Performance Evaluation of IEEE 802.16e (Mobile WiMAX) in OFDM Physical Layer

BY Prof. Sunil .N. Katkar, Prof. Ashwini S. Katkar ,Prof. Dattatray S. Bade

(VidyaVardhini's College Of Engineering And Technology,

Vidyalankar Institute of Technology, Mumbai University).

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Abstract

WiMAX is introduced by the Institute of Electrical and Electronic Engineers (IEEE) which is standard designated 802.16d-2004 (used in fixed wireless applications) and 802.16e-2005 (mobile wireless) to provide a worldwide interoperability for microwave access. At present, telecommunication industries are highly concerned with the wireless transmission of data which can use various transmission modes, from point- to-multipoint links. It contains full mobile internet access. Various applications have already been applied so far using WiMAX, as alternative to 3G mobile systems in developing countries, Wireless Digital Subscriber Line (WDSL), Wireless Local Loop (WLL). IEEE 802.16e-2005 has been developed for mobile wireless communication which is based on OFDM technology and this enables going towards the 4G mobile in the future. In this prject work, we built a simulation model based on 802.16e OFDM-PHY baseband and demonstrated in different simulation scenarios with different modulation techniques such as BPSK, QPSK and QAM (Both 16 and 64) to find out the best performance of physical layer for WiMAX Mobile. All the necessary conditions were implemented in the simulation according to the 802.16e OFDMA-PHY specification. The noise channel AWGN, Rayleigh fading, SUI, data randomization techniques, FFT and IFFT, and Adaptive modulation is used for the whole simulation procedure. The performance has been concluded based on BER, SNR and Pe output through MATLAB Simulation.

1.Introduction

WiMAX is called the next generation broadband wireless technology which offers high speed, secure, sophisticate and last mile broadband services along with a cellular back haul and Wi-Fi hotspots. The evolution of WiMAX began a few years ago when scientists and engineers felt the need of having a wireless Internet access and other broadband services which works well everywhere especially the rural areas or in those areas where it is hard to establish wired infrastructure and economically not feasible.

IEEE 802.16, also known as IEEE Wireless-MAN, explored both licensed and unlicensed band of 2-66 GHz which is standard of fixed wireless broadband and included mobile broadband application. WiMAX forum, a private organization was formed in June 2001 to coordinate the components and develop the equipment those will be compatible and inter operable. After several years, in 2007, Mobile WiMAX equipment developed with the standard IEEE 802.16e got the certification and they announced to release the product in 2008, providing mobility and nomadic access. The IEEE 802.16e air interface based on Orthogonal Frequency Division Multiple Access (OFDMA) which main aim is to give better performance in non-line-of-sight environments. IEEE 802.16e introduced scalable channel bandwidth up to 20 MHz, Multiple Input Multiple Output (MIMO) and AMC enabled 802.16e technology to support peak Downlink (DL) data rates up to 63 Mbps in a 20 MHz channel through Scalable OFDMA (S-OFDMA) system [2]. IEEE 802.16e has strong security architecture as it uses Extensible Authentication Protocol (EAP) for mutual authentication, a series of strong encryption algorithms, CMAC or HMAC based message protection and reduced key lifetime

The IEEE standard committee introduced standards for networking elements, for an instance, IEEE 802.16 in 1999. The 802.16 family standard is called Wireless Metropolitan Area Network (MAN) commercially known as WiMAX (Worldwide interoperability for Microwave Access) which is an industry-led, non-profit organization and responsible for testing, certificating and promoting the compatible interoperable wireless products based on IEEE 802.16 working group and ETSI's HiperMAN standard. The original IEEE standard addressed 10 to 66 GHz in licensed bands and 2 to 11 GHz in unlicensed frequency range.

2.Problem definition

The goal of this project is to implement and simulate the OFDM Physical layer specification of IEEE 802.16e-2005. Using Adaptive Modulation Techniques we analyze the performance of OFDM physical layer in mobile WiMAX based on the simulation results of Bit-Error-Rate (BER), Signal-to-Noise Ratio (SNR) and Probability of Error (Pe). The performance analysis of OFDMA-PHY is done in MATLAB R2008b under reference channel model with channel equalizer.

