



QoS Based Analysis in IEEE 802.11 and IEEE 802.16 Integrated Networks

Vimmi Malhotra^{*}, Lalit KumarDepartment of Computer Science,
PEC University of Technology, Chandigarh, INDIA

Abstract— With the success of wireless technologies in consumer electronics, standard wireless technologies is envisioned for the deployment in engineering environment. Engineering applications involving mobile subsystems or just the desire to save cabling make wireless technologies attractive. Nonetheless these applications often have rigorous requirements on reliability and timing. The main aim of this paper is to simulate an environment of integrated network i.e. Wi-Fi and Wimax and investigate the comparative performance of individual environment i.e. Wi-Fi, Wimax, and an integrated Wi-Fi and Wimax with respect to QoS parameters. For this we used Ns2 and LTE tool and further proves integration shows better results.

Keywords— Wi-Fi, Wimax, Merged Wi-Fi and Wimax, Qos, QoS parameters.

I. INTRODUCTION

Wireless access networks based on IEEE 802.11 and IEEE 802.16, known as Wireless Broadband Technologies (WiBro), have become very popular in providing different data services. Wireless technologies are consistently improving many different aspects of their functionalities such as transmission speed, coverage, and quality of service. Traditionally, WLANs are connected to the Internet and/or other WLANs through a wired network infrastructure. Give that there are limitations inherit to Wi-Fi standard. Conventionally Wi-Fi setups still would require a wired connection as their backend to be able to connect to internet. One such solution is the IEEE 802.16 family of Wireless Metropolitan Area Network (WMAN) technologies that render a promising solution to provide backhaul support for WLANs. Another important thing to notice is that the apparent similarity between Wi-Fi and Wimax, the complementary nature in terms of key factor is same between them. Wi-Fi has a short coverage range of approximate 100 meters while Wimax support a significantly greater coverage range of 500 meters and beyond, on the other hand Wi-Fi offers high raw data capacity with poor traffic control capabilities whereas Wimax is capable of highly sophisticated traffic management and QoS control. Normally Wimax works in licensed frequency bands, Unlike Wi-Fi. So optimal solution for this kind of situation is integration of Wi-Fi and Wimax, which is very hot and popular issue these days. The main reason for doing this is the legacy of wide deployment of Wi-Fi and the big coverage of Wimax. There have been numerous researches in variety of methods on how to develop an integrated Wimax and Wi-Fi systems [1][2][3] and provide various establishments such as QoS services to these architectures, comparing various routing protocols, etc. For instance, in [1], the authors suggested an integrated Wi-Fi/Wimax network which provide uninterrupted service to all subscribers, we need to incorporate a low cost, flexible Heterogeneous network which can able to couple any kind of network for efficient spectrum utilization, hence improve system capacity. Further it provides, high throughput, low end to end delay, flat and low jitter. Also in [2], the author describes various different merged Wi-Fi and Wimax and targets low-cost, high-performance Wireless access to residential and business applications. As technology evolves to address portable and mobile applications, the required features and performance of the system will increase. Further in [3], authors propose a new routing protocol that integrates WLANs and WMANs (Wi-Fi and Wimax), allowing seamless interconnectivity.

In this paper our first goal is to design and implement an integrated Wimax and Wi-Fi network. Our design simulates the handover effects between IEEE 802.11 (Wi-Fi) and IEEE 802.16 (Wimax) networks. Our simulated architecture consists of a Source Node (A) generating 1.57Mbps CBR/UDP traffic, 2 intermediate routers (A and B), IEEE 802.11 Access Point (AP), IEEE 802.16 Base Station (BS) and a Mobile Node (E) placed in a simulated area. Two environments are created Wi-Fi and Wimax in NS2. Then, we created a multi-interface node using Wi-Fi and Wimax technologies. There is a TCP connection between the source node and multiface node in LTE simulator.

Our next goal is to define and study implementing a QoS system on our integrated network. Three individual scenarios were created namely, Wi-Fi, Wimax and integrated Wi-Fi and Wimax and measure and compared their performance with respect to QoS metrics mainly, average delay, packet loss ratio, and instant throughput.

