Communications on Applied Electronics (CAE) – ISSN : 2394-4714
Foundation of Computer Science FCS, New York, USA
Volume 7 – No.1, May 2017 – www.caeaccess.org

Performance Analysis of IEEE 802.16e under different Wireless Channel Environments

Emad A. Mohammed
Technical Engineering College of Mosul
Northern Technical University

ABSTRACT
IEEE 802.16e is a mobile WiMax standard that provides broadband internet access. It uses radio frequency to offer both communication criteria, which are, line of sight and non-line of sight. IEEE 802.16e apply different modulation and coding techniques in its physical layer, which are adaptively varying according to user environments. In this paper IEEE 802.16e physical layer performance was analyzed using different modulation techniques such as QPSK, 16-QAM and 64-QAM with different coding rates 1/2, 2/3, and 3/4. BER and channel behavior of different wireless channels such as, AWGN, multipath Rayleigh and Rician channels were also introduced.

General Terms
Computer Networks, Wireless Networks

Keywords
WiMax, IEEE 802.16e, Physical layer, BER , AWGN, OFDM, Multipath channels, QPSK,QAM, Adaptive modulation, Convolutional code.

1. INTRODUCTION
Due to huge demands of high speed broadband mobile access, the conventional wired networks, such as digital subscriber line (DSL) are no longer have a solution for such requirements. Wireless broadband access (WBA) is the best solution for this types of networks which can serves a large areas with low cost. World Interoperability for Microwave Access (WiMax) is a wireless technology that can be meet the demands of high speed rural area internet access with relatively low cost [1]. IEEE 802.16 is the first wireless protocol that assists high speed data rate Wide Area Networks (WAN) using microwave access with both line of sight (LOS) and non-line of sight (NLOS) . IEEE 802.16e is the modified version of the standard that serves both fixed and mobile users [2]. IEEE 802.16e has the ability to provide broadband access for mobile users with high speed up to 120 Km/h. Point to multipoint communication for last mile is achieved between the base station (BS) and the users in the cell with cell radius up to 40 Km. IEEE 802.16e define the air interface by medium access control (MAC) layer and physical (PHY) layer. Orthogonal Frequency Division Multiple Access (OFDMA) is the main multiple access in the network with OFDM modulation used in the physical layer. [3].

In wireless system the most challenge is the communication channel characteristics that can cause distortion and interference due to noise and multipath effect.

Bit error rate (BER) is the main factor that affects the performance of the network at the physical layer. BER is a function of signal to noise ratio (SNR), so in WiMax networks there are different modulation schemes and coding rates that are adaptively changing according to the noise floor in the channel[4].

2. IEEE 802.16e PHYSICAL LAYER
The physical layer (PHY) of IEEE 802.16e responsible of delivering data from BS to users and vice versa. The standard operates in several different band of frequencies range from 2 GHz to 11GHz [5]. OFDM is robust against multipath, so it is the main modulation techniques used in WiMax specially for NLOS operation. OFDM applies different FFT size up to 2 KFFT with different cyclic prefix (CP) according to the type of wireless channel, OFDM frame structure is shown in figure (1). PHY defines four types of bandwidth according to the service demanded by the user, which are: 1.25MHz, 3.5MHz, 5MHz and 10MHz [6]. IEEE 802.16e PHY provides flexibility in the term of channelization by using Frequency Division Duplex (FDD) in combination with time Division Duplex (TDD) which provides high speed realiable communication for uplink (UL) and downlink (DL) streams.

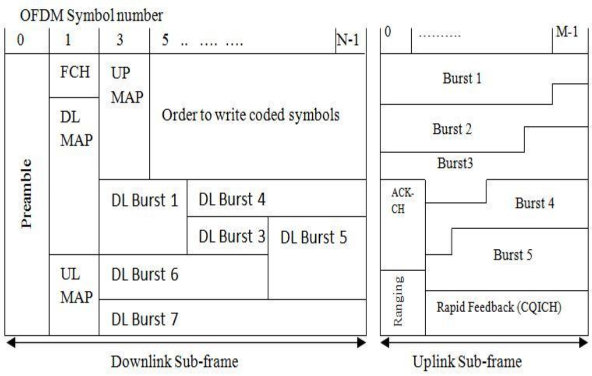

Fig 1. OFDM Frame

Different modulation schemes and coding techniques are applied to the digital data that can be exchanged between BS and network users as shown in table (1).

