Computing and Software Engineering (JSCSE), Vol.2, No.3, pp. 1-14, 2012.