Simulation of Physical layer of WiMAX Network using OPNET Modeller

Narendra Bagoria[#1], Anita Garhwal [*2]

[#1] Department of Electronics & Communication Engineering
Jagannath University , Jaipur, Rajasthan, India

[#2] Department of Electronics & Communication Engineering
Sobhasaria Group of Institutions, Sikar, Rajasthan, India

Abstract— Worldwide interoperability for Microwave Access (WiMAX) standard is based on the IEEE 802.16-2005. It provides wireless broadband to fixed and mobile terminals. The demand for broadband wireless services is increasing day by day. WiMAX provides wireless broadband to fixed and mobile terminals. It is one of the latest developments and considered as a 4G (Fourth Generation) technology. It is based on Wireless Metropolitan Area Networking (WMAN). In this paper, firstly delay, load and Throughput is discussed. Then performance analysis of physical layer of WiMAX system for uplink/ downlink on the basis of BER and SNR is given.

Keywords— WiMAX, OFDM, OPNET, BER, Throughput

I. Introduction

Wimax stands for Worldwide Interoperability for Microwave Access formed by WiMAX forum in 2001. It provides wireless broadband to fixed and mobile terminals in a large geographical area. The 2005 version of WiMAX provides data rate up to 40Mbits/s and 2011 version can support data rate up to 1 Gbit/s for fixed stations [1]. WiMAX system uses OFDM in the physical layer. OFDM is based on the adaptive modulation technique in non-line-of-sight (NLOS) environments. Base stations of WiMAX can provide communication without the need of line-of-sight (LOS) connection. WiMAX base station has enough available bandwidth so at a time it can serve number of subscribers and also cover large area range. WiMAX standard have two versions: IEEE 802.16-2004 and IEEE 802.16d. It supports Orthogonal Frequency Division Multiplexing (OFDM) in physical layer. It provides wireless DSL technology where broadband cables are not available. WiMAX standard 802.16e uses (Orthogonal Frequency Division Multiple Access) OFDMA technique. It provides support for nomadic and mobility services so it also known as mobile WiMAX [2].

WiMAX is a wireless broadband technology it has several improvement then Wi-Fi and UMTS (Universal Mobile Telecommunication Services) / HSDPA (High Speed Downlink Packet Acess). Wi-Fi (Wireless Fidelity) provides wireless high speed internet and network connections [3]. UMTS is based on 3G GSM standard. HSDPA is an enhanced 3G (Third Generation) communication protocol that supports high data transfer speed and capacity [4, 5].

WiMAX is based on Wireless Metropolitan Area Network (WMAN). IEEE 802.16 group developed WMAN and it is adopted by ETSI (European Telecommunication Standard Institute) in HiperMAN group i.e. High Performance Radio Metropolitan Area Network [2]. Although the work on IEEE standard started in 1999, it was only during 2003 that the standard received wide attention when the IEEE 802.16a standard was ratified in January.

WiMAX can be classified into Fixed WiMAX [6] and Mobile WiMAX. Fixed WiMAX is based upon Line Of Sight (LOS) condition in the frequency range of 10-66GHz whereas Mobile WiMAX is based upon Non-Line of Sight (NLOS) condition that works in 2-11 GHz frequency range [7]. For 802.16e standard, MAC layer & PHY layer has been defined, but in this paper, emphasis is given only on the PHY layer. PHY layer for mobile WiMAX which is IEEE-802.16e standard [8] has scalable FFT size i.e. 128-2048 point FFT with OFDMA, Range varies from 1.6 to 5 Km at 5Mbps in 5MHz channel BW, supporting 100Km/hr speed.

Multi-Input Multi-Output (MIMO) technology has also been renowned as an important technique for achieving an increase in the overall capacity of wireless communication systems. In this multiple antennas are employed at the transmitter side as well as the receiver side [8]. One can achieve spatial multiplexing gain in MIMO systems realized by transmitting independent information from the individual antennas, and interference reduction. The enormous values of the spatial multiplexing or capacity gain achieved by MIMO spatial multiplexing technique had a major impact on the introduction of MIMO technology in wireless communication systems [9]. This paper is organized as follows. Simulation model of network using OPNET modeller is given in section II. Section III gives the simulation results. Conclusion is given in section IV.

