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Performance Analysis of WiMAX with Different Modulation and Encoding Techniques

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Abstract: Worldwide Interoperability for Microwave Access (WiMAX) emerged with an aim of providing voice, data, video and multimedia services on mobile phones at high speeds and cheap rates.For this we study system architecture, radio aspects of the air interface (such as frequency band, radio access modes, multiple access technologies, multiple antenna technologies and modulation), mobility and Quality of Service (QoS). For this we need to discuss various modulation schemes such as Quadrature Amplitude Modulation, Quadrature Phase Shift Keying, encoding methods such as RS, CRC, Convolution and OFDM that are vital for performance of WiMax system. Then first compare the performance of different modulation schemes such as Quadrature Amplitude Modulation and Quadrature Phase Shift Keying with these systems and get the best modulation schemes with less BER. Then with the combination of modulation schemes analyze the different encoding schemes such as Cyclic Redundancy Code and Reed – Solomon encoding with these systems. After that redesign the WIMAX system with best encoding and modulation schemes.

Keywords: WiMAX, OFDM, BER, CRC, RS.

I. INTRODUCTION OF WIMAX

WiMAX, or 802.16, is a fast-emerging wide-area wireless broadband technology that provides high-speed Internet access into homes and businesses and covers wider, metropolitan or rural areas[1]. It can provide data rates up to 75 megabits per second (Mbps) per base station. The IEEE 802.16a standard provides wireless broadband access over the frequency bands between 2 and 11 GHz, a range that enables non line-of-sight performance. This makes the IEEE 802.16a standard the appropriate technology for last-mile applications where obstacles like trees and buildings are present, or where base stations must be mounted on homes and buildings rather than towers and mountains[2].

To support a profitable business model, operators and service providers need to sustain a mix of high-revenue business customers and high-volume residential subscribers. 802.16a systems can help meet this requirement by supporting differentiated service levels[3]. This can be achieved by proper use of frequency band of WiMax. For this purpose OFDM is used as a frequency division multiplexing scheme in WiMax. The basic principle of OFDM is to split a high-rate data stream into a number of lower rate streams that are transmitted simultaneously over a number of sub carriers. The relative amount of dispersion in time caused by multipath delay spread is decreased because the symbol duration increases for lower rate parallel sub carriers.

The other problem to solve is the intersymbol interference, which is eliminated almost completely by introducing a guard time in every OFDM symbol[4]. This means that in the guard time, the OFDM symbol is cyclically extended to avoid intercarrier interference. An OFDM signal is a sum of sub carriers that are individually modulated by using quadrature phase shift keying (QPSK) or quadrature amplitude modulation (QAM). The OFDM is frequency-division multiplexing (FDM) scheme utilized as a digital multi – carrier modulation method. This greatly simplifies the design of both the transmitter and receiver, unlike conventional frequency-division multiplexing (FDM), a separate filter for each sub channel is not required[5]. So by using the OFDM in WiMax the data transmission rate increases and the interference of the system also reduces.

II. SYSTEM MODEL OF WIMAX

A WIMAX system has the three main parts: transmitter, channel and receiver. The basic block diagram of an WIMAX system is shown in the Figure 1..The basic components of an WIMAX transmitter are channel coding, QPSK modulator, sub-carrier assignment i.e. OFDM baseband modulator and single carrier modulator. The data is generated from a random

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source, consists of a series of ones and zeros. Since the transmission is done block wise, when forward error correction (FEC) is used, the size of the data generated depends on the block size used, modulation scheme used to map the bits to symbols (QPSK, 16QAM). The generated data is passed on to the next stage, either to the FEC block or directly to the symbol mapping if FEC is not used. In case error correcting codes are used, the data generated is randomized so as to avoid long run of zeros or ones, the result is ease in carrier recovery at the receiver. The randomized data is encoded using tail biting convolutional codes (CC). Finally interleaving is done by two stage permutation, first to avoid mapping of adjacent coded bits on adjacent subcarriers and the second permutation insures that adjacent coded bits are mapped alternately onto less or more significant bits of the constellation, thus avoiding long runs of lowly reliable bits. The coded bits are then mapped to form symbols. Modulation scheme used is QPSK or 16 QAM with gray coding in the constellation map. Since WIMAX is preferably used for the uplink in a multiuser environment, low-order modulation such as QPSK with Gray mapping is preferred. However, basically high-order modulation (64-QAM) can also be employed. The sub-carrier assignment can be fixed or dynamic. In practice, in order to increase the system robustness a dynamic assignment of sub-carriers (i.e., frequency hopping) for each user is preferable. For pulse shaping, rectangular shaping is usually used which results for K users in an OFDM-type signal at the receiver side. In summary, where only one sub-carrier is assigned to a user, the modulator for the user could be a single-carrier modulator [5]. If several carriers are used for a given terminal station, the modulator will be a multi-carrier modulator. At the receiver the main components are the OFDM baseband demodulator, QPSK demapping, channel decoder (with soft decisions) is used for receiving the transmitted signal and then processed this signal to get the original transmitted data.

