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Performance Analysis of a WiMax/Wi-Fi System Whilst Streaming a Video Conference Application

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***Abstract*—**WiMAX and Wi-Fi are considered as the promising broadband access solutions for wireless MAN's and LANs, respectively. In the recent works WiMAX is considered suitable as a backhaul service to connect multiple dispersed Wi-Fi 'hotspots'. Hence a new integrated WiMAX/Wi-Fi architecture has been proposed in literatures. In this paper the performance of an integrated WiMAX/Wi-Fi network has been investigated by streaming a video conference application. The difference in performance between the two protocols is compared with respect to video conferencing. The Heterogeneous network was simulated in the OPNET simulator.

***Keywords*—**Throughput, delay, delay variance, packet loss, Quality of Service (QoS).

I. Introduction

WiMAX is a popular technology for broadband access in Wireless Metropolitan Area Networks (WMAN) environment. It offers a rich set of features and flexibilities in terms of deployment options and it supports new applications. The physical layer of WiMAX is based on Orthogonal Frequency Division Multiplexing (OFDM), which is widely recognised as the modulation technique for mitigating multipath fading problem associated with any broadband wireless system. WiMAX is capable of supporting very high peak data rates. In fact a peak rate of 74Mbps can be achieved when operating with a 20MHz wide spectrum. Under very good signal conditions, even higher peak rates may be achieved by using multiple antennas and spatial multiplexing [1].

One of the potential applications of WiMAX is to provide backbone support for mobile Wi-Fi hotspots. Traditionally wired connections are used as backhaul support for Wi-Fi hotspots. But wired infrastructure is always considered expensive and it should be replaced by wireless backbones. Heterogeneous wireless networks consisting of WiMAX and Wi-Fi have been proposed in the literatures [2], [3]. The architecture of this type of network is shown in Fig. 1.

In this network model a WiMAX base station (BS) serves both WiMAX subscriber and Wi-Fi access points in the coverage area.

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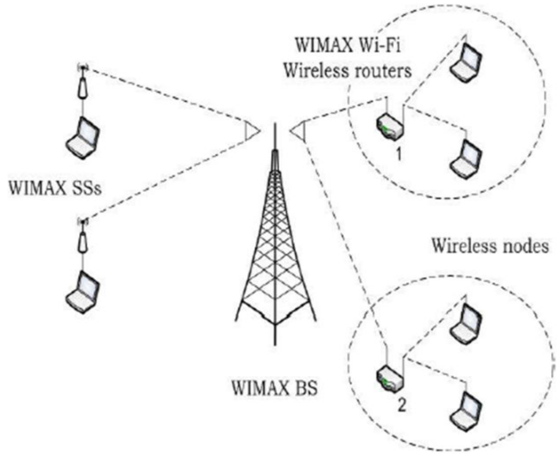

Fig. 1 Heterogeneous network architecture (WiMAX/Wi-Fi)

The connection between the WiMAX base station and the WiMAX subscriber station is based on the WiMAX protocol and the connection between the Wireless LAN access points and the Wireless LAN nodes is based on Wi-Fi protocol. Several QoS provisioning mechanisms for integrating WiMAX /Wi-Fi systems have been proposed in literatures [4], [5].

The Quality of Service (QoS) of a Video Conference application is determined by the following parameters; Packet loss: it's a comparative measure of packets received to the total number of packets that were transmitted, Delay: it's a finite amount of time that a packet takes to reach the receiving end point after being transmitted from the sending endpoint, throughput and delay variance (jitter).

In this article investigated the performance of the WiMAX/Wi-Fi network for a Video application.

II. QoS Requirements of a Video Conference Application

QoS parameters for a video conference application are as follows:

A. Bandwidth and Throughput

Bandwidth is the available capacity of connection between two terminals, the most popular term for that is (bps). Throughput slightly differs from bandwidth as it stands for effective bandwidth that is provided by the network.

B. Delay or Latency

It specifies the time it takes for a packet to leave the source and reach the destination.

C. Jitter (Delay Variation)

Jitter is an interval between subsequent packets. It is caused by network congestion, route alteration etc.

D. Packet Loss

It is the number of packets out of the total number sent that is not received, to a large extent the QoS depends on this factor.

