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Research Paper Engineering

"Performance Analysis of WiMAX Physical Layer Using Different Code Rates & Modulation Schemes"

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ABSTRACT

WiMAX (Worldwide Interoperability for Microwave Access) is a technology based on the IEEE 802.16 specifications. Since it offers high level of services by many it is considered as 4G technology. All the work is done in WiMAX physical layer, which is based on OFDM system. This Paper deals with the performance analysis of Convolution coded WiMAX system at different rates (e.g.1/2, 1/3 & 1/4) in AWGN & Rician fading channel. Performance of AWGN & Rician fading channels are compared in WiMAX based system. With result we could say that AWGN channel shows better result then Rician channel. BPSK and QPSK modulation techniques are also compared at each rate; BPSK modulation technique shows better results at different rates & as the code rate decreases performance increases. Orthogonal Frequency Division Multiplexing have been used to achieve high data rate necessary for intensive application. Orthogonality is maintained by use of FFT (size is 256).

Keywords : OFDM, Convolution code, Additive White Gaussian Noise, Fading Channel, BPSK, QPSK.

1. INTRODUCTION

Conventional high speed broadband services are based on wired access technology, this type of solution is difficult to deploy in remote areas. Another point is that wired solution could not be used for Mobile services. Due these reasons there is huge demand of Wireless broadband solution. WiMAX technology offers good solution to overcome with these problems. It addresses the following needs.

1) The cost associated with the deployment is low.
2) It covers both Fixed and mobile networks.
3) It has flexible network architectures.

WiMAX is a technology based on the IEEE 802.16 specifications also known as IEEE wireless MAN air interface is an emerging standard for fixed portable and mobile BWA in MAN. The WiMAX offers data-transfer rates of up to 75 Mbit/s, which is superior to conventional cable-modem and DSL connections. Able to be deployed in both licensed and unlicensed spectra. WiMAX is IP based, wireless broadband access technology that provides performance similar to 802.11/Wi-Fi networks with the coverage and QOS (quality of service) of cellular networks. It intended for wireless "metropolitan area networks". WiMAX can provide broadband wireless access (BWA) up to 30 miles (50 km) for fixed stations, and 3 - 10 miles (5 - 15 km) for mobile stations. In contrast, the WiFi/802.11 wireless local area network standard is limited in most cases to only 100 - 300 feet (30 - 100m). The Paper which we have taken as reference, has analyzed WiMAX physical layer using Reed Soloman codes, But decoding process becomes easy in convolution codes, that why we analyzed WiMAX physical layer with convolution code. viterbi decoder is used for decoding process in convolution codes. So WiMAX system could be simplified and can be made more useful.

Organisation of rest of paper is as follows. In section 2,Simulation model Fig.1 shows the flow chart of WiMAX system & different blocks of WiMAX system are discussed like Randomization, FEC, interleaving, cyclic prefix addition, symbol mapping, encoding of convolution code, AWGN channel, Rician fading channel etc. Fig.2 shows convolution code encoder & Fig.4 shows the Gaussian noise distribution. In Table.1 convolution code rates at which we analyzed the performance, type of channel &modulation schemes are mentioned. In Section 3 Results & Discussion, results of AWGN channel are shown in Fig.5 which shows that BPSK modulation scheme with rate 1/4 gives better results then other scheme and code rates. Similarly, All the results of Rician Fading are shown in Fig.6.

2. SIMULATION MODEL

In Fig.1 Flow Chart of WiMAX system is explained and details of each block are discussed below in brief.

2.1Randomization-: Randomizer uses a Linear Feedback shift register (LFSR) to scatter long data strings of zeros or ones.

2.2FEC-: Capable of correcting a certain number of errors, i.e. it should be capable of locating the positions where the errors occurred. In this paper convolution code is used.

