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Research Article

ANALYZING THE PERFORMANCE OF CODED OFDM BASED WIMAX SYSTEM UNDER FADING ENVIRONMENTS WITH QAM

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ABSTRACT

Today is a world of Technologies. In terms of communication, the demands of high speed applications are growing and starting from 2G to 3G, now we are moving towards 4G to meet these requirements. Most of applications are now uses 4G technology. COFDM based WiMax is outcome in this direction which promises to cater these high quality and high speed applications. WiMax is an IEEE 802.16 standard-based broadband wireless access (BWA) technology which employs Coded orthogonal frequency division multiplexing access (COFDM). This paper includes the theory and concepts behind OFDM, WiMAX IEEE 802.16, IEEE 802.16a, IEEE 802.16d, IEEE 802.16e standard and other blocks algorithms, its architectures used for designing as well as a presentation of how they are implemented and evaluates the performance of coded OFDM at different fading with 256 QAM Modulation. Further, Rayleigh, Rican, MIMO fading channels are investigated in detail. It has been observed that MIMO fading 256 QAM channel has better performance rather than other channels

INTRODUCTION

Before we start to read about Wimax, let us first discuss the related concepts that help in better understanding of WiMAX. Wireless refers to transmitting signals using radio waves as the medium as an alternative of wires. Wireless operations allow working in long-range communications that are not possible to implement with the use of wires. The term "Wireless" refer to telecommunications systems which use some form of energy to transfer information without the use of wires. The IEEE 802.16-2004 standared, which was also previously called 802.16d was published for fixed access in October 2004 [Theodore S. Rapaport, 2004]. Wireless technology has turned out to be part of everyday life. The whole thing, from phones and satellites, to computer equipment and the Internet, no longer requires long, bulky wires to work correctly. Wireless technologies are used for tasks as simple as switching off the television or as complex as supplying the sales force with information from an automated enterprise application while in the field.

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Now cordless keyboards and mice, PDAs, pagers and digital and cellular phones have become part of our daily life Quality of Service (QoS) and adaptability within the same network or among networks of different technologies and service providers. The users should be able to get its potential whatever they are using (PC, cell phone, electronic pad, etc. wise), and where ever they are sitting; at home, walking and even driving. Worldwide Interoperability for Microwave Access (WiMAX) is one of the future generations (4G) promising networks to cover some of the consumers needs. It is an emerging Broadband Wireless Access technology that is designed to deliver fixed mobile broadband connectivity. The WiMAX trade name is used to group a number of wireless technologies that have emerged from the Institute of Electrical and Electronics Engineers (IEEE) 802.16 Wireless Metropolitan Area Network (MAN) standards. The main standards introduce mobility and currently receive a great deal of interest in the telecoms world. The IEEE community has defined the IEEE 802.16e amendment (i.e. mobile WiMAX) to support mobility. Mobile WiMAX of IEEE 802.16e defines wireless communication for mobiles, moving at speed of 125 KMPH in the range of 2-6 GHz (802.16e).

IEEE 802.16e is implemented with Orthogonal Frequency-Division Multiple Access (OFDMA) as its physical layer scheme [Jeffrey, ?]. It support seems to be one of the major hindrances to its deployment com-pared to other standards such as IEEE 802.11 WLAN, since mobility support is widely considered one of the key features in wireless networks. It is natural that the new IEEE 802.16e released earlier this year has added mobility support. This is generally referred to as mobile WiMAX. Mobile WiMAX adds significant enhancements: It improves NLOS coverage by utilizing advanced antenna diversity schemes and hybrid automatic repeat request (h-ARQ). It adopts dense sub-channelization, thus increasing system gain and improving indoor penetration. It uses adaptive antenna system (AAS) and multiple input multiple output (MIMO) technologies to improve coverage. It introduces a downlink sub-channelization scheme, enabling better coverage and capacity trade-off.

