Volume 4, Issue 10, October 2014 ISSN: 2277 128X

International Journal of Advanced Research in Computer Science and Software Engineering

Research Paper

Available online at: www.ijarcsse.com

QoS Analysis and Enhancement in OFDM Systems

Harmanjit Kaur
Post Graduation Student
Department of ECE
RBIEBT, Mohali, India

Er. Pradeep Sharma
Assistant Professor
Department of ECE
RBIEBT, Mohali, India

Abstract —The orthogonal frequency division multiplexing (OFDM) technique is a next generation wave technology in wireless communication. The emergence of OFDM and its manifold pros has led to the creation of various wireless standards and made it possible to transmit the larger digital data over radio waves. Based on OFDM is a next generation technology came to be known as, WiMAX (Worldwide Interoperatability for Wireless Microwave Access). WiMAX is considered as the forthcoming wireless broadband access technique which permits the transmission of high speed data, voice and video services over greater range as compared to existing broadband wireless standards. This paper elucidates the mandatory features of phy-layer WIMAX model. This paper aims at analysing the BER performance in OFDM based WiMAX-2004 model in worst conditions. An approach is being made to inspect the performance of WiMAX under the effect of noise. The physical layer of OFDM based WiMAX using BPSK has been modelled under the AWGN and fading environment i.e. Rayleigh and Rician channels. The MATLAB Simulink is being used for carrying out the analysis. Plots between BER and SNR have been investigated for the abovementioned model.

Keywords— BER, SNR (dB), OFDM, WiMAX, BPSK, AWGN, Multipath Rayleigh channel, Multipath Rician channel

I. INTRODUCTION

Wireless communication is on the path of continuous improvement. The evolution in wireless communication has made it possible to reach the every nook and cranny of the world. Orthogonal frequency Division Multiplexing is a modern modulation technique that is based on parallel transmission of data through orthogonal subcarriers. The idea of OFDM is to split the total transmission bandwidth into a number of orthogonal sub carriers in order to transmit the symbols using these sub carriers in parallel [4]. Each subcarrier is in turn modulated using conventional modulation techniques like BPSK, QPSK, and QAM etc. OFDM is spectrally very efficient when compared to traditional FDM as all the subcarriers lie in an orthogonal manner to each other. OFDM is well suitable for mitigating ISI by the use of cyclic prefix and by increasing the symbol duration. OFDM is the one among the many solutions to combat ISI as it supports multi carrier modulation for data transmission. OFDM is as compared to Code Division Multiple Access (CDMA), which is mostly incorporated in existing 3G systems [4]. It has become the modulation format of choice for researchers and design enginee rs. Based on the OFDM, various standards are being developed.

WiMAX that is abbreviated for the Worldwide Interoperatability for Microwave Access is based on the OFDM and is a forthcoming broadband wireless access (BWA) technology. The conventional broadband systems are based on wired-access technology e.g. digital subscriber links (DSL). BWA offers a flexible and cost-effective solution to the problems faced by wired access like lack of mobility and difficulty of deployment in rural and remote areas. WiMAX is one of the culminations of the massive developments that took place in the field of wireless communication. It is technology more suited for non-LOS environment. WiMAX is a part of an IEEE 802.16 standard. It was developed by the IEEE (Institute of Electrical and Electronics Engineers). The IEEE 802.16d-2004 and IEEE 802.16e-2005 are known as fixed WiMAX and mobile WiMAX, respectively. They were introduced for offering the interoperatability of microwave access globally. WiMAX is also called a wireless MAN standard. The 2011 update of WiMAX provides data rate of up to 1 Gbit/s for fixed stations [10] .The key feature of WiMAX is enabling anywhere, anytime access to applications and information at low cost involving small investment. Theoretically, WiMAX can reach a coverage radius of 30 miles and achieve data rates up to 75 Mbps. But there is trade-off between coverage distance and data rates. If the distance has to be 30 miles the data rates decrease and similarly if data rate has to be 75 mbps then the coverage is less. When obstructions are present, actual throughput might be under 20 Mbps. WiMAX has two layers: physical and MAC layer. The roles of physical layer are: to set up the connection between the communicating devices, to transmit the bit sequence, defines the type of modulation and demodulation and to define transmission power. The role of MAC layer is to provide an interface between the physical layer and the upper transport layer of WiMAX.