II. QUALITY OF SERVICE

QoS (Quality of Service) refers to an extensive collection of networking technologies and techniques. The purpose of QoS is to provide guarantees on the ability of a network to deliver expected results. The elements of network performance within the scope of QoS often include throughput, packet delivery ratio, jitter, energy efficiency, end to end

delay, error rate. QoS is especially important for the new generation of Internet applications such as VoIP [5], video-on-demand and other customer services. Wireless access techniques are continuously expanding their transmission bandwidth, coverage, and Quality of Service (QoS) support in recent years and has become a widely spread method to exchange information, leading to more interactive information and thus a larger requirement of bandwidth. An important factor in the competition between different wireless technologies is the capability of meeting Quality of Service (QoS). Controversy exists whether QoS is needed or not. Those who are against it state that when traffic has reached a level beyond the capacity of the network, QoS will not manage to satisfy user demands and if the network has sufficient resources for the entire traffic, QoS is unnecessary.

In response to the increasing QoS challenge in wireless networks, researchers have made significant modifications in Wireless Fidelity (Wi-Fi) in the legacy IEEE 802.11 standards to make possible QoS to end users. The design constraints at several layers of the IEEE 802.11 restrict its capacity to deliver guaranteed QoS. Recently, the IEEE 802.16 standard has emerged as the strongest contender for broadband wireless technology with promises to give guaranteed QoS to wireless application end users over Wi-Fi wireless technology [6]. We expressed the following QoS parameters for integrated architecture:

- 1) *Average Delay*: Delay or latency could be defined as the time taken by the packets to reach from source to destination. It is measured in milliseconds (ms).
- 2) *Packet Loss Ratio*: Packet loss Ratio (PLR) signifies the number of packets lost during the transmission from source to destination. It is actually the measure of number of packets undelivered or lost in the network.
- 3) *Instant Throughput*: It is defined as the total number of data packet divided by total time, where total time can be calculated as the difference between the current data packet time and the previous data packet time. It will be measured in kilo bit per second (kbps).

III. SYSTEM DESIGN

Our design shown in fig 1 simulates the handover effects between IEEE 802.11 (Wi-Fi) and IEEE 802.16 (Wimax) networks. It consists of a Source Node (A) generating 1.57Mbps CBR/UDP traffic (packets of 512 bytes at an interval of 2.6ms), 2 intermediate routers (A and B), IEEE 802.11 Access Point (AP), IEEE 802.16 Base Station (BS) and a Mobile Node (E) positioned in a simulated area of 2000m * 2000m. The IEEE 802.16 BS provides complete coverage over the total simulation area, whereas the IEEE 802.11 AP covers a spherical area with a radius of 40m placed within the IEEE 802.16 covered region.