Application	Bandwidth	Sensitivity to:		
		Delay	Jitter	Loss
VOIP	Low	High	High	Med
Video Conferencing	High	High	High	Med
Streaming Video	High	Med	Med	Med
Streaming Audio	Low	Med	Med	Med
Client/Server Transactions	Med	Med	Low	High
Email	Low	Low	Low	High
File Transfer	Med	Low	Low	High

Fig. 2 Applications QoS metrics sensitivity

As can be seen from the figure above Video Conference applications are highly sensitive to the factors of Delay, Jitter and packet loss. Hence this factors need to be kept at minimum values in order for the QoS to be as high as possible in transmitting or streaming a video application.

For best quality of a picture the above mentioned factors should be kept at the following values [6].

Packet loss: should not exceed 1%. End to end delay should be below 150mS. Jitter should be kept under 30mS.

III. Simulation Methodology

In order to investigate the performance of the integrated WiMAX /Wi-Fi network with respect to a video conference application the OPNET modeller simulation tool was used. The OPNET modeller supports both WiMAX and Wi-Fi technology. It also allows one to stream a video conference application of high resolution over the investigated network. The network consists of a centrally placed BN_ASN router that has 12 Point-to-point (PPP) links. The router is connected to an application server running the video conference application and 4 logical subnets. Within each logical subnet there is a Base station (BS) based on the WiMAX protocol. Each base station is connected to a WiMAX subscriber Station (SS) which connects to 4 Wireless LAN subscribers such as Laptops etc. The WiMAX subscriber station has two interfaces, the WiMAX interface to communicate with the WiMAX base station and the Wireless LAN interface to communicate with the Wireless LAN based nodes.

The application profile is running in serial mode which means that each application initiates packet generation in a serial manner. The packet generation started at times that is uniformly distributed. The whole process of packet generation lasts till the end of the simulation.

All traffic is discrete. The WiMAX layer was configured with the Best Effort scheduling technique with a Maximum sustained traffic rate of 10Mbps and a minimum reserved traffic of 5Mbps.

The Fig. 3 shows the overall network topology. The topology inside of a subnet can be seen in Fig. 4. The parameters of the WiMAX system are shown in the Table I.

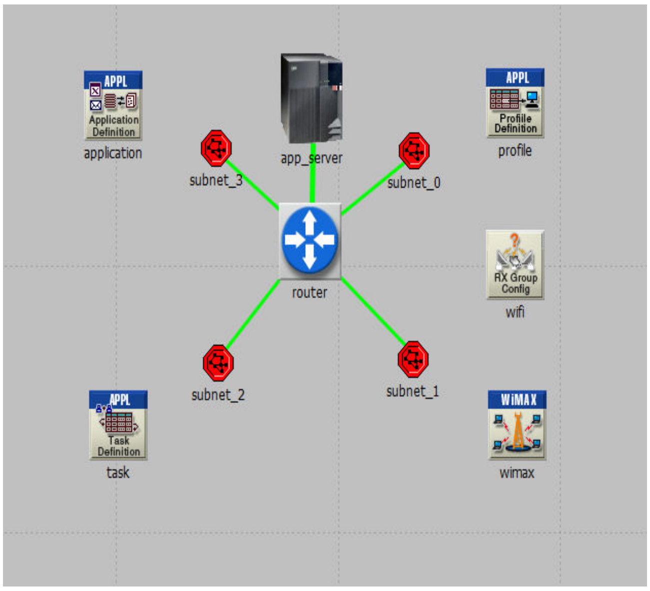

Fig. 3 The network topology

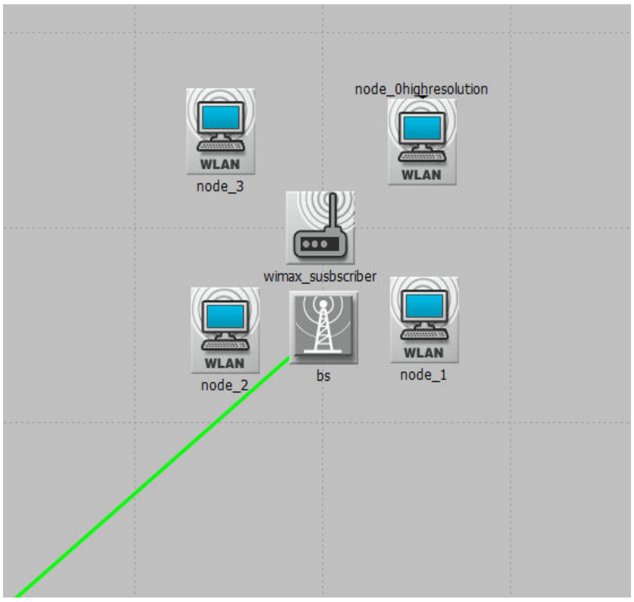

Fig. 4 Subnet topology

TABLE I
PARAMETERS OF THE WIMAX SYSTEM

Parameters Selected	Values Set
Max No of SS Nodes Supports	100
Transmits Power (W)	0.5
Physical Profile	OFDMA20MHz
Modulation	Adaptive
Average SDU Size (bytes)	1500
Connection Retries	16
Antenna Gain	15dbi
Service Class Used	Bronze
Scheduling type	Best Effort