In wireless mobile communication, there are some obvious environmental obstacles that block the line of sight; thereby the signal is unable to reach the mobile user directly from the base station. A signal that initiates from the transmitter travels down to the receiver over a multipath-reflection path, thus causing rapid fluctuations in the amplitude and phase of the receiver signal, this is called fading. In wireless systems, fading may either be due to multipath propagation,

referred to as multipath induced fading, or due to shadowing from obstacles affecting the wave propagation, sometimes referred to as shadow fading [11]. The multipath propagation depicts three mechanisms–Reflection, Scattering and Diffraction, influencing the signal propagation from Base Station to Mobile User.

There are basically three channels that are to be analyzed here. They are AWGN channel and frequency selective fading channel. The Rayleigh and Rician are the two models to explain the observed statistical nature of a mobile channel.

A. AWGN Channel

AWGN is Additive White Gaussian Noise. It is a noise that affects the transmitted signal when it passes through the channel. It contains a uniform continuous frequency spectrum over a particular frequency band.

B. Rayleigh fading

It is a type of frequency selective fading. It is taken into account when no LOS propagation path exists in between transmitter and receiver, but only have indirect path called NLOS path than the resultant signal received at the receiver will be the sum of all the reflected and scattered waves. The strength of the received multipath components is relatively same.

C. Rician Fading

It is also a frequency selective fading channel. It occurs when there is both LOS as well as the non-LOS propagation path in between the sender and receiver, i.e. the received signal comprises on both the direct and scattered multipath waves. The signal at the receiver appears as a continuous component added with a random multipath component.

This paper is aimed at exploring the BER performance of OFDM based WiMAX system model for BPSK modulated signals through Multipath Fading Environment. Additive White Gaussian Noise will add noise to the WiMAX Multipath fading channel in Simulink. The variations of BER will be noted over a particular SNR (dB) range. The BPSK modulation technique is analysed because of its low error rate probability as compared to other higher modulation techniques. BPSK is used in low data rate applications and it proves to be robust against noises. Lower BER in a system means better QoS.

The paper is organized in following sections. Section II explores the OFDM based PHY-layer WiMAX model in MATLAB. Section III simulates and analyses the results. Section IV concludes the work.

II. WIMAX MODEL

The WiMAX model itself consists of three main components namely transmitter, receiver and channel. The channels used are AWGN, Rayleigh channel and Rician channel. The WiMAX system is modelled as below.

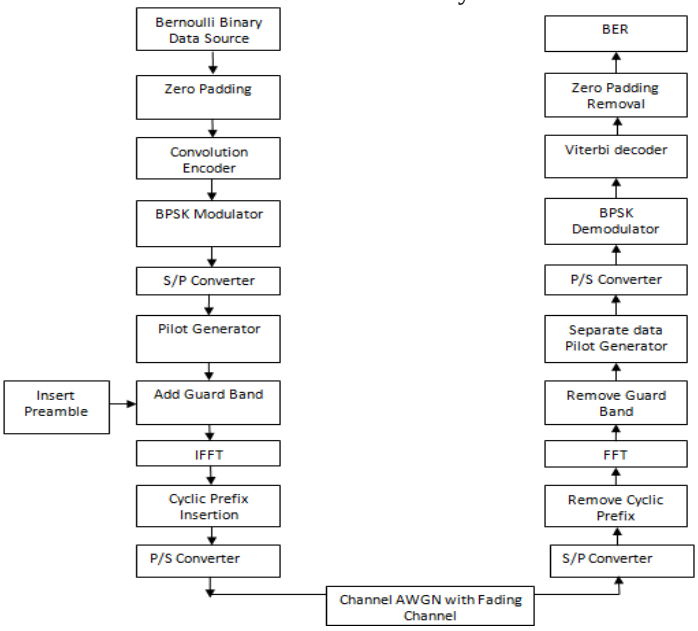

Fig. 1 PHY-Layer OFDM WiMAX Model

The block-wise description of the WiMAX model is as below:

Bernoulli binary data source is used to generate the Bernoulli-distributed random binary numbers input to the system. The probability of zero is set to 0.9 and data type is set to Boolean Output. The convolutional encoder is used to encode the binary data. A convolution code is a type of FEC code used to correct the random errors in the data transmission. It is specified by C(m, n, k), in which each m-bit information symbol to be encoded is transformed into an n-bit symbol, where m/n is the code rate ($n \geq m$) and the transformation is a function of the last k information symbols, where k is the constraint length of the code[3].The Trellis structure parameter is set to poly2trellis(7,[171 133]). The constraint length taken is 7. The Viterbi decoder is used to decode the convolutionally encoded signal by using Viterbi algorithm. The modulation is done using the BPSK where one bit per symbol is used. Guard band and pilot carriers are inserted in the

structure before using the IFFT to convert the frequency domain signals into time domain. These time domain signals are then transmitted through the channel. Orthogonal Frequency Division Multiplexed (OFDM) transmission includes channel estimation using the inserted preambles. It uses 192 sub-carriers, 8 pilots, 256-point FFTs, and a variable cyclic prefix length. The OFDM symbol threats the source symbols to perform frequency-domain into time domain. If there are N number of subcarriers for the system to evaluate the performance of WIMAX the basic function of IFFT receives the N number of sinusoidal and N symbols at a time. Cyclic prefix is added at the beginning of the signal before transmission on channel. Cyclic prefix is added in OFDM signals. The CP reduces the delay due to multipath propagation and maintains the frequency orthogonality. The ISI is totally eliminated by the system design when the CP length L is greater than multipath delay. The S/P block is used to convert the serial data to parallel data and P/S is a parallel to serial data converter. AWGN and multipath fading channels like Rayleigh and Rician are used for simulation. The OFDM receiver is the reverse of the OFDM transmitter. The BER block is used to analyze the value of BER, no. of errors and number of transmitted bits.

III. SIMULATION RESULTS AND ANALYSIS

The simulation of WiMAX system is done by using MATLAB software. The MATLAB version used for simulation is R2007b. The result is based on the BER, SNR and probability of zero. The graph BER vs. SNR for the WiMAX model is shown. The performance analysis of the simulated WiMAX network based on IEEE-802.16d is shown in the set of figures below.

Simulation parameters:

Table 1- various parameters required for simulation

Coding technique	Convolutional Coding
Generator polynomial	[171 133]
Constraint length	7
FFT length	256
Probability of zero	0.9
Phase shift	0 radians
CP length	Variable
No. of subcarriers	192
No. of pilots	8
Data type	Frame-based
Modulation Scheme	BPSK
Transmission Rate	10 GHz
SNR Range	0 to 20 dB
WiMAX model	IEEE 802.16d (fixed)
Channels	AWGN, Rayleigh, Rician

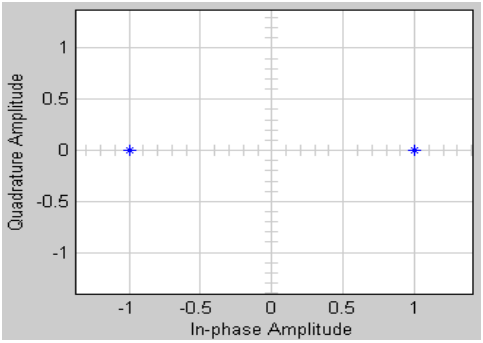

Fig. 2 Constellation diagram of BPSK transmitted signal

Fig.2 shows the transmitted signal using the BPSK modulation. The two bits 0 and 1are used to represent a signal.

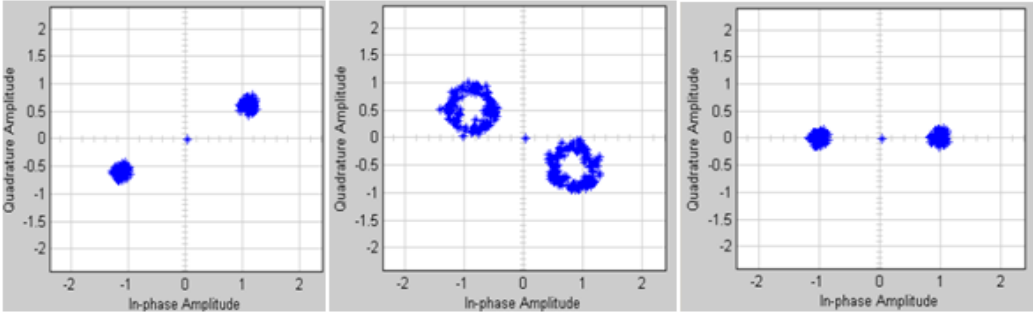

Fig.3 Received signal of (a) Rician Channel, (b) Rayleigh Channel (c) AWGN Channel at 20 dB SNR