Table 1. Modulation and coding techniques

	Downlink	Uplink
Modulation	BPSK, QPSK, 16 QAM, 64 QAM; BPSK optional for OFDMA-PHY	BPSK, QPSK, 16 QAM; 64 QAM optional
Coding	**Mandatory:** convolutional codes at rate 1/2, 2/3, 3/4, 5/6 **Optional:** convolutional turbo codes at rate 1/2, 2/3, 3/4, 5/6; repetition codes at rate 1/2, 1/3, 1/6, LDPC, RS-Codes for OFDM-PHY	**Mandatory:** convolutional codes at rate 1/2, 2/3, 3/4, 5/6 **Optional:** convolutional turbo codes at rate 1/2, 2/3, 3/4, 5/6; repetition codes at rate 1/2, 1/3, 1/6, LDPC

3. WIRELESS CHANNELS

In wireless communications, natural or human made obstacles, such as, buildings, high trees and mountains cause reflection, diffraction, scattering and shadowing of the radio waves and multipath propagation. Due to the multipath the transmitted signals can be received in different phase angles, amplitude and time interval. Also the amplitude fluctuation of the received signal is affected by fading, which causes frequency selective or time variant of the multipath channel. The fading process can be as Rayleigh distribution or Rician distribution, depending on the strength of scattering components during transmission. Rician distribution will be considered for strength of scattering (LOS) and the Rayleigh distribution will be considered for the strength of scattering (NLOS). For rural area with no obstacles, there is only one path for the transmitted signal and it is always LOS, so the communication channel will only add a noise to the transmitted signal with no distortion, this type of channel is called Additive White Gaussian Noise channel (AWGN) [6].

4. BER CALCULATION OF IEEE 802.16e.

During data transmission from one point to another, change in one bit value or more can be happened due to channel impairments. The performance of any system can be measured through system bit error rate (BER).

BER is directly proportional to the SNR presented by the channel and hence the modulation technique that can be used in the system.

For M-array modulation schemes such as QAM, each symbol carry more than one bit, so symbol error rate (SER) can be used to evaluate system performance.

The probability of error (Pe) in OFDM system is expressed as the mean (Pe) of total data subcarriers.

$$P_e = \frac{1}{K}\sum_{N=1}^{K} P_e[N] \qquad (1)$$

Where: Pe [N] is the probability of error for Nth subcarrier.

The probability of an error for different modulation scheme can be determined as:

$$P_{e-QPSK} = Q\left(\sqrt{\frac{E_s}{N_0}}\right) \qquad (2)$$

$$P_{e-MQAM} = \frac{\left(4-2^{(2-r/2)}\right)}{r} Q\left(\frac{\sqrt{3(E_s/N_0)}}{M-1}\right) \qquad (3)$$

Where:

Es is the symbol energy.

N0 is the noise power density.

r is the number of bits represent each symbol.

M is the modulation scheme level and it can be represented as:

$$M = 2^r \qquad (4)$$

5. SIMULATION PROCEDURE AND RESULTS

IEEE 802.16e network has been simulated with different wireless channels. AWGN, Rayleigh and Rician channels has been took into consideration. OFDM signal was generated using1024 FFT size and different modulation schemes such as QPSK, 16QAM and 64QAM for 10 MHz bandwidth. Convolutional code with different code rate has been applied to the data.

The general block diagram of BER calculation is shown in figure (2).

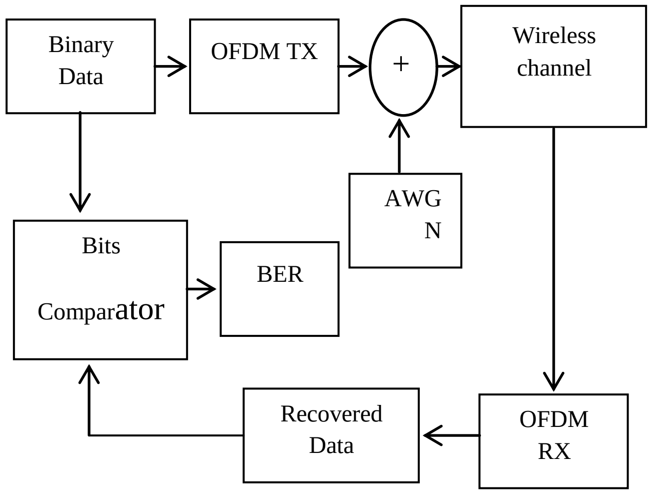

Fig 2. General block diagram of BER calculation

5.1 BER Performance Over AWGN Channel

The performance of IEEE 802.16e over AWGN channel has been evaluated using 1024 FFT and three constellation mapping schemes. Complex AWGN components are added to the data in the channel . BER versus Es/N0 is illustrated in figure (3) for the three different modulation schemes, QPSK, 16QAM and 64QAM, while figure (4) shows the BER versus Eb/N0, where Eb is the bit energy.