2.3Interleaving-: By interleaving data is ordered in some other fashion so that errors do not accumulate at one place. Types of interleaves are as follows. Pilot Insertion-: Some pilot symbols are added to each frame. It is mainly is used to reduce ISI (inter symbol interference). Channel estimation is a major challenge for reliable wireless transmissions.

$$h_i^{LMMSE} = R_{hh} Ls R_{hLS}^{-1} hLs h_i^{LS}$$

2.4Cyclic Prefix-: Cyclic prefix is actually a copy of the last portion of the data attached to the front of the symbol during the guard interval. Let us first define a new base function for transmission;

$$g_n(t) = \exp\left[j2\pi n \frac{W}{N} t\right] \quad \text{for } -T_{cp} < t < Ts$$

Where again W/N is the carrier spacing, and T_s =N/W. the symbol directionT_s is now T_s =$_{Ts}$ +T_{cp} this definition of the base function means that for duration 0< t <T_s the "normal" OFDM symbol is transmitted. During time -T_{cp} < t < 0, a copy of the last part of the symbol is transmitted.

2.5Symbol Mapping-: Modulation by the use of PSK (phase shift keying)-:here in this project BPSK(Binary phase shift keying) & QPSK(quadrature phase shift keying) Modulation schemes are used

2.5.1Binary Phase Shift Keying: BPSK is the simplest form of phase shift keying (PSK). It uses two phases which are separated by 180^0 and so can also be termed 2-PSK. The general form for BPSK follows the equation:

$$S_n(t) = \sqrt{\frac{2E_b}{T_b}}\cos\left(2\pi f_c t + \pi(1-n)\right), n = 0,1.$$

This yields two phases, 0 and π .

2.5.2Quadrature phase-shift keying (QPSK)
The mathematical analysis shows that QPSK can be given as

$$S_n(t) = \sqrt{\frac{2E_s}{T_s}}cos\left(2\pi f_c t + (2n-1)\frac{\pi}{4}\right), \quad n = 1,2,3,4.$$

This yields t□ □□$\frac{7\pi}{4}$)hase$\frac{\pi}{4}$,$\frac{3\pi}{4}$,$\frac{5\pi}{4}$ and as needed.
FFT-: Fast Fourier transform is done. It is necessary for orthogonality of subcarriers..

$$x(n) = \frac{1}{N}\sum_{n=0}^{N-1} x(k)\, e^{j2\pi kn/N} \quad for\ n = 0,1,2 \ldots \ldots N-1$$

Where X(k) is the transmitted data symbol at the kth subcarrier of the OFDM symbo1, N is the fast Fourier transform(FFT) size.

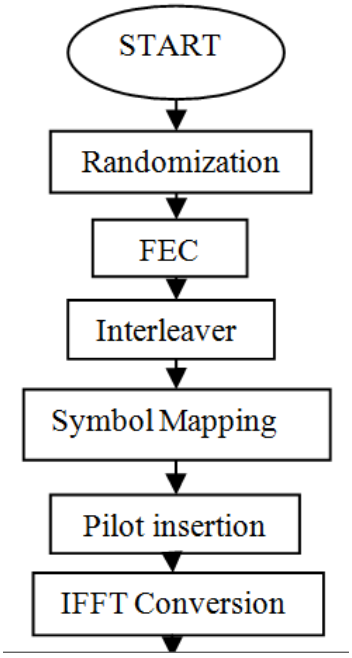

Fig 1: Flow Chart of WiMAX system

2.6OFDM (Orthogonal frequency division multiplexing)-: Splits the information into N parallel streams, which are then transmitted by modulating N distinct carries (henceforth called subcarriers or tones) . symbol duration on each subcarriers thus become larger by a factor of N. in order for the receiver to be able to separate signal carried by different subcarriers , they have to be orthogonal

$$\int_{iT_s}^{(i+1)T_s} exp(j2\pi f_k t)\, exp(-j2\pi f_n t)dt = \delta_{nk}$$

2.7Encoding of Convolution codes -:
A Convolutional encoder is shown in Fig.2 below It consists of k-Stage shift register, v modulo-2 adders, a commentator, and a set of connections between the K stages of the shift registers and the v modulo-2 adders. Operation of the basic convolutional encoder is simple. For each information symbol, the sequence (v1, v2, v3) is generated. It follows from the figure that

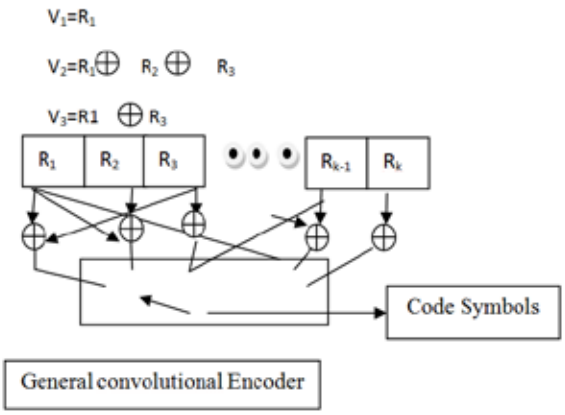

Fig.2 Convolution code Encoder

In which R1 denotes the contents of the ith register. Since the first symbol in the output sequence is the information symbol, this particular convolutional code is systematic thus V2 and V3 can be viewed as parity symbols.