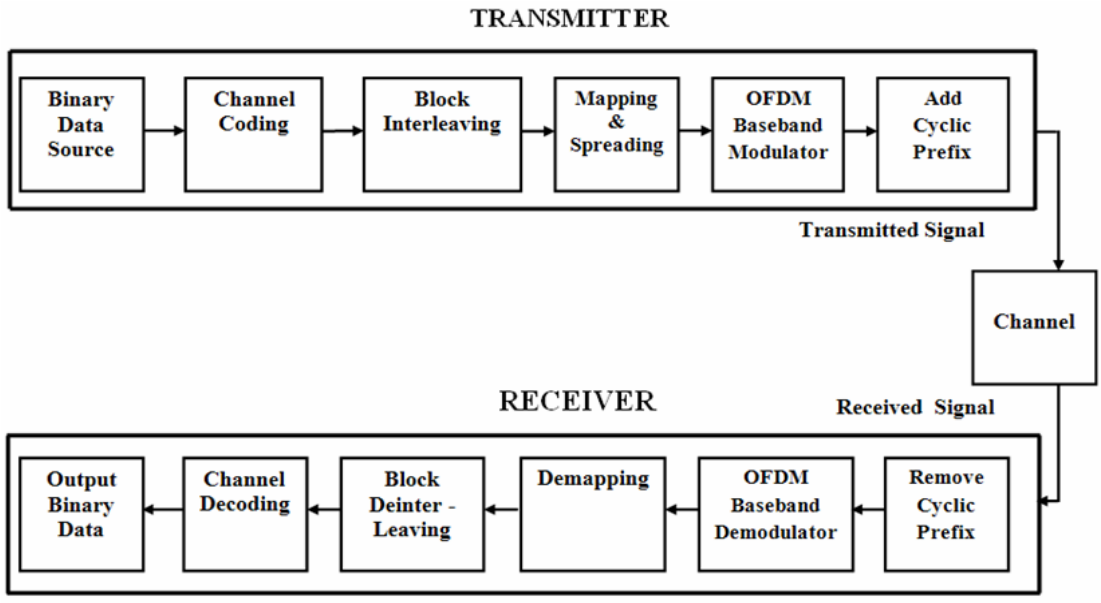

Figure 1: WiMax System.

In between transmitter & receiver channel is there, during transmission of the signal through channel some noise is added. This noise is additive white Gaussian noise, Rayleigh fading, Rician fading. Fading occur due to presence of obstacles in the path of the signal.

III. WIMAX PERFORMANCE ANALYSIS

First the Wimax system is analyzed with different modulation and encoding schemes. The four modulation techniques including 4 – QAM, 16 – QAM, 32 – QAM and QPSK are analyzed and the Bit Error Rate of Wimax system with these modulation schemes is calculated to check the system capacity and system robustness. Analysis was done by observing the simulation result and tabulating the analysis results to make it more convenient to be read. In the performance analysis of Wimax system the transmitted signal, received signal, scatter plots and bit error rate of the systems are analyzed.