BER performance of IEEE 802.16e using convolutional code with different constellation mapping and code rate is presented in figure (5). Three code rates are used which are 1/2 , 2/3 and 3/4 to improve BER.

5.2 BER Performance over Multipath Fading Channel

The performance of IEEE 802.16e over multipath fading channel can be simulated based on the following assumptions:

1. NFFT size is 1024.
2. Three different modulation schemes have been used which are, QPSK, 16-QAM and 64-QAM.
3. The cyclic prefix is assumed to be 1/4.
4. Channel bandwidth is 10 MHz.
5. Pedestrian speed of 3Km/H for mobile receiver has been assumed.

Two types of multipath channels were simulated, Rician and Rayleigh channels.

Figure (6) shows the BER of IEEE 802.16e network over Rician channel.

The BER performance in a Rician channel directly depends on the following factors:

Number of taps, K factor of the Rician channel, Doppler shift, sampling time, and the power delay profile.

BER performance in a Rayleigh channel mainly depends upon the following factors:

Communications on Applied Electronics (CAE) – ISSN : 2394-4714
Foundation of Computer Science FCS, New York, USA
Volume 7 – No.1, May 2017 – www.caeaccess.org

Number of taps, sampling time, Doppler shift, and power delay profile.

Figure (7) shows BER of IEEE 8092.16e over Rayleigh channel

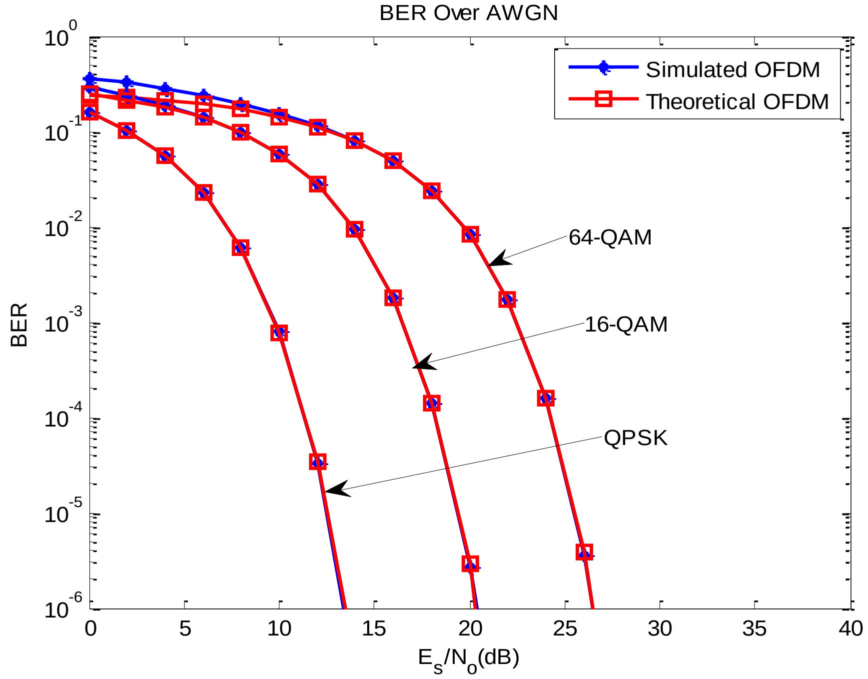

Fig 3. BER Performance Over AWGN Channel

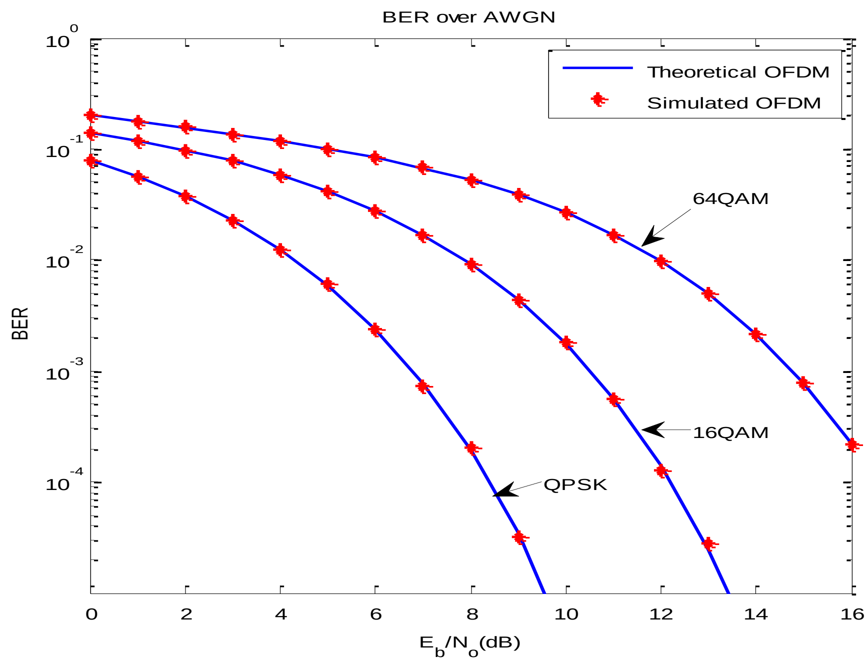

Fig 4. BER of un-coded over AWGN channel

Communications on Applied Electronics (CAE) – ISSN : 2394-4714
Foundation of Computer Science FCS, New York, USA
Volume 7 – No.1, May 2017 – www.caeaccess.org