Specification of IEEE 802.16

IEEE 802.16 is a set of standards used for providing wireless multimedia services in Wireless Metropolitan Areas. The IEEE 802.16d standard came into existence in 2004 which operates on both 10-66 GHz (LOS) and 2-11 GHz (NLOS) frequency range. All the previous standards were limited for line-of-sight (LOS) communication. The IEEE 802.16d provides NLOS propagation by making use of OFDM and OFDMA. The Line-of-sight propagation can be carried by making use of single carrier modulation. This standard specifies an OFDM physical layer that splits an information signal across 200 separate subcarriers. The resulting subcarrier frequency spacing is 31.25 KHz with 256 frequency slots. shows all the parameters considered for carrying out simulation work based on this standard.

Simulation parameters

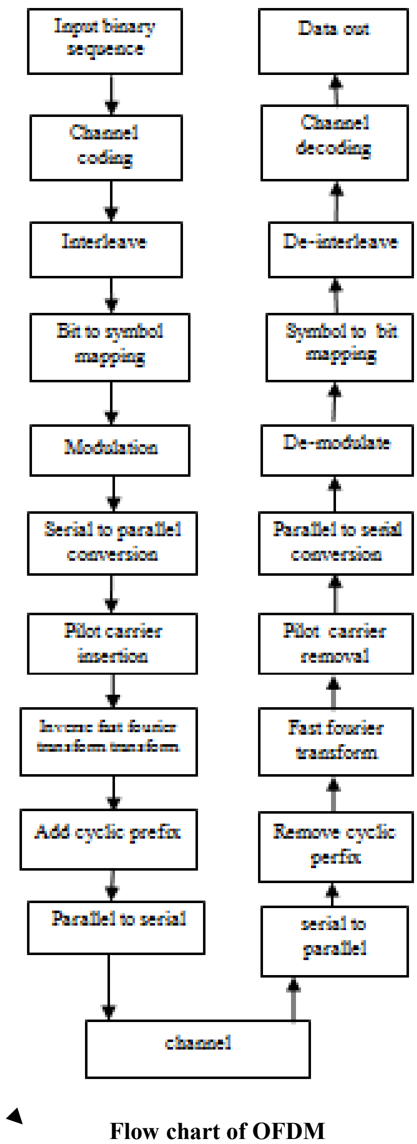
Parameter	Value
FFT Size	256
Cyclic prefix Interval	¼
OFDM Symbol	10,50, 100
Modulation Scheme	BPSK
Channel conditions	Rayleigh, Rician, MIMO Fading
OFDM Symbol spectrum of demodulation process.	No 0

IMPLEMENTATION OF OFDM

To implement the OFDM transmission scheme, the whole design is divided into three sections: transmitter,channel and receiver as shown fig 1 In the transmitter, random binary input data sequence is generated. Channel Coding can be provided using Forward Error-Correction Coding (FEC) like block code and convolutional code [Md. Ashraful Islam, 2012; Raj Jain, 2012]. Further, interleaving is done to provide frequency diversity [Md. Anamul Islam, ?]. Thus the input sequence is encoded by a FEC encoder comprising of convolutional codes. Then Interleaving is applied to randomize the occurrence of bit errors to increase performance. After interleaving, the binary values are converted to symbol values, on which modulation scheme BPSK is carried out .

The modulated data is then divided into low data rate streams using serial to parallel conversion. Each parallel stream is then modulated on a separate subcarrier in the allocated spectrum using IFFT. Previously, multi-carrier systems were implemented using of separate local oscillators which was both inefficient and costly. But with the advent of cheap powerful DSP processors, the sub-carriers can now be implemented by the FFT which keep subcarriers to orthogonal with each other. The symbol is modulated onto sub carriers by applying the Inverse Fast Fourier Transform (IFFT). Then cyclic extension is added to make the system robust to multipath propagation. The parallel data is then further converted to serial form using serial to parallel conversion. For WiMax system, 200 subcarriers (192 data and 8 pilot subcarriers) are used while 56 null subcarriers are used thus making FFT size equal to 256.

This serial data is then transmitted over multipath fading channel. The multipath fading channels used for this work are Rayleigh, Rician and mimo fading.The receiver performs the reverse operations of the transmitter. After removing the cyclic extension, the signal can be applied to a Fast Fourier Transform (FFT) to recover the modulated values of all subcarriers. The modulated values are then demapped into binary values, and finally de interleaving and decoding is performed to get back information bits.