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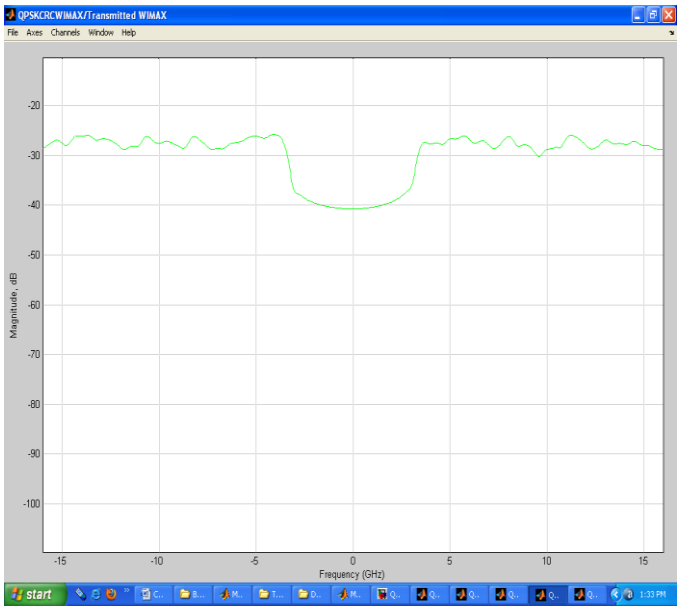

Figure 2. Transmitted Signal of Wimax System

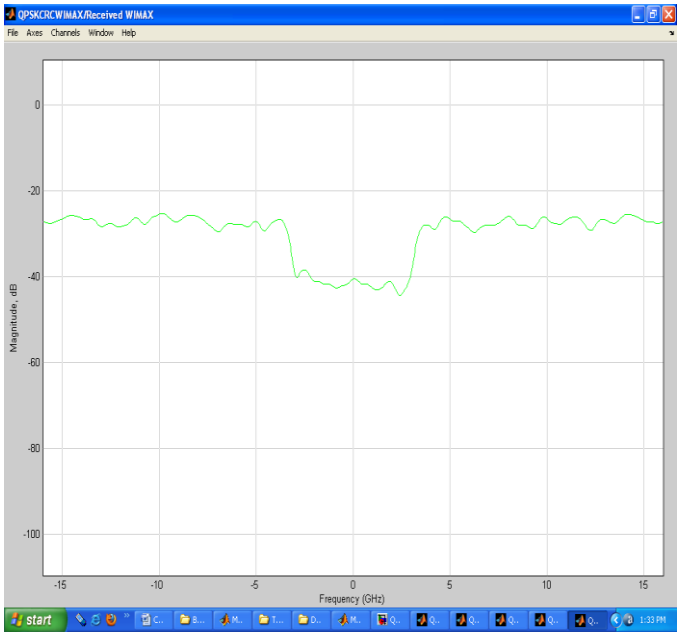

Figure 3. Received Signal of Wimax System

The Figure 2 and 3 shows the transmitted and received signal of Wimax system. To plot these signals spectrum scope is used. The Spectrum Scope block computes and displays the periodogram of the input. From the plot of transmitted and received signal it is clear that the received signal so much distorted as comparison to transmitted signal due to channel. The Scatter Plot Scope displays constellation diagram of a modulated signal, to reveal the modulation characteristics, such as pulse shaping or channel distortions of the signal. The scatter plot also shows the strength of the signal at any point in the coverage area. The constellation diagram of Wimax system with different modulation schemes are plotted by using scatter plot scopes. The Figure 4 shows the constellation diagrams of Wimax system with quadrature phase shift keying modulation. As clear from scatter plot distortion is less in this modulation technique.

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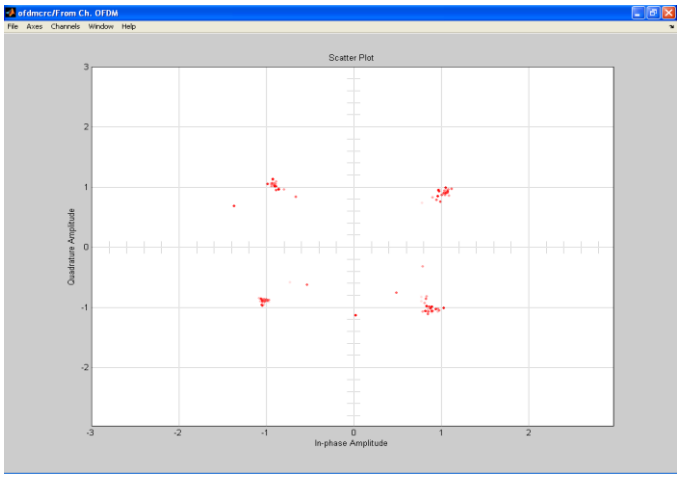

Figure 4. Constellation Diagram of Wimax System with QPSK Modulation.