Essentially the parameters set up for the Wi-Fi hotspots are the data rate of between 65Mbps and 600Mbps, the physical layer technology of 802.11n 2.4GHz and the buffer size of 1,024,000 are all done to enable a video conference application stream over the network without much packet loss and delay, the reason being that the video conference application of high resolution requires high bandwidth of as much as 150Mbps in this case.

The Parameters of the Wi-Fi Hotspots are shown in Table II below.

TABLE II
PARAMETERS OF THE WI-FI HOTSPOT

Parameters Selected	Values Set
Physical layer Technology	HT PHY2.4GHz (802.11n)
Data Rates bits/sec	65Mbps(base)/600 Mbps max
Transmit power	0.005W
Packet received power	-95
Large Packet Processing	Drop
Antenna Gain	14dbi
Access point Functionality	Enabled
Buffer Size	1,024,000
Antenna Gain	14dbi

IV. SIMULATION RESULTS

As earlier on stipulated the requirements of a video conference application for good picture quality should be as follows [6];

Packet loss: should not exceed 1%. End to end delay should be below 150mS. Jitter should be kept under 30mS.The performance of the integrated network with respect to the above mentioned factors is as follows.

A. Packet End-to-End Delay

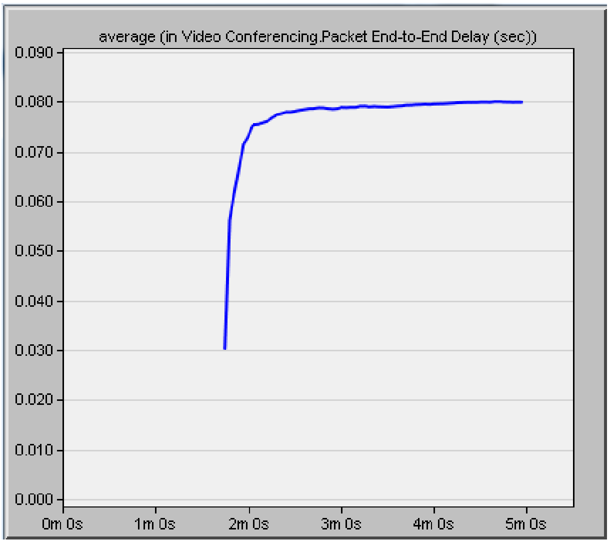

Fig. 5 Packet end-to-end delay

For the integrated WiMAX /Wi-Fi network the overall end-to-end delay is approaching 80mS after a simulation time of about 5mins as seen in Fig. 5. However the accepted value for a video conference application is below 150mS. Hence the above mentioned network is able to stream a video conference application without a serious delay that could reduce the QoS below accepted values for a video conference application.

B. Jitter or Delay Variance

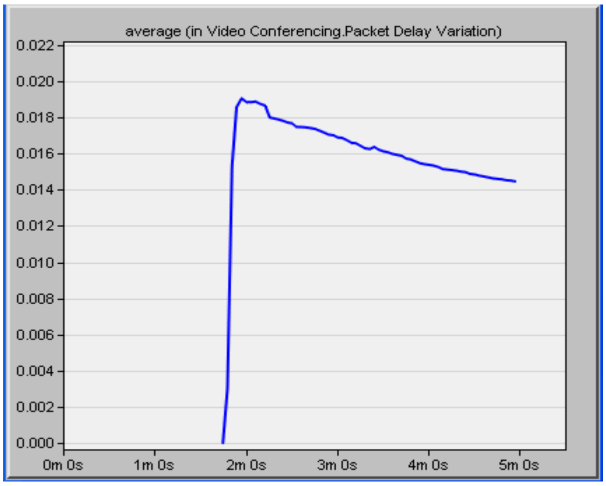

Fig. 6 Packet delay variation

With respect to Jitter or delay variance the value after a simulation time of 5mins tends to approach 14mS as seen in Fig. 6, whilst the accepted value for a video conference application is about 30mS, hence the simulation results of 14mS which is below 30mS shows a good value of jitter for a video conference application to generate a good picture quality.