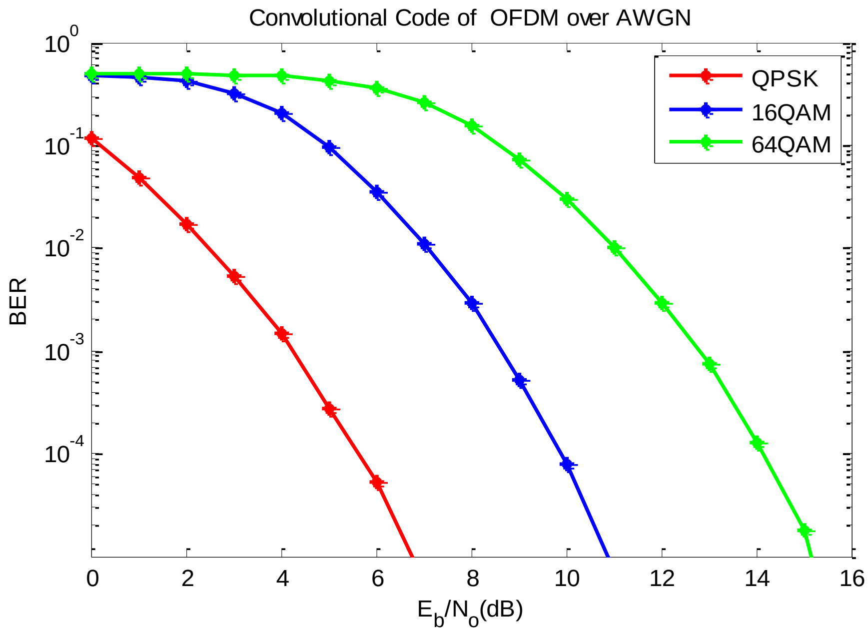

Fig 5. BER of coded OFDM over AWGN channel

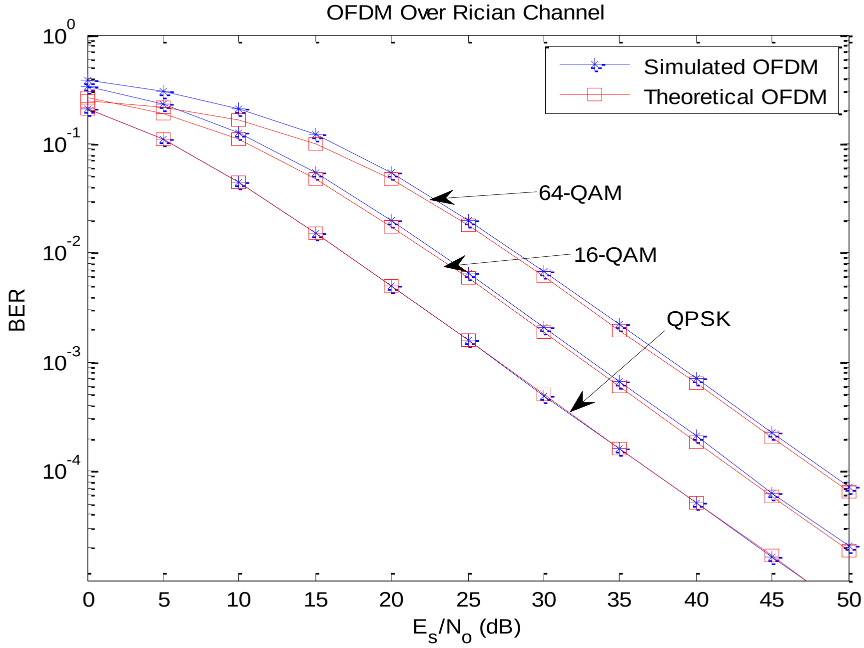

Fig 6. BER over Racian channel

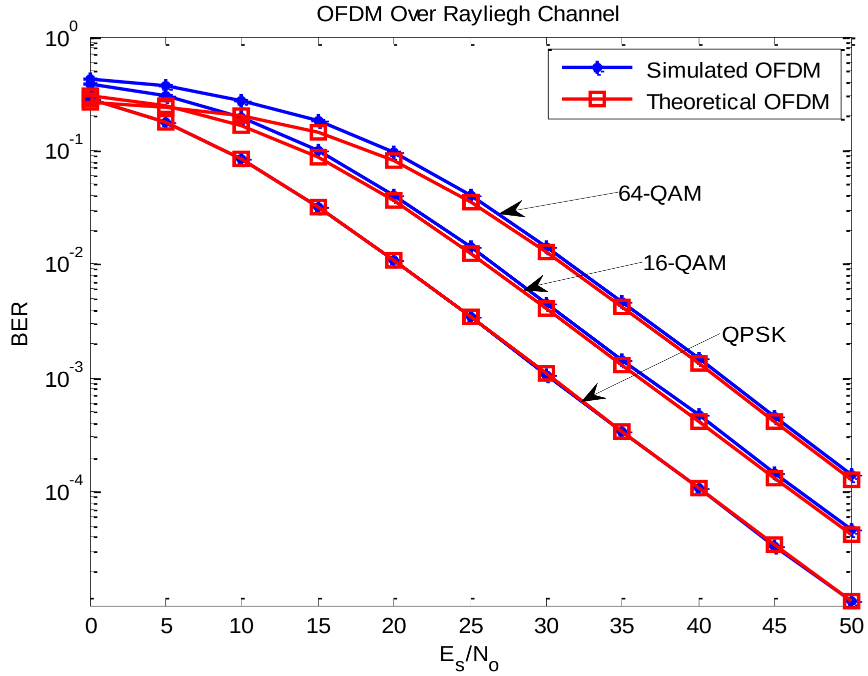

Fig 7. BER over Rayleigh channel

6. CONCLUSIONS

The performance of IEEE802.16e has been analyzed in this paper. The results shows that BER (≤10-3) can be obtained in AWGN for three mapping schemes which are QPSK,16QAM and 64QAM when ES/N0 are 10dB, 16 dB and 22 dB respectively. BER against Eb/N0 for QPSK,16QAM and 64QAM, introduced BER≤10-3 at 6.5 dB, 10.5 dB and 14.5 dB by using un-coded OFDM. About 3 dB gain can be achieved when using coded OFDM. For multipath fading channel Racian channel has better performance that Rayleigh channel.

7. REFERENCES

[1] Jha Rakesh, Wankhede Vishal and Upena Dalal " A survey of mobile WiMAX IEEE 802.16m standard," (IJCSIS) International Journal of Computer Science and Information Security, Vol. 8, No. 1,pp. 125-131, April 2010.

[2] M.A. Mohamed, F.W. Zaki, R.H. Mosbeh " Simulation of WiMAX physical layer: IEEE 802.16e," IJCSNS International Journal of Computer Science and Network Security, VOL.10 No.11,pp. 49-55, November 2010.