3.Physical Layer Setup

Basically physical layer handles error correction and signal connectivity, as well as registration, initial ranging, connectivity channels and bandwidth request for data and management. Physical layer consists of some sequence of equal length frames which transmit through modulation and coding of RF signals. OFDM technology has been using by WiMAX technology. Different user assigning different sub carries which are allowed in orthogonal

frequency division multiplexing (OFDM) techniques. It is durable to multi-path which helps to overcome multipath signals hitting the receiver. OFDM signals divide into 256 carries in IEEE-802.16 2004 standard and IEEE 802.16e use scalable OFDMA. Wide range of frequencies supported by IEEE 802.16 standard and physical layer contains several multiplexing and modulation forms. Modulation methods in the uplink (UL) and downlink (DL) are Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK) and Quadrature Amplitude Modulation (QAM).

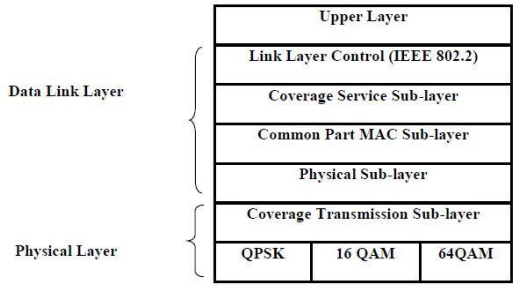

Fig 1 Physical Layer

Simulation Procedure

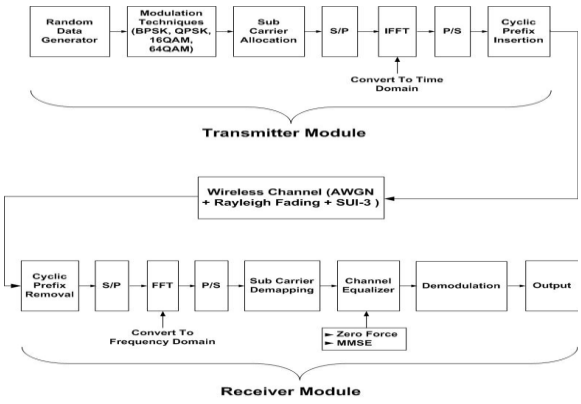

Fig 2 Mobile WiMAX Performance Simulation Block Diagram

4.BER vs SNR Plot

We put some theoretical values in our simulation to find out Bit Error Rate against Signal-to- Noise Ratio for all modulation techniques using AWGN and Rayleigh Fading respectively.

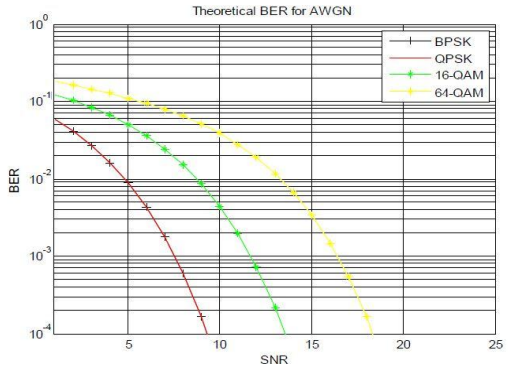

Fig 3. Theoretical Value used for BER Vs SNR under AWGN channel

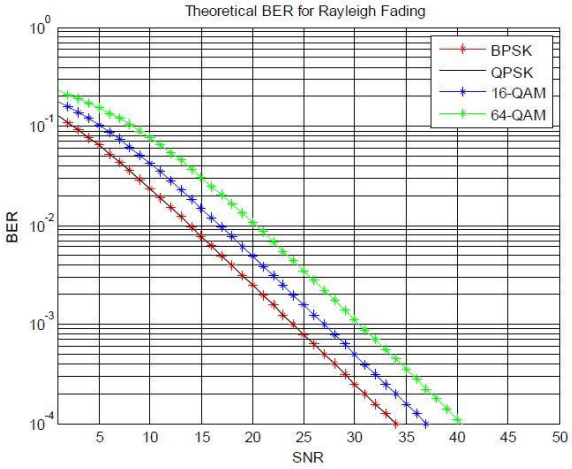

Fig 4. Theoretical Value of BER Vs SNR under Rayleigh Fading

5.Adaptive modulation of Probability of Error (Pe)