Flow chart of OFDM

FADING CONDITIONS

Multipath fading is a very common process in wireless communication system. In this paper, the following fading channels are several mathematical models have been developed to study the fading phenomenon so as to improve the quality of wireless communication. Examples of such mathematical models are Rayleigh fading, Rician fading and MIMO fading Environment. Knowing how waves fade in an urban setting enables telecommunication companies to effectively set up rebroadcast and relay stations, increasing its coverage area. The study of fading may be applied in this manner, amongst others.

Rayleigh Fading

According to Rayleigh distribution magnitude of a signal which has passed though the communication channel and varies randomly.When no LOS path exists in between transmitter and receiver, but only have indirect path than the resultant signal received at the receiver will be the sum of all the reflected and scattered Waves. On the other hand Rician Fading is more applicable than Rayleigh Fading when there is dominant line of sight.

The received signal s(t) can be expressed as

$$s(t) = \sum_{i=1}^{N} \alpha_i \cos(w_c t + \varphi_i)$$

where N is number of replica paths, wc is carrier frequency and iis phase of signal on ith path. If there is a relative motion between transmitter and receiver the Doppler shift should be considered. The received signal s(t) under this condition can be expressed as

$$s(t) = \sum_{i=1}^{n} a_i \cos(w_c t + w_{di} t + \varphi_i)$$

where *wdi* is Doppler shift for *i*th path. The phase φ_i is assumed to be uniformly distributed over *(0,2þ).* If N is large, the in-phase and quadrature Components Ω of received signal becomes zero mean Gaussian with standard deviation. The probability density function (PDF) of the received signal envelope can be given as [Nuzhat Tasneem Awon, 2012; Prabhu and Shankar, 2002]

$$f(r) = \frac{r}{\sigma^2}\{ \frac{r}{2\sigma^2}\} \qquad r \geq 0$$

Rician Fading

Rician fading is similar to Rayleigh fading but it considers LOS propagation instead of NLOS as in the case of Rayleigh fading. In this scenario, if *kd* is the strength of LOS component and *wd* is the Doppler shift along the LOS path, the received signal *s(t)* can be written as [Prabhu and Shankar, 2002; Nuzhat Tasneem Awon,?]

$$ss(t) = \sum_{i=1}^{n} a_i \cos(w_c t + w_{di} t + \varphi_i) + k_d \cos(w_c t + w_d t)$$

The probability density function (PDF) of the received signal envelope can be given asThe probability density function (PDF) of the received signal envelope can be given as [Khan and Ghauri, 2008; Hadj Zerrouki, ?]

$$F(r) = \frac{r}{\sigma^2}\{-\frac{r^2+k_d{}^2}{2\sigma^2}\} I_0\{\frac{r k_d}{\sigma^2}\} \qquad r \geq 0$$

MIMO Fading

The future demand must be met using more data throughput wireless technologies since bandwidth is limted and user demand continuous to grow, spectral efficiency is vital one way to improve link capacity , and potential increase spectral efficiency ,is the application of MIMO. It is well reported in the literature that MIMO physical layer techniques have potential to significantly increase bandwidth in a rich scattering environment [Kai-Ting Shr, 2010]

MIMO scenarios description

Space-Time Block Coding (STBC)

Our Fixed WIMAX simulator implements the Alamouti scheme [Khan and Ghauri, 2008] on the Downlink to provide transmit and receive diversity. This scheme uses a transmission matrix $[s_1, -s_2^* ; s_2, s_1^*]$, where s_1 and s_2 represents two consecutive OFDMA symbols.

Spatial Multiplexing (SM)

WiMAX system supports SM to increase the peak error free data rate [Alamouti, 1998]. The idea behind spatial multiplexing is that multiple independent streams can be transmitted in parallel over multiple antennas and can be separated at the receiver using multiple receive chains through appropriate signal processing. This can be done as long as the multipath channels as seen by the various antennas are sufficiently decorrelated, as would be the case in a scattering-rich environment. Spatial multiplexing provides data rate and capacity gains proportional to the number of antennas used, a 2x2 SM system can double the peak data rate. This comes at the expense of sacrificing diversity gain, and hence a much higher SNR is required.