C. Packet Loss

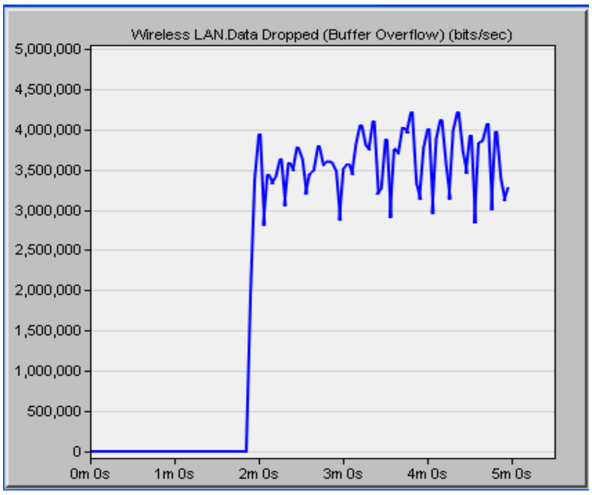

Fig. 7 Data dropped

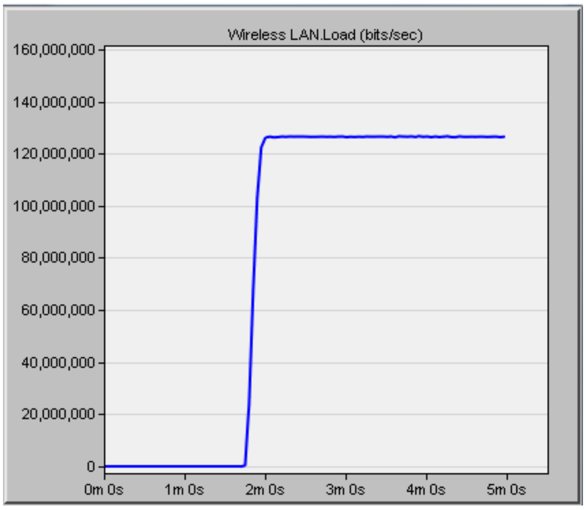

Fig. 8 Network Load

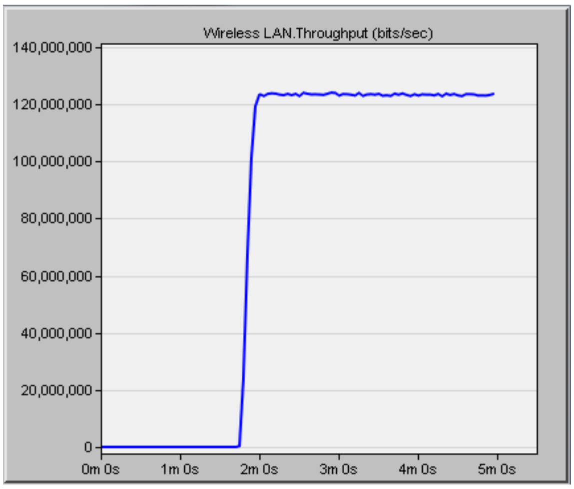

Fig. 9 Network Throughput

For the packet loss factor one has to compare the Load on the network which as seen in Fig. 8 is about 135Mbps and the throughput in the network which is about 132Mbps as seen in Fig. 9, hence the difference which is the data dropped is about 3.4Mbps. The fraction of data dropped over the total load gives us about 2.5%. Hence the packet loss is about 2.5% which is still not too bad for a video conference application.

Hence overall the network would be able to sustain a video conference application with as high a bandwidth requirement as 140Mbps, for example a high resolution video.

D. Comparison between the WiMAX and Wi-Fi Subsystems

The two main components of this integrated network are the WiMAX subsystem and the Wi-Fi subsystem.

Generally the WiMAX protocol is able to support higher bandwidth applications than the Wi-Fi systems at a lower delay for the applications [7]. However in this model the Wi-Fi parameters included the use of the 802.11n standard of 2.4GHz which can sustain a data rate of 65Mbps up to 600Mbps, whilst the individual components in the WiMAX network had a maximum sustained traffic of 10Mbps (Bronze service class), such that the WiMAX subsection would overall drop more packets and have a higher delay than the Wi-Fi component.

Fig. 10 below shows the throughputs of the WiMAX and Wi-Fi systems.