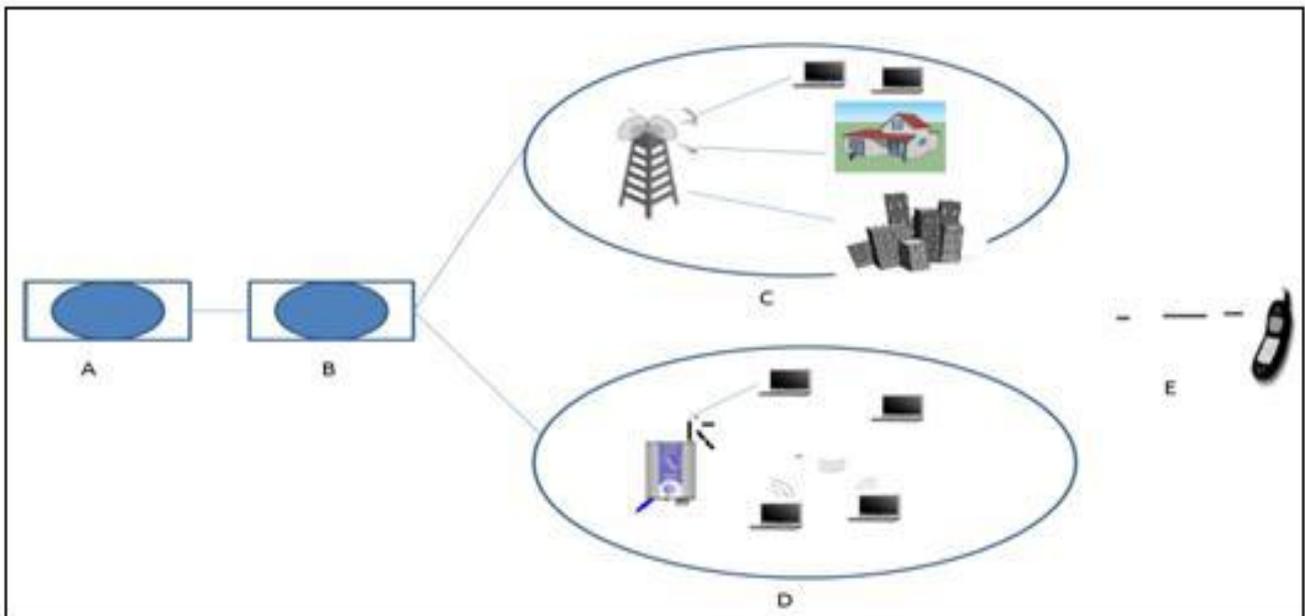


Fig. 1 Integrated Architecture of Wi-Fi and Wimax

Our architecture defined following parts:

- 1) A acts as source node (router 0).
- 2) B acts as router 1.
- 3) C consists of Wimax base station (tower) providing services to many multiple subscriber station and forming different cells.
- 4) D consists of Wi-Fi access point providing services to many users.
- 5) E is a multi mobile interface nodes moving either in coverage of Wimax or Wi-Fi or both which is integrated with handover concept.

The Mobile Node (E) is placed in the IEEE 802.11 covered area at any random position of the simulation establishing a Wi-Fi link with the IEEE 802.11 AP. Then, the Mobile Node (E) starts to move with a constant speed of 1 m/s leaving

the Wi-Fi coverage area and entering the IEEE 802.16 coverage region. The IEEE 802.21 technology is used to facilitate the handovers or handoffs. So this linkage, i.e... when the nodes are present in between coverage area of Wimax and Wi-Fi is done through handovers. Merging of these technologies namely Wi-Fi and Wimax is done in LTE simulator and later on embedded in NS2.

We will analysis QoS parameters metrics on this architecture with respect to average delay, packet loss ratio, instant throughput and last users versus number of nodes. We measure users as pedestrian user and vehicular user. Also we compare this architecture with individual environment of Wi-Fi as well as Wimax. After this, we compared their results on QoS metrics. Our stimulated architecture offers guarantees QoS by integrating Wimax and Wi-Fi. Also, this architecture provides mobility, scalability, coverage and speed and reliability as well.

IV. MEASURING QoS IN THE INTEGRATED NETWORK

To measure the QoS in the proposed architecture we consider four parameters namely, average delay, packet loss ratio, instant throughput and users. On the basis of above scenario we measure the performance of individual environment mainly, Wi-Fi, Wimax and integrated Wi-Fi and Wimax and examine the result.

V. SIMULATION PROCESSING

We have used NS2 software version 2.31 for our simulations due to its ease of node deployment and network set up. Further LTE [7] simulator is used for integration of two technologies namely Wi-Fi and Wimax. With the help of NS2 we were able to critically analyse our results and compared individual environment with integrated architecture of Wimax and Wi-Fi with respect to QoS parameters. These parameters are defined below:

- 1) *Average Delay*: The delay of a network specifies how long it takes for a packet to travel across the network from one node to another. It is normally measured in multiples or fractions of seconds. Here we will be measured in milliseconds.
- 2) *Packet Loss Ratio*: Packet loss occurs when one or more packets of data travelling across a computer network fail to reach their destination. We calculated it as per following formula:

$$PLR = [n1 / (n1 + n2)]$$

where n1=Number of lost packet, and
n2=Number of packets received successfully.

- 3) *Instant Throughput*: It is defined as the total number of data packet divided by total time, where total time can be calculated as the difference between the current data packet time and the previous data packet time. It will be measured in kilo bit per second (kbps).