Adaptive Modulation and Coding

WiMAX systems use adaptive modulation and coding in order to take advantage of fluctuations in the channel. The basic idea is quite simple: Transmit as high a data rate as possible when the channel is good, and transmit at a lower rate when the channel is poor, in order to avoid excessive dropped packets. Lower data rates are achieved by using a small constellation, such as QPSK, and low-rate error-correcting codes, such as rate convolutional or turbo codes. The higher data rates are achieved with large constellations, such as 64 QAM, and less robust error correcting codes; for example, rate convolutional.. In all, 52 configurations of modulation order and coding types and rates are possible, although most implementation of WiMAX offer only a fraction of these [Matthias Kamuf, 2008]

WiMax under different fading channel conditions

Under this section, the comparison of BER versus SNR under various channel conditions is done. Convolutional code of code rate 1/2 is used.

The number of subscribers used is 200 with FFT size of 256.The value of guard interval is 1/4. Fig.1 shows the probability of Error comparison of the SNR based WiMax system under various fading environments.

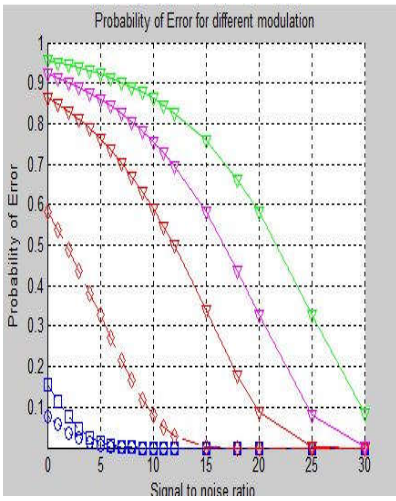


Figure 1. Shows that probability of Error versus signal to noise ratio for Different Modulation Technique

Table 1 Shows the Bit Error Rate vs Signal to noise ratio for different modulation

Eb/No	64 QAM	128 QAM	256 QAM
0	0.4945	0.4999	0.4995
2	0.4981	0.5002	0.5029
4	0.4780	0.4961	0.5013
6	0.4147	0.4942	0.5030
8	0.1972	0.4759	0.4974
10	0.1172	0.4132	0.4990
12	0.0024	0.3257	0.4860
14	0	0.1052	0.4735
16	0	0.0021	0.3054
18	0	0	0.0839
20	0	0	0
22	0	0	0
24	0	0	0
26	0	0	0
28	0	0	0

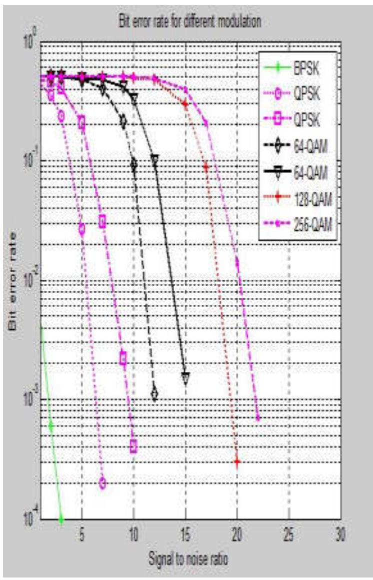


Fig. 2. Wimax under various channel conditions like BPSK, QPSK, 16 QAM and 64 QAM, 128QAM, 256QAM are the different bit error rate for modulation technique

Table 2. Shows the different spectrum efficiency and signal to noise ratio

Eb/No	16 QAM	64 QAM	128 QAM
0	0.4768	0.4989	0.5052
2	0.4475	0.4999	0.5050
4	0.4198	0.4966	0.4960
6	0.1740	0.4824	0.4948
8	0.0274	0.4193	0.4774
10	0.0016	0.2003	0.4274
12	0.0005	0.1040	0.3168
14	0	0	0.1186
16	0	0	0.0028
18	0	0	0
20	0	0	0
22	0	0	0
24	0	0	0
26	0	0	0
28	0	0	0