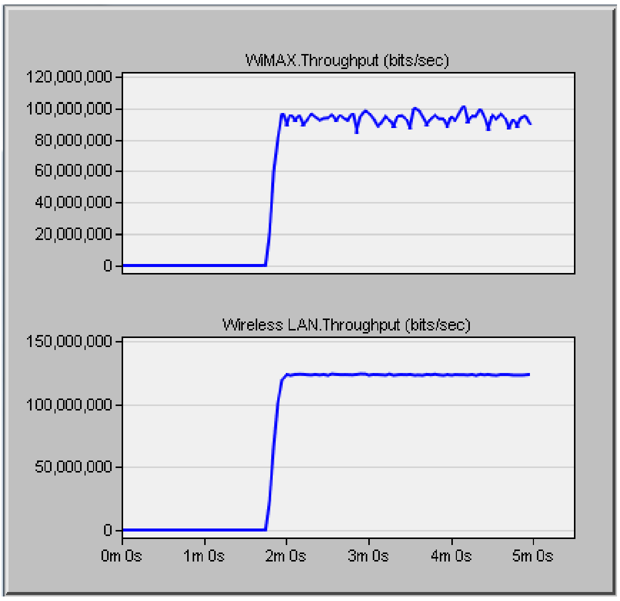

Fig. 10 Throughputs of WiMAX and Wi-Fi systems

As can be seen in Fig. 11 below the WiMAX system has a higher delay approaching 80mS whilst the Wi-Fi system approaches 25mS. This is due to the fact that the Wi-Fi system is overall faster in transmitting the Video packets and has a higher data rate.

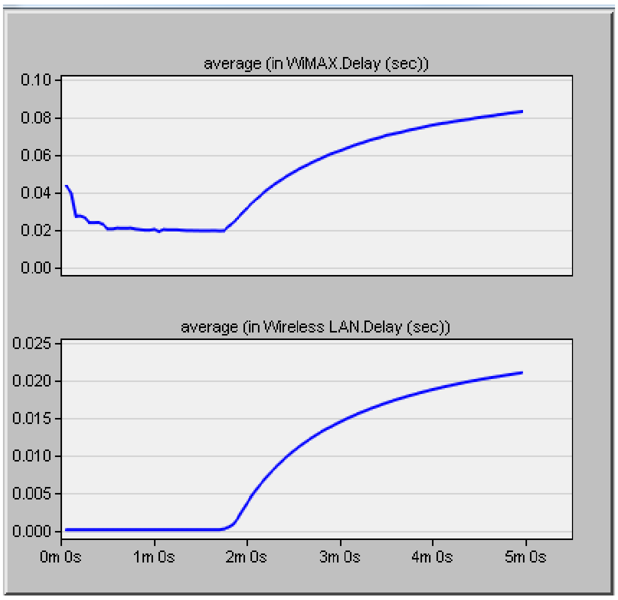

Fig. 11 Delay in WiMAX and Wi-Fi subsystems

V. CONCLUSION

In this paper an Integrated WiMAX /Wi-Fi network was modeled whilst streaming a video conference application to determine the performance of the integrated network with respect to the QoS requirements of a high resolution video conference application. In addition the WiMAX and Wi-Fi subsystems were compared with respect to their individual performance whilst streaming a video conference application.

It was determined according to Table III that, with the network model simulated which integrated the WiMAX and Wi-Fi protocol. It will be possible to stream a high resolution video conference application over the network since the parameters required for a high QoS are mostly met with the exception of packet loss which is 2.5%. This is not however very far away from the required standard for a high QoS requirement.

TABLE III
QOS PARAMETERS FOR VIDEO CONFERENCE APPLICATION

Parameters	Expected values for a good QoS	Obtained results for network
Packet Loss	<1%	2.5%
Overall Packet delay	<150mS	<80mS
Jitter (Delay Variance)	<30m	14mS

With respect to the performance of the individual WiMAX and Wi-Fi subsystems, it is observed that Wi-Fi to an extent out performs WiMAX in this case since the throughput of Wi-Fi is higher and the delay across lower. This can be explained with the fact that the Wi-Fi system utilises the 802.11n, 2.4 GHz standard that uses a high data rate of 65Mbps-600Mbps, whilst the WiMAX system on individual network nodes utilises the Bronze service class that restricts the maximum sustained data rate to 10Mbps. Of course cumulatively the overall throughput is about 105Mbps for WiMAX.

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