The following methodology is used for integration as well as analysis of QoS in these integrated networks. Firstly a Wi-Fi environment is created in ns2 simulator of 500 nodes. Specifications are given in table 1. Secondly a Wimax environment is created same in ns2 simulator. Then we created a multi-interface node using Wi-Fi and Wimax technologies. There is a TCP connection among the router0 and multiface node. We first use the LTE interface, and then we switch the traffic to the 802.11 interface when it becomes accessible. Now the Ethernet link is linked and we toggle to that interface. To verify disconnection, we disconnect Ethernet to control to 802.11, and then the node leaving the coverage region of 802.11 creates a link going down event to redirect to LTE. The merging of these two technologies is done in LTE stimulator which is embedded in ns2 simulator. After simulating an integrated architecture, we analysis QoS performance. We measure following parameters, namely average delay, packet loss ratio, and instant throughput.

TABLE 1: METRICS FOR INTEGRATED WI-FI AND WIMAX

S.No	Parameter Metrics	Value
1	Number of Nodes	20 to 500
2	Data Pattern	Node-UDP
3	MAC Type	802.11 and 802.16
4	Channel Type	Wireless
5	Speed	0.5m/s to 1.5 m/s
6	Simulation Time	200 sec
7	Geographical Area	500 m

VI. RESULTS AND DISCUSSION

We had made four cases consists of **number of nodes** Vs. **QoS parameters**.

A. Average Delay

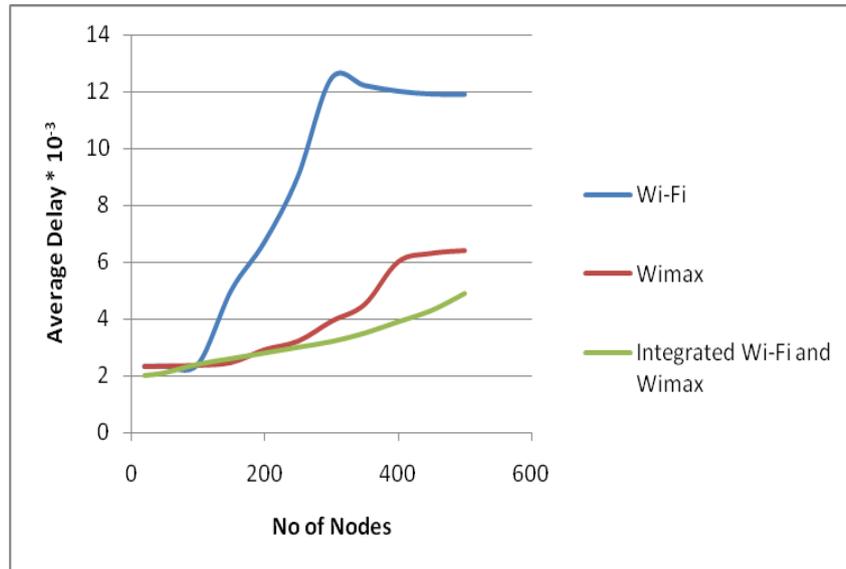


Fig. 2 Average Delay

As seen from fig 2 graph, as the number of nodes increases for Wi-Fi network, the delay increases up to a certain point due to high network traffic and less coverage by Wi-Fi but in Wimax network it becomes constant to up to an average value of 6 milliseconds. But in integrated Wi-Fi and Wimax it is constant from starting. An integrated Wi-Fi and Wimax has a constant delay since it acquires benefits of both networks.