II. Simulation Model

The Network consists of three WiMAX cell i.e. single BS (base station) and three SS (subscriber station) per cell. The parameters of SS and BS are given in Table I and Table II. Each BS is connected to the IP backbone. The channel was configured to vary according to ITUPedestrian A multipath fading model. For traffic configuration, all SS nodes had an uplink application load of 20 Kbps for a total of 0.4 Mbps. All SS nodes were configured to use QPSK, 16 QAM and 64 QAM for both uplink and downlink applications to measure the characteristics. The cell used an SOFDMA frame with 512 subcarriers and frame duration of 5 milliseconds. Simulation time is taken as 400 seconds. We have used OPNET modeller 14.5 is for simulation [10].

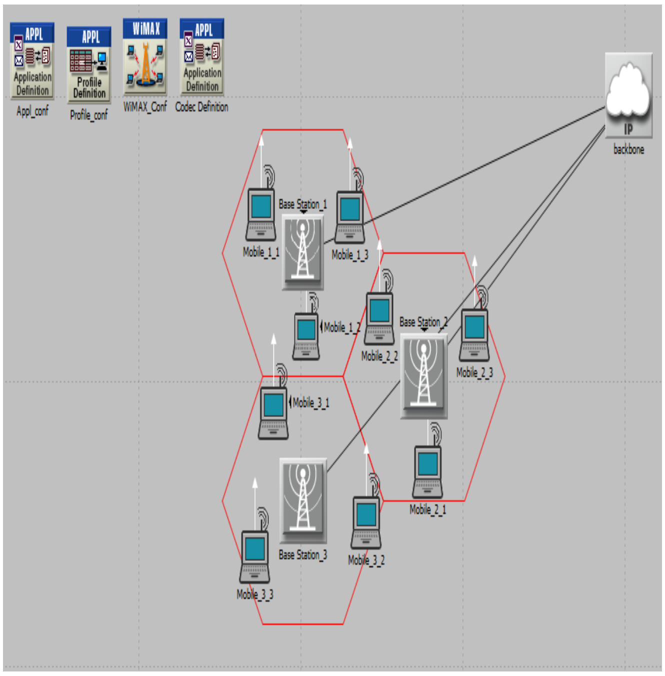

Fig. 1 Network model

Following are the necessary steps for WiMAX network to simulate over OPNET modeller.

- Create the initial technology
- Create the wireless development scenario
- Add traffic to wireless network mod
- Configure BS, SS and WiMAX parameters.
- Running and analysing simulation results

TABLE I

SUBSCRIBER STATION PARAMETERS

Antenna Gain (dBi)	-1 dBi
Max Power Transfer (W)	0.5
PHY Profile	Wireless OFDMA 20 MHz
PHY Profile Type	OFDM
Modulation and coding	QPSK, QAM 16, QAM 64
Pathloss Model	Free Space
Buffer Size	64 KB
Terrain Type	Terrain Type A

TABLE III

BASE STATION PARAMETERS

Antenna Gain (dBi)	15 dBi
Maximum Number of SS nodes	100
Maximum Power density (dBm/subchannel)	-110
Ranging Backoff Start	2
Ranging Backoff End	4
PHY Profile	Wireless OFDM 20MHz
PHY Profile Type	OFDM

Application profile used audio application and video applications. WiMAX configuration attributes are shown in figure 3. [10].

