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Performance evaluation of Wi-MAX system using PSK and QAM in AWGN, Rayleigh and Rician Channel

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ABSTRACT
The Wi-MAX (Worldwide interoperability for Microwave Access) system is use to provide high data rate to mobile user for conventional cellular system (4G). OFDM (Orthogonal Frequency Division Multiplexing) is major part of physical layer of Wi-MAX. QOS of physical layer is BER. This paper investigates the evolution of various modulation techniques and to yield the best suitable technique, so far as channel and modulation scheme is concerned, to reduce BER at receiver side.
Keywords - Wi-MAX, OFDM, AWGN channel, Rayleigh channel, Rician channel.

I. INTRODUCTION

Wi-MAX stands for Worldwide Interoperability for Microwave Access form by Wi-MAX forum in 2001. It provide wireless broadband for both fixed and mobile terminals in large geographical area. The 2005 version of Wi-MAX provide data rate up to 40Mbits/sec and 2011 version can support data rate up to1 Gbits/sec 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. The Base stations of WiMAX can provide communication, even 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. Wi-MAX 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 line where broadband cables are not available. Wi-MAX 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 [5].

WiMAX is a wireless broadband technology it has several improvement then Wi-Fi and UMTS (Universal Mobile Telecommunication Services) / HSDPA (High Speed Downlink Packet Access). Wi- Fi (Wireless Fidelity) provides wireless high speed internet and network connections. UMTS is based on 3G GSM standard. HSDPA is an enhanced 3G (Third Generation) communication protocol that supports high data transfer speed and capacity [2, 3].

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 [5]. 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. 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. 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 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.[5,7].

The paper organization is as follow. Section II gives system model block diagram, section III gives The Channel environment while Section VI ends the paper with our conclusion.

II. SYSTEM MODEL BLOCK DIAGRAM

The concept of using parallel-data transmission and Frequency Division Multiplexing (FDM) was first published in the mid of 1960s. The basic idea was to use parallel data and FDM with overlapping sub-channels to avoid the use of high-speed equalization to combat impulsive noise and multipath distortion and fully utilize bandwidth. Although the idea of OFDM was conceived in 1960s, it was not realizable until the advent of FFT. With the advent of FFT/IFFT it became possible to generate OFDM using the digital domain for orthogonally of sub carriers. Figure shows a block diagram of a discrete time OFDM system, where an N complex-valued data symbol modulates N orthogonal carriers
Using the IFFT forming. The transmitted OFDM signal multiplexes N low-rate data streams, each experiencing an almost flat fading channel when transmitted.

In single carrier systems each symbol occupying an entire bandwidth could be lost due to frequency selective fading, but when transmitted on low data parallel streams, symbol time

increases and channel become flat fading [7].OFDM structure basically relies on two principles:

• The IFFT and FFT [5] are used for modulating and demodulating individual OFDM sub carriers to transform the signal spectrum to the time domain for transmission over the channel and then by employing FFT on the receiving end to recover data symbols in serial order.

• The second key principle is the cyclic prefix (CP) as Guard Interval (GI). CP keeps the transmitted signal periodic. One of the reasons to apply CP is to avoid Inter Carrier Interference (ICI).

demodulating the OFDM signal the CP is removed. By exploiting the structure imposed using CP.

Symbol synchronization can be achieved. Due to the carrier orthogonality it is possible to use the Fast Fourier Transform (FFT) and the Inverse Fast Fourier Transform (IFFT) for modulation and demodulation of the signal [7]. To obtain high spectral efficiency, there can be different modulation schemes can be applied i.e. BPSK (Binary Phase Shift Keying), QPSK (Quadrature Phase Shift Keying), 16-QAM (16- Quadrature Amplitude Modulation),64-QAM (64- Quadrature Amplitude Modulation).

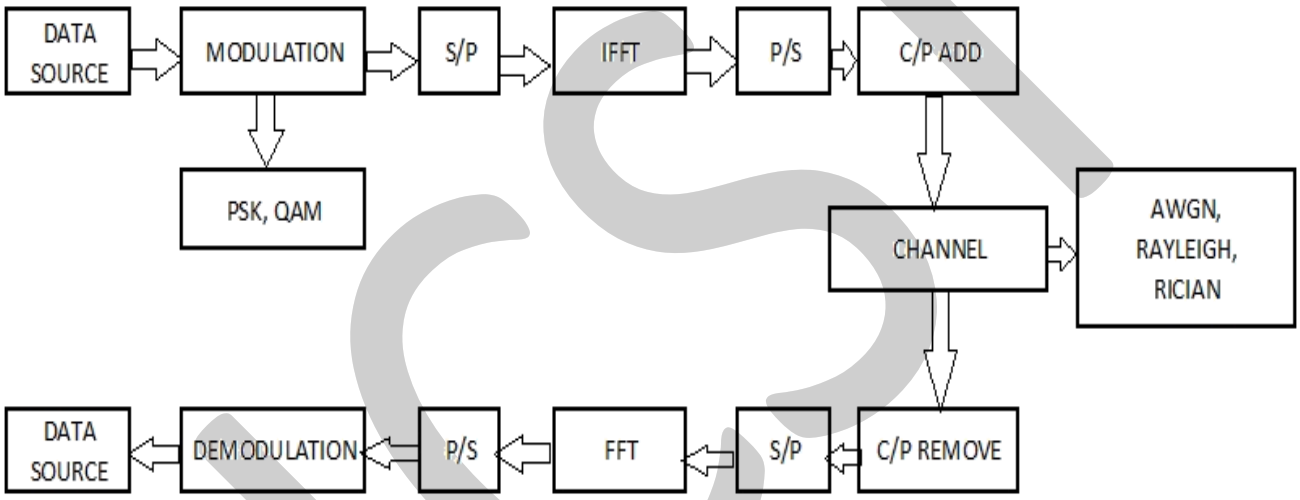


Fig. 1 Block diagram of OFDM System

III. Channel Environment

Different channel like AWGN, Rayleigh, and Rician channel are proposed in the literature. These are given as below.