2.8AWGN Channel (Additive White Gaussian Noise)-: The AWGN (Additive white Gaussian noise channel attenuates the transmit signal, causes phase rotation, and adds Gaussian distributed noise. The distribution of white noise is shown Fig.3 Attenuation and rotation is temporally constant, and is thus easily taken into account. Thus, the received signal (in complex baseband notation) is given by:

$$r_{LP}(t) = \alpha s_{LP} + n_{LP}(t)$$

Where α is the (complex) attenuation and n(t) is a (complex) Gaussian noise process.

$$S_{n,LP}(f) = \begin{cases} N_o & |f| \le \frac{B}{2} \\ 0 & otherwise \end{cases}$$

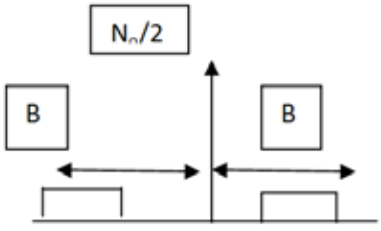

Fig.3 White Noise distribution

Note that $S_{n,LP}(f)$ is symmetric with respect to f i.e.$S_{n,LP}(f) = S_{n,LP}(-f)$

Fig.3 White Noise distribution

Note that $S_{(n)LP}$ (f) is symmetric with respect to f i.e. $S_{(n)LP}$ (f) =

$S_{(n)LP}$ (-f)

Modulation	CC Code rate	Noise Channels
BPSK,QPSK	1/2,1/3,1/4	AWGN Channel
BPSK,QPSK	1/2,1/3,1/4	Rician Channel

Gaussian Probability Density:
The Gaussian (also called normal) probability density function is defined as the mean and variance of this Gaussian density function the density has been adjusted to unity.Gaussian distribution curve is shown in Fig.4.

$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-(x-m)^2}{2\sigma^2}}$$

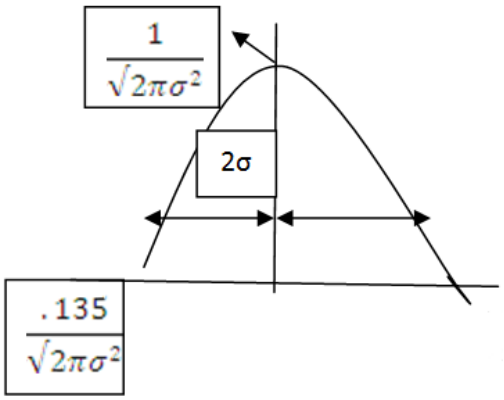

Fig.4 Gaussian probability density function

When x-m=±σ that is values of x separated from m by the standard deviation, The noise n(t) is assumed to be white Gaussian noise of power spectral density $n/2$.

2.9Rician Fading Channel-: The Rician Noise Generator block generates Rician distributed noise. The Rician probability density function is given by

$$f(x) = \left\{\frac{x}{\sigma^2}\left(\frac{mx}{\sigma^2}\right) exp\left(-\frac{x^2+m^2}{2\sigma^2}\right)\right\} \quad x \geq 0$$

- σ is the standard deviation of the Gaussian distribution that underlies the Rician distribution noise
- $m^2 = m_I^2+m_Q^2$, where mI and mQ are the mean values of two independent Gaussian components
- I_0 is the modified 0th-order Bessel function of the first kind given by

$$I_0(y) = \frac{1}{2\pi}\int_{-\pi}^{\pi} e^{ycost}\, dt$$

3. RESULTS & DISCUSSION

In Tabel 1 Modulation Schemes through analysis have been done are shown. In this table different convolutional code rates and type of channel choosen is mentioned.

Table 1: Modulation Techniques, Convolution Code rates & Noisy channels.