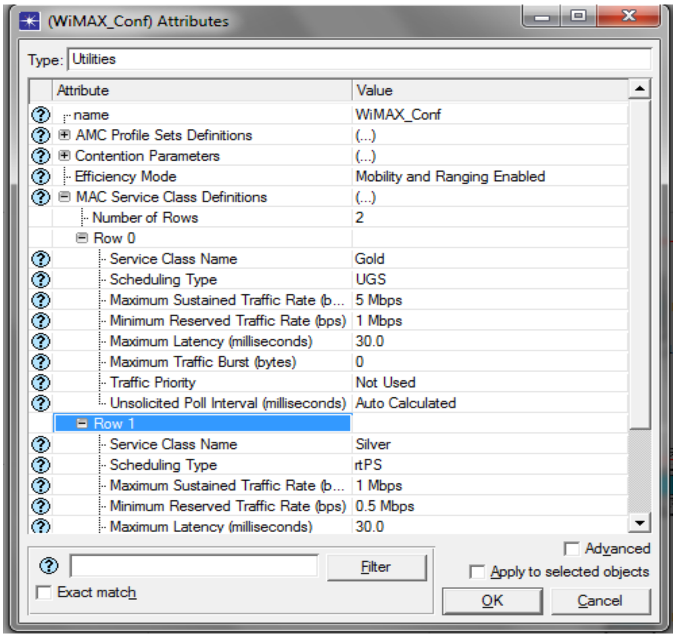

Fig. 2 WiMAX configuration attributes

IEEE 802.16 standard supports UGS, rtPS, nrtPS and BE (best effort) services [10].

UGS (Unsolicited Grant Service)

It supports VoIP (Voice over Internet Protocol) and streaming applications. When this service used then wastage of bandwidth during the off period of voice calls.

rtPS (Real-Time Polling Service)

When rtPS service is used, in every polling interval, BS polls a mobile and the polled mobile transmits Bw-request (bandwidth request) if it has data to transmit. The BS grants the data burst using UL-MAP-IE upon its reception.

III. SIMULATION RESULTS

After configuring all the BS, SS and WiMAX profile, application attributes. Then individual DES statistics for SS and IP are defined. Global parameters like delay, throughput and load are also defined evaluate the performance of the network. Then network model is simulated.

In all figures from 3 to 8, first scenario that is blue line shows qpsk modulation, scenario 2 of red line shows QAM-16 and scenario 3 of green line shows QAM 64 adaptive modulation techniques.

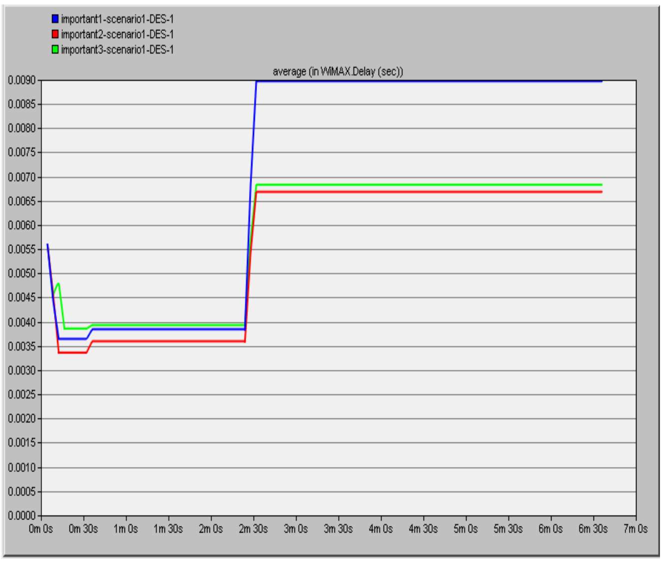

Fig 3. Comparison of average in WiMAX delay (sec)