Fig 3(a), (b), (c) represents the constellation diagrams of received signals transmitted through the Rician channel, Rayleigh Channel and the AWGN channel using the BPSK technology at SNR=20dB. The received signals proved that the Rician channel has the better constellation diagram than the Rayleigh. It shows that in case of Rician channel, the received signal is concentrated at one point and not scattered like that in Rayleigh channel. The received signal in case of AWGN is better than both as the phase shift is zero and it is the ideal case when there is no fading. When fading is thrusted upon AWGN the response of Rician is better than Rayleigh because in Rayleigh the phase shift occurs and is negative so the response is poor. Thus, it is proved that the effect of fading is worst in case of Rayleigh and the noise has caused the scattering in the received signal.

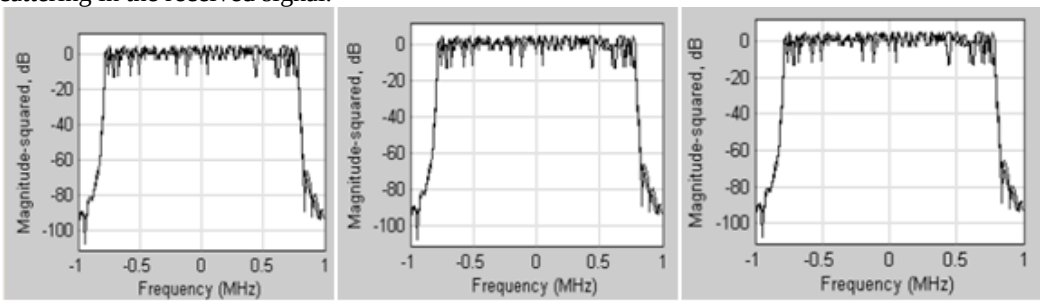

Fig.4 Frequency Spectrum of (a) Rician Channel, (b) Rayleigh Channel (c) AWGN Channel at 20 dB SNR

Fig. 4 (a), (b), (c) shows the frequency spectrum of the signal propagating through the Rician channel, Rayleigh channel and AWGN channel at an SNR value of 20 dB. The diagrams show that the Rician channel has better frequency response in the worst case scenario of the transmission medium as compared to Rayleigh. The magnitude of the signal versus frequency should be least for the better performance of any system. And as compared to Rayleigh the magnitude is lesser in case of Rician. The non-linearity is more in Rayleigh channel and least in Rician channel.

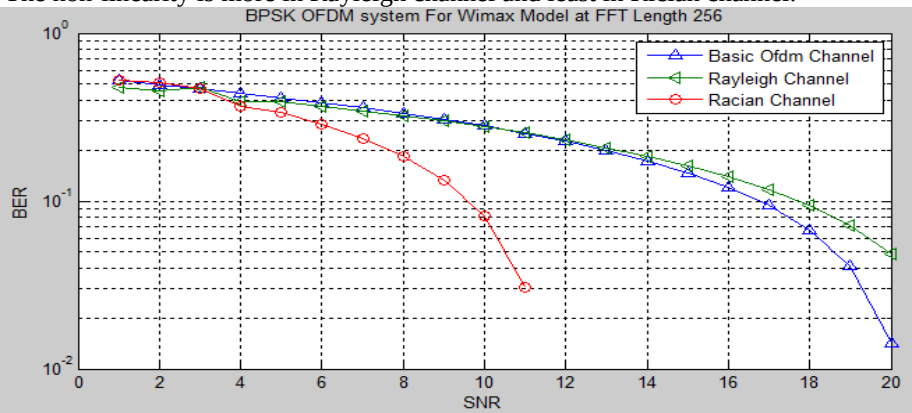

Fig. 5 BER versus SNR graph through AWGN and fading channels

Fig. 5 shows the graph between the BER and the SNR at probabilities of zeros = 0.9 under different propagation mediums. The probability of zero at 0.9 depicts that the worst case scenario has been taken into account as the number of data bits will be reduced as compared to number of zeros. Therefore, the non-linear region is formed. The three channels are analysed namely, AWGN, Rayleigh and Rician. The graph gives the following conclusions:

- First the AWGN channel was analysed and it was estimated at an SNR of 20 dB. Thus, now 20 dB is the highest range of SNR and all the results are based upon it.
- At SNR<3dB, the BER response of Rayleigh channel is the better than other two. The BER performance of AWGN is worse than Rayleigh but better than Rician. Thus, at this value of SNR, the Rician channel has the worst response.
- At 11dB<SNR<3dB, the BER performance of Rician channel becomes quite better as compared to other two, the worst being the AWGN channel. At 11 dB, the Rician channel experiences the least BER response. The BER response of Rayleigh is worse than Rician but slightly better than AWGN. Thus, at this value of SNR, the worst performance is given by the AWGN channel.
- At SNR>11dB, the BER performance of Rician channel is still the best as it has entered in the linear region. The response of AWGN channel becomes better than the Rayleigh. Thus, the worst performance is given by Rayleigh channel. At SNR=20 dB, we analysed that the BER is Rayleigh channel is more as compare to AWGN.
  Thus, the Rician channel gives the best response and lower BER value in poor channel conditions.

IV. CONCLUSIONS

This paper described the analytical behavior of a WiMAX model in the fading scenario. The paper mentioned the current trends in WiMAX systems for achieving high speed mobile wireless access and outlined the technologies supporting these systems. The performance of the WiMAX-PHY layer based on the IEEE 802.16d standard was evaluated on the basis of their propagation through the frequency selective channels adopting the BPSK modulation. The BPSK is a low

rate modulation technique. The impact of the fading on the transmitted signal was analyzed and compared. As a result of the comparative study, it was found that the response of Rician channel is the better than other two in worst case of the transmission. The worst response is of Rayleigh channel.

REFERENCES

[1] Ramjee Prasad, "*OFDM for wireless Communications systems*", Artech House Publishers, ISBN 1-58053-796-0, 2004.

[2] Navgeet Singh, Amita Soni, "BER ANALYSIS OF WiMAX IN MULTIPATH FADING CHANNELS" *IJRET: International Journal of Research in Engineering and Technology*, eISSN: 2319-1163 | pISSN: 2321-7308, Volume: 03 Issue: 06 | Jun-2014.

[3] Abdul Rehman, Tauheed Khan, Sunil Kumar Chaudhry, "Study of WiMAX Physical Layer under Adaptive modulation Technique using Simulink" *International Journal of Scientific Research Engineering & Technology (IJSRET)*, Volume 1 Issue 5 pp 005-011, ISSN 2278 – 0882, August 2012.

[4] A.Salleh, N.R. Mohamad, M.Z.A. Abd Aziz, M.H. Misran4, M.A. Othman, N.M.Z. Hashim , "Simulation of WiMAX System Based on OFDM Model with Difference Adaptive Modulation Techniques", *International Journal of Computer Science and Mobile Computing*, Vol.2 Issue. 9, pg. 178-183, September –2013.

[5] M. R. Dey and M. S. Islam, "Performance Analysis of PAPR reduction for OFDM-BPSK, -QPSK and -QAM using Forward Error Correcting Code" *International Conference on Electrical and Computer Engineering*, December- 2012, IEEE.

[6] Dr.S.Bhargavi, "Design And Implementation Of An Efficient Ofdm Transreceiver Chain For Wimax" *International Journal of Engineering Research and Applications (IJERA)*, ISSN: 2248-9622 www.ijera.com Vol. 3, Issue 1, pp.992-997, January -February 2013.

[7] A. Md. Anamul Islam, C. Md. Julkarnain, B. Md. Abdul Kader, "BER Performance Analysis of a Real Data Communication through WiMAX-PHY Layer over an AWGN and Fading Channels" *International Journal of Electrical & Computer Sciences IJECS-IJENS*, Vol:10 No:04, August 2010

[8] Taewon Hwang, Chenyang Yang, Gang Wu, Shaoqian Li, and Geoffrey Ye Li, "OFDM and Its Wireless Applications: A Survey*" IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY*, VOL. 58, NO. 4, MAY 2009.

[9] http://en.wikipedia.org/wiki/Orthogonal_frequency-division_multiplexing

[10] http://en.wikipedia.org/wiki/WiMAX

[11] http://en.wikipedia.org/wiki/Fading

[12] http://en.wikipedia.org/wiki/Phase-shift keying