[3] T.Manochandar, R.Krithika " Bit error rate of mobile Wimax (Phy) under different communication channels and modulation technique," International Journal of Engineering Inventions ISSN: 2278-7461, Volume 1, Issue 3, pp.06-11, 2012.

[4] Navgeet Singh, Amita Soni " BER analysis of WiMax in multipath fading channel," IJRET: International Journal of Research in Engineering and Technology, Volume: 03 Issue: 06 , pp. 172-178, Jun-2014.

[5] Chakchai So-In, Abdel-Karim Tamimi " Capacity evaluation for IEEE 802.16e mobile WiMAX," Journal of Computer Systems, Networks, and Communications, Vol. 1, No. 1, pp. 1-10 April 2010

[6] Maan A. S. Al-Adwany " A performance study of wireless broadband access Wimax," Iraq J. Electrical and Electronic Engineering, Vol.7 No.2, pp.125-129, 2011.

[7] Mehul V. Desai and Shilpi Gupta " Downlink Channel Estimation in Mobile WiMAX(IEEE 802.16e)System " NCIET conference, Dabhi, Unjha Mehsana Gujarat, India, January, 2014.

[8] M.S. Chavan, R.H. Chile and S.R. Sawant " Multipath Fading Channel Modeling and Performance Comparison of Wireless Channel Models " International Journal of Electronics and Communication Engineering. ISSN 0974-2166 Volume 4, Number 2 (2011), pp. 189-203.