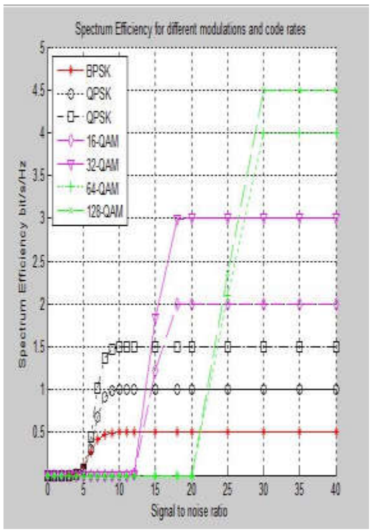


Fig 3. Shows the Comparison of spectrum efficiency versus signal to noise ratio

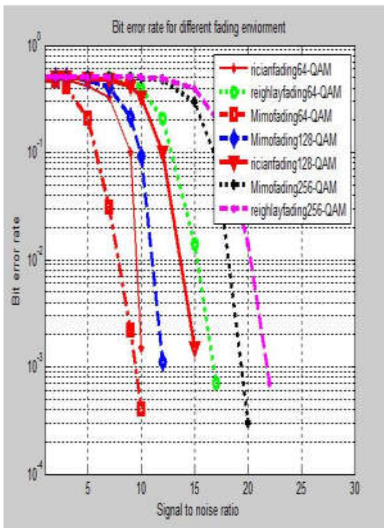


Fig. 3. Graph shows that the rician fading , Rayleigh fading and MIMO fading are different environment

Table 3. shows the Rician fading, Rayleigh fading and MIMO fading.

Rician fading 64QAM	Rayleigh Fading 64QAM	MIMO Fading 256QAM	MIMO Fading 128QAM	Rician fading 128QAM	MIMO Fading 64QAM	Rayleigh Fading 256QAM
0.4993	0.5005	0.4811	0.5001	0.5005	0.4999	0.5002
0.4952	0.5009	0.4608	0.4983	0.4994	0.4995	0.5005
0.4799	0.4995	0.4105	0.4968	0.4993	0.5001	0.5005
0.4119	0.4988	0.2059	0.4814	0.4952	0.5013	0.5009
0.3252	0.4980	0.0305	0.4093	0.4799	0.4994	0.4995
0.1009	0.4887	0.0022	0.2129	0.4119	0.4966	0.4988
0.0015	0.3969	0.0004	0.0918	0.3252	0.4935	0.4980
0.0000	0.2058	0.0000	0.0011	0.1009	0.4724	0.4887
0	0.0141	0	0	0.0015	0.2936	0.3969
0	0.0007	0	0	0.0000	0.0871	0.2058
0	0	0	0	0	0.0003	0.0141
0	0	0	0	0	0	0.0007
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0					

It is observed that the comparision of different modulation technique and their Performance against BER versus SNR and results shows that the performance of OPSK Modulation is poor and 128 QAM perform best. In this we investigated the 128QAM Spectrum efficiency is better than other channel .So these energy spectrum efficiency of the bandwidth is utilized and the 128 QAM is best among all the channels. It is observed that the performance of Wimax – coded Ofdm, we can analysis of this graph we can say that the performance of MIMO Fading 256QAM in terms of bit error rate is optimum and minimum as compared to the other Fading environment. MIMO fading 256QAM is the best performance than Rayleigh and Rician fading

Conclusion

The IEEE 802.16 standard, often called WiMax is a current technology being used for broadband wireless access applications.These performance of COFDM based of WiMax system is investigated under various fading channels. The three fading channels namely Rayleigh, Rician and MIMO Fading environment are examined.

It is concluded that performance of MIMO Fading 256 QAM is the minimum Bit Error Rate is among all channels while Rayleigh fading channel gives worst performance in terms of BER. The performance of MIMO Fading channel is better than Rayleigh and Rician. Further the work is carried out for Rayleigh and Rician and MIMO Fading. It is also observed that as signal to noise ratio increases the BER decreases

Adaptive Modulation and Coding

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