In the Fig.5 we have presented various BER v/s SNR graphs in AWGN(additive white Gaussian noise) channel.

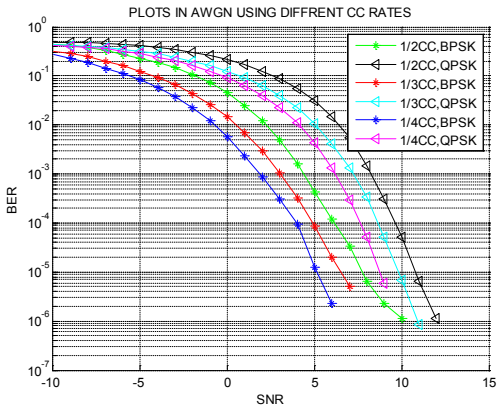

Fig.5 Plots in AWGN Channel at different CC rates (1/2, 1/3 & 1/4)& Modulation Schemes.

These graphs are plotted firstly by taking different convoutional code rates like 1/2, 1/3, 1/4. By using using different code rates we analyzed that as the code rate decreases the performance of the system enhances, as we could see in graphs that graph plotted with green colour is 1/2 rated BPSK, graph by red colour is 1/3 rated BPSK, and graph by blue colour is 1/4 rated BPSK, graph by blue colur is more tilted towards y-axis thus shows lesser errors. Secondly we analysed by modulating with different modulation techniques like BPSK and QPSK, in this case we compare the plots

a) By blue (1/4,BPSK) & Magenta(1/4 ,QPSK)
b) By red (1/3,BPSK) & cyan(1/3, QPSK)
c) By green (1/2,BPSK) & Black(1/4 QPSK)

All plots by BPSK modulation scheme are more tilted towards Y-axis as Comared to the plots by QPSK modulation scheme, thus BPSK modulation technique gives better results at all code rates.

In the Fig.6 we have presented various BER v/s SNR graphs in Rician Fading channel.

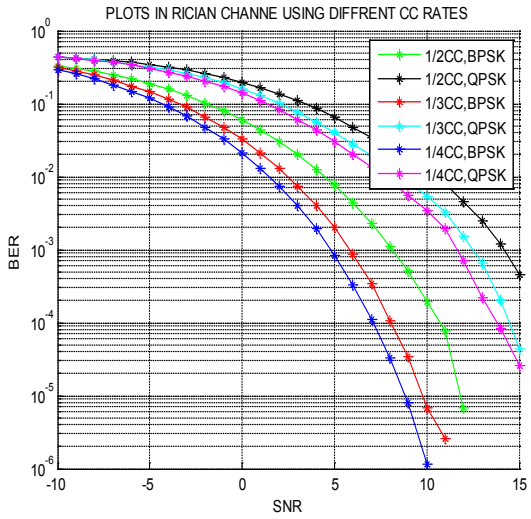

Fig.6 Plots in Rician Fading Channel at different CC rates (1/2, 1/3 &1/4) & Modulation Schemes.

These analysis are done at 1Hz Doppler frequency & Rician K-factor was kept 2.The results shown by Rician fading channel are worst as compared to AWGN channel, as we could see from Fig.5 (AWGN Channel) & Fig.6 (Rician Fading Channel) that plots of Fig.6 are away from Y-axis as compared to plots of Fig.5, Thus Rician fading Channel shows worst results as compared to Rician Fading channel. These

graphs are plotted firstly by taking different convoutional code rates like 1/2, 1/3, 1/4. By using using different code rates analyzed that as the code rate decreases the performance of the system enhances, as we could see in graphs that graph plotted with green colour is 1/2 rated BPSK, graph by red colour is 1/3 rated BPSK,and graph by blue colour is 1/4 rated BPSK, graph by blue colur is more tilted towards y-axis thus shows lesser errors. Secondly we analyzed by modulating with different modulation techniques like BPSK and QPSK, in this case we compare the plots

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c) By green (1/2,BPSK) & Black(1/4 QPSK)

All plots by BPSK modulation scheme are more tilted towards Y-axis as Comared to the plots by QPSK modulation scheme, thus BPSK modulation technique gives better results at all code rates.

Thus, by analyzing Fig.5 and Fig.6 we can see that AWGN channel gives better results at each convolutional code rate as Compared to Rician Fading channel.

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