A. Rayleigh fading channel

Rayleigh fading is a rational model when there are many objects in the environment that scatter the transmitted signal before it arrives at the receiver. The central limit theorem holds

In OFDM, Guard Interval (GI) is introduced because of multipath propagation as it affects the symbols to delay and attenuate, which causes Inter Symbol Interference (ISI). In GI, Cyclic Prefix (CP) is used to counter Inter Carrier interference (ICI) within an OFDM frame. The CP is simply a copy of the last symbols of the samples placed first, making the signal appear as periodic in the receiver as shown in Figure.1.Before

that, if there is sufficiently much scatter, the channel impulse response will be well-modelled as a Gaussian process regardless of the distribution of the individual components.

When there are large numbers of paths, applying Central Limit Theorem, each path can be modeled as circularly symmetric complex Gaussian random variable with time as the variable. This model is called Rayleigh fading channel model. If there is no dominant component to the scatter, then such a process will have zero mean and phase evenly distributed between 0 and 2π radians. The envelope of the channel response will therefore be Rayleigh distributed [6].

A circularly symmetric complex Gaussian random variable is of the form,

$$Z = X + jY$$

Where real and imaginary parts are zero mean Independent and Identically Distributed (IID) Gaussian random variables.

For a circularly symmetric complex random variable,

$$E[Z] = E[e^{j\theta} Z] = e^{j\theta}[Z]$$

The statistics of a circularly symmetric complex Gaussian random variable is completely specified by the variance,

$$\sigma^2 = E[Z^2]$$

The magnitude |Z|, which has a Probability Density Function (PDF), p(Z) is called the Rayleigh Random Variable,

$$p[Z] = \frac{Z}{\sigma^2} e^{\frac{-Z^2}{2\sigma^2}}, Z > 0$$

B. Rician fading channel

Rician Fading is a non-deterministic model for the anomaly that occurs when a transmitted signal accidentally cancels itself. The signal arrives at the receiver by several different, and at least one of the paths is changing. Rician fading occurs when one of the paths, typically a line of sight signal, is much stronger than the others. In Rician fading, the amplitude gain is characterized by a Rician distribution. When there isn't any line of sight path occurring between the OFDM transmitter and the receiver than the Rican Fading can be categorised by Rayleigh Fading [4].

Rician Fading channel can be defined using two parameters: K and Ω, where K is called the Rice Factor and it is the ratio between the power in the direct path and the power in the other, scattered, paths and Ω is the total power from both paths and acts as a scaling factor to the distribution. The received signal amplitude not considering the power R is then Rice distributed with parameters:

$$v^2 = \frac{K}{1+K^2}\Omega$$

And,

$$\sigma^2 = \frac{\Omega}{2(1+K)}$$

The resulting Probability Density Function (PDF) is then given by-

$$f(x) = \frac{2(K+1)x}{\Omega} \exp\left(-K - \frac{(K+1)x^2}{\Omega}\right) I_0\left(2\sqrt{\frac{K(K+1)}{\Omega}}x\right)$$

Where Is the 0th order modified Bessel function of the first kind. Now if the Rice Factor is 0 then the Rician Faded Envelope reduces down to Rayleigh faded Envelope.

C. AWGN channel

An Additive White Gaussian Noise (AWGN) [5,6] channel adds White Gaussian noise to the signal when it is passed through the channel. In the case of white Gaussian noise the values at any pair of times are identically distributed and statistically independent on each other.

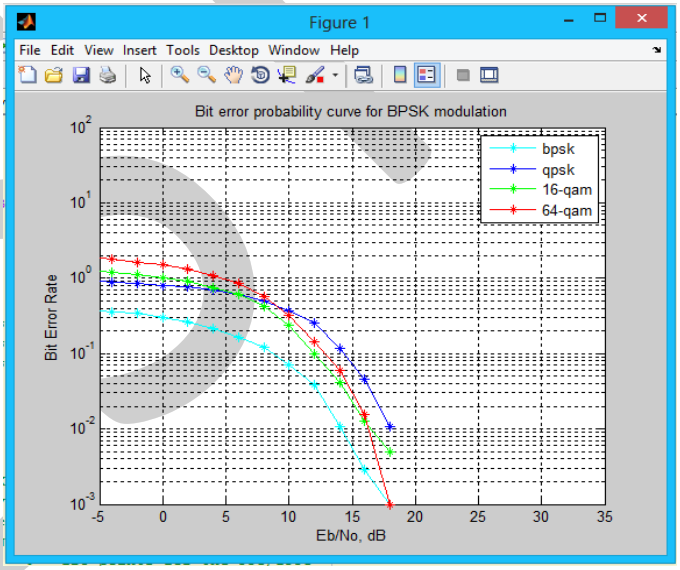
AWGN channel is not associated with either fading or any other system parameters. It is just the noise that is added to the OFDM modulated signal when it is travelling through the channel. The channel capacity of AWGN Channel is given by-

$$C = \frac{1}{2}\log\left(1+\frac{p}{n}\right)$$

Where, C is the channel capacity

IV. CONCLUSION

We present the several modulation scheme like BPSK, QPSK, 16QAM, 64QAM and transmit this OFDM signal into Different channel like AWGN, Rayleigh, and Rician. From the literature survey we can conclude that for a particular value of Bit error rate, SNR value for BPSK/QPSK is lower than 16QAM and 64QAM in AWGN channel. So, 64QAM has highest value of SNR. The research will continue for Rayleigh and Rician channel.



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