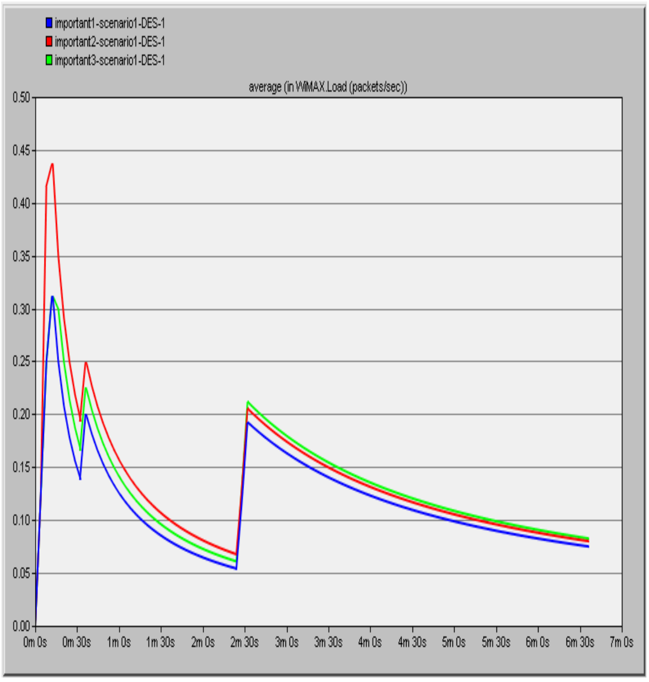

Fig. 4 Comparison of average in WiMAX load (packets /sec)

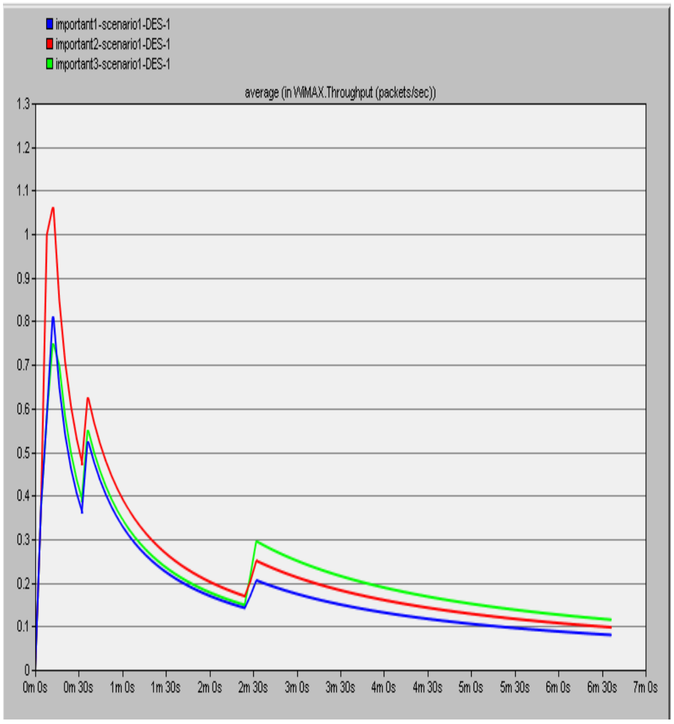

Fig. 5 Comparison of average in WiMAX Throughput (packets /sec)