B. Packet Loss Ratio

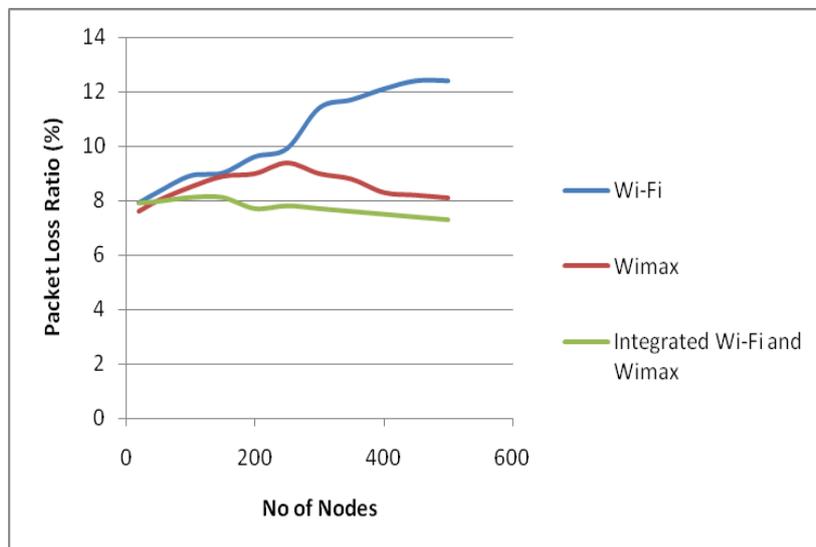


Fig. 1 Packet Loss Ratio

As predicted from fig 3 graph, as the no of nodes increases Wi-Fi loss ratio goes on increasing due to shorter range of Wi-Fi as compared to others. As the number of nodes increases the Packet loss Ratio increases, because of packet drops due to the congestion in network. In integration it is constant throughout the process as it covers all flaws of Wi-Fi and Wimax. This advantage is provided by handover, because when no of nodes move from one region to another then its coverage is given by 802.21.

C. Instant Throughput

In Wi-Fi due to their range up to metres they take more time to reach their destination as compared to others. In Wimax, it takes kilometres for packet delivery in time, but it is smooth in integrated architecture, since it covers both technologies advantages. As the number of nodes increases throughput also get increases. This growth is linear in nature. But in Wi-Fi after 400 nodes, nodes move away from access point so their coverage become less, hence decrease throughput.

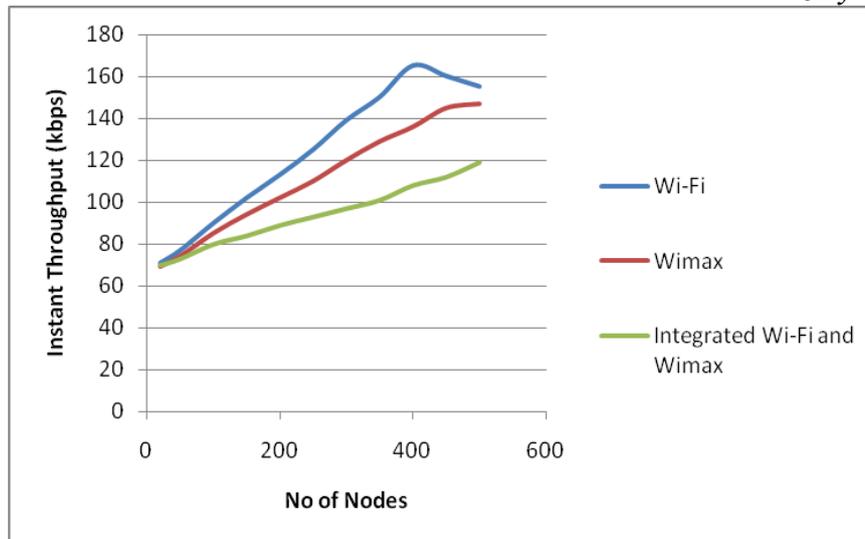


Fig. 4 Instant Throughput

VII. CONCLUSION

In the course of this research we derived that Wi-Fi and Wimax both have their advantages and disadvantages and widely used technologies these days. Wi-Fi in comparison to Wimax is superior response of a wireless network. The problem in Wi-Fi network is overcome by the Wimax network. Comparing these, Wi-Fi network and Wimax technology is more secure and reliable service. As a result, merging these two technologies gives us better result and response with respect to quality of service, mobility, coverage and practicability. Together, Wimax and Wi-Fi are ultimate partners for service providers to deliver appropriate, reasonable mobile broadband Internet services in additional places. They are open IEEE wireless standards built from the ground up for Internet Protocol (IP)-based applications and services. Our stimulated architecture shows better result in above parameters as compared to other individual environments such as Wi-Fi and Wimax. So merging of two technologies results in better delivery of QoS services especially in case of voice with data. Now day integration is very common. It provides us with benefits which are proved by above results.