Probability of Error (Pe) is important to find out the error rate in a system because it affects

fading and noise in a channel at transmitting and receiving end. From the following formula Probability of Error for M-array PSK has been calculated.

$$P_e \cong erfc\left(\sqrt{\frac{E_S}{N_o}}\sin\left(\frac{\pi}{M}\right)\right)$$

Probability of Error for M-array QAM has been calculated through this formula which is as follows,

$$P_e \cong 2\left(1-\frac{1}{\sqrt{M}}\right)erfc\left(\sqrt{\frac{3E_s}{2(M-1)N_0}}\right)$$

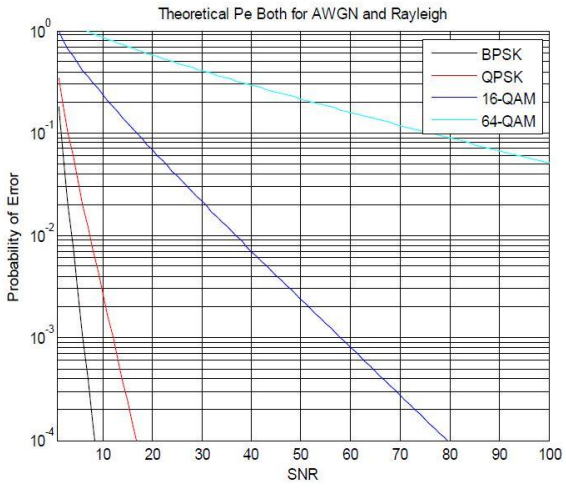

Fig 5.Theoretical Value of Pe Vs SNR under Rayleigh Fading and AWGN When Probability of Error = 10-

12. Conclusion

After all conditions we applied and the results we got we can conclude our work as follows,

✓ We studied WiMAX OFDM physical layer, mobile systems, modulation techniques and features of WiMAX networks properly, with the help of necessary figures and tables.

✓ We studied SUI-3 channel model and also implemented it through Matlab simulation to evaluate the performance of Mobile WiMAX.

✓ We also used and understood the adaptive modulation techniques like, BPSK, QPSK, 16-QAM and 64 QAM according to IEEE 802.16e standard.

We know that fading is one of the main parts of wireless communication. At the beginning of our simulation, we used multipath fading and then got some results using Rayleigh fading and AWGN. After that SUI-3 channel was used according to the characteristics of Rician fading. In all aspects of adaptive modulation technique, we can conclude the performance of Mobile WiMAX as,

❖ Binary Phase Shift Keying (BPSK) is more power efficient and needs less bandwidth.

❖ On the other hand 64-Qadrature Amplitude Modulation (64-QAM) has higher bandwidth with very good output.

❖ In another case, Quadrature Phase Shift Keying (QPSK) and 16-QAM modulation techniques are in middle of those two (BPSK and 64-QAM) and they requires higher bandwidth.

❖ QPSK and 16-QAM are less power efficient than BPSK.

❖ During all simulations we got, BPSK has the lowest BER and 64-QAM has the highest BER than other modulation techniques.

We also add some more things in here,

- ✓ We included Cyclic Prefix (CP) and random signals which reduced noise resulting lower Bit error Rate (BER) for OFDM system but increased the complexity in the system.
- ✓ Cyclic Prefix requires higher power but non Cyclic Prefix requires lower power.

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Author:

Mr. Sunil N. Katkar

VidyaVardhini's College Of Engineering & Technology, Vasai

Mumbai University