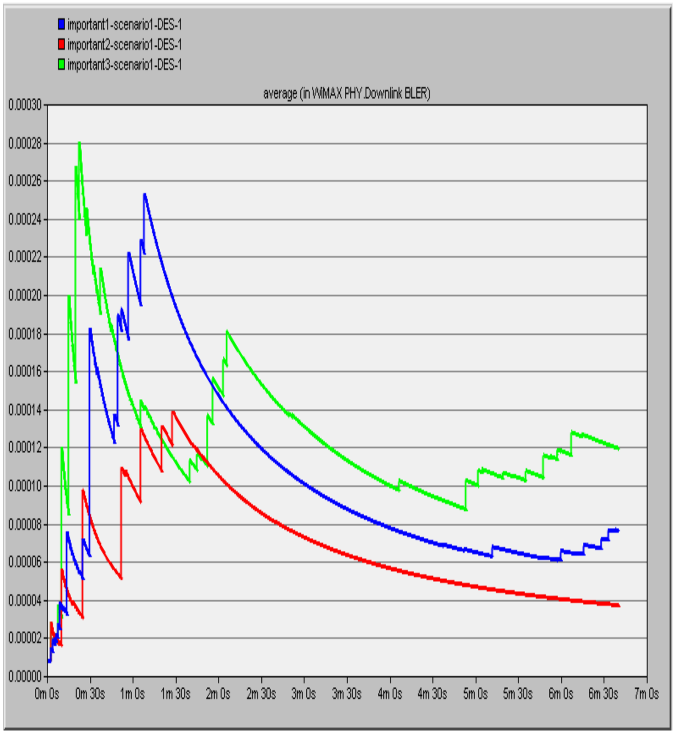

Fig. 6 Comparison of WiMAX PHY downlink BLER

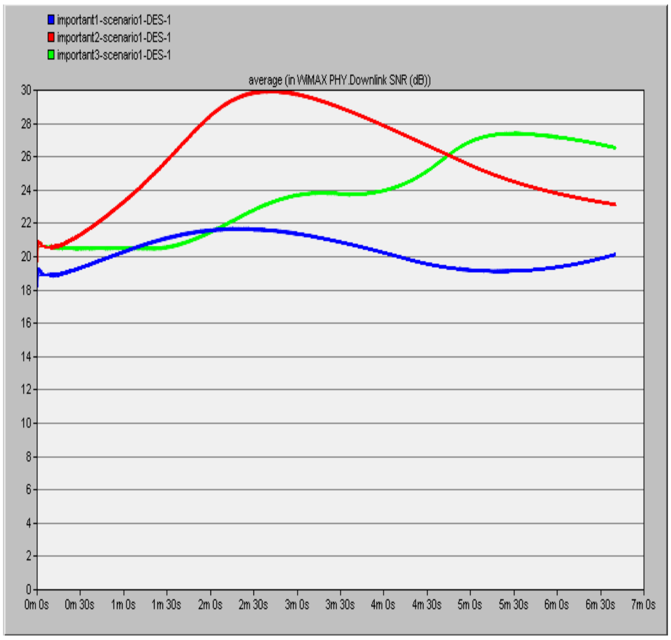

Fig. 7 Comparison of WiMAX PHY downlink SNR (dB)

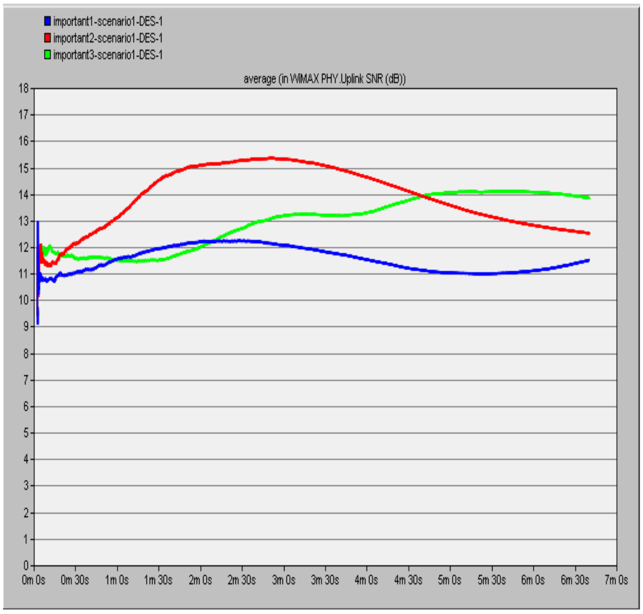

Fig. 8 Comparison of WiMAX PHY uplink SNR (dB)

It is clear from the figure 3 that delay is maximum for qpsk and minimum for 16 QAM while from figure 4 load of 16 QAM is maximum and minimum for qpsk modulation technique. From figure 5 maximum value of throughput is 1.05 for 16 QAM. Bit error rate of 64 QAM is highest and qpsk is lowest while 16 QAM has moderate bit error rate as shown in figure 6. Downlink / uplink SNR is shown in figures 7 and 8 respectively.

IV. CONCLUSIONS

In this paper performance analysis of physical layer of WiMAX system using OPNET modeller is done. Firstly, delay, load and throughput for all adaptive modulation techniques is discussed. Then performance of physical layer of WiMAX system is evaluated on the basis of uplink /downlink BER and SNR

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