VIII. FUTURE WORK

We can stimulate an integrated architecture of 3G and 4G using LTE stimulator and measure its performance on QoS parameters such as jitter, speed, CBR, instant delay, etc. Further these applications can be used in delivering voice over data calls at higher data rate. Overall cost of this architecture can be costly but output will be highly satisfied.

ACKNOWLEDGMENT

I wish to acknowledge the importance of those whose help and leadership has been instrumental to the production of this paper. In particular, I owe an enormous intellectual debt to Lalit K.. Jindal, Assistant Professor at PEC University, whose vision and tenacity has influenced my thinking during the preparation of this research paper and has taken his students to a different set of heights. I wish to express his sincere appreciation and support in editing the material and for suggesting changes that made the presentation more effective and read able of this research paper as well as with ideas how to work and make research presentable.

REFERENCES

- [1] Poulomi Das, Prof. Siladitya Sen, Arindam Banerjee, "Integrated WiMAX / Wi-Fi Network Coupler & Its Performance Analysis through QUALNET 5.0.1 Simulator", International Journal of Engineering Research and Applications, Vol. 3, Issue 1, January -February 2013, pp.1552-1556.
- [2] Awanish kumar kaushik, "A comparative study of Technical aspect of WiMAX & WiFiNetworks Technology", International Journal of Advances in Electrical and Electronics Engineering, Volume1, Number 3, 2013.
- [3] Ebrahim Doulatyari and Payam Aghel Kohan, and Amir Esmailpour, "Quality of Service Support for a WiFi-WiMAX Network in a Test-bed Environment", International Conference on Innovations in Information Technology (IIT), 2012.
- [4] M.Sreerama Murthy, D. Veeraiah and A.Srinivas Rao, "Performance Evaluation of Wi-Fi comparison with Wimax Networks", International Journal of Distributed and Parallel Systems, Vol.3, No.1, January 2012.
- [5] M. Atif Qureshi, Arjumand Younus, Muhammad Saeed, Farhan Ahmed Siddiqui, Nasir Touheed and M. Shahid Qureshi, "Comparative Study of VoIP over WiMax and WiFi", IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 3, No. 1, May 2011.
- [6] Md. Alimul Haque, Yashi Amola and Dr. N. K. Singh, "Performance of Wimax over Wi-Fi with Reliable QoS over Wireless Communication Network", World Applied Programming Journal, Vol.1, December 2011.
- [7] Shihab Jimaa, Kok Keong Chai, Yue Chen, Yasir Alfadhl, "LTE-A an Overview and Future Research Areas", IEEE 2011.

- [8] Vikas Solomon Abel and Rodney Rambally, “*Wimax and Wi-Fi in Current World*”, International Journal of Scientific and Engineering, Vol.2, Issue 9, September 2011.
- [9] Rajiv Chechi, Dr.Rajesh Khanna, “*QoS Support in Wi-Fi, WiMAX & UMTS Technologies*”, International Journal of Electronics & Communication Technology, Vol. 2, Issue 3, Sept. 2011.
- [10] Mohsen Gerami, “*A Survey on Wimax*”, International Journal of Computer Science and Information Security, Vol.8, 2010.
- [11] Hui-Tang Lin, Ying-You Lin, Wang-Rong Chang, and Rung-Shiang Cheng, “*An Integrated WiMAX/WiFi Architecture with QoS Consistency over Broadband Wireless Networks*”, IEEE 2009.
- [12] A.F.M Sultanul Kabir, Md.Razib Hayat Khan, Abul Ahsan Md.Mahmudul Haque and Mohammad Saiful Islam Mamun, “*WiMAX or Wi-Fi: The Best Suited Candidate Technology for Building Wireless Access Infrastructure*”, IEEE Computer Society, 2008.