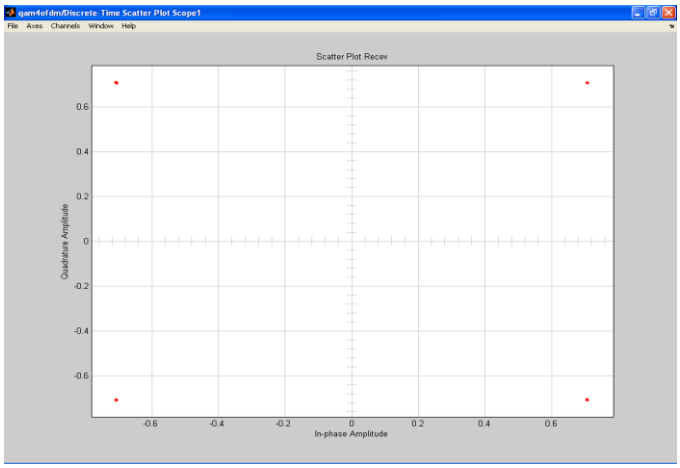

Figure 5. Constellation Diagram of Wimax System with 4 – QAM Modulation

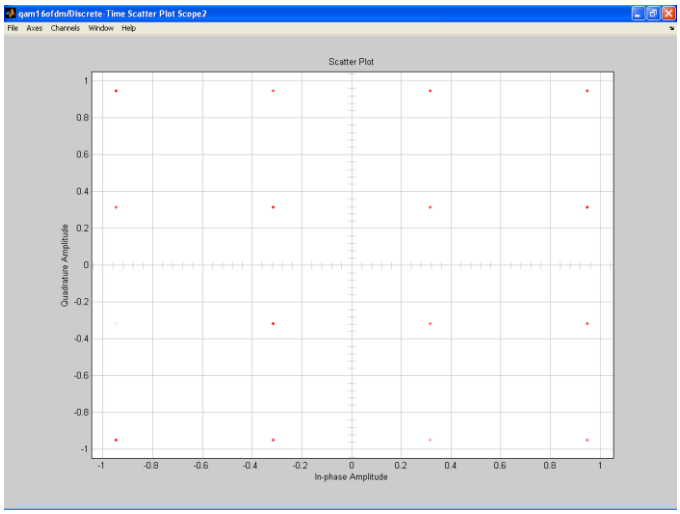

Figure 6. Constellation Diagram of Wimax System with 16 – QAM Modulation

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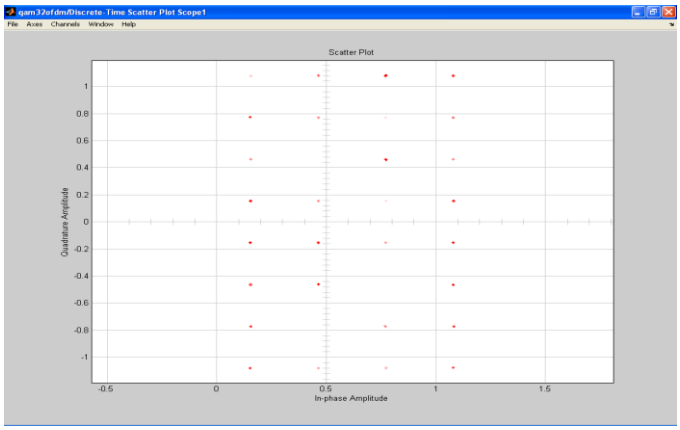

Figure 7. Constellation Diagram of Wimax System with 32 – QAM Modulation

Figure 7 shows constellation diagram of 32 – QAM. In 32-QAM BER is more as compare to other modulation techniques.It is clear that QPSK modulation is better for WiMAX system as compare to QAM modulation schemes. Because in QAM modulation as the modulation index increases, the fading effect increases which is clear from Figure 7, in this figure due to large effects of distortion the constellation points are not clear or shown at some points.

IV. BER COMPARISON OF WIMAX SYSTEM

The simulation results are plotted in term of the performance of Wimax system, that is transmitted, received signal and constellation diagrams. Now the Bit Error Rate of Wimax system is analyzed. First calculate the BER for the Wimax system with different modulation schemes such as 4 – QAM, 16 – QAM, 32 – QAM and QPSK modulation. The BER is calculated with error rate calculation block. In this block the transmitted and received signals are compared to calculate the BER. Table 1 shows the BER of Wimax with these modulation schemes.

Table 1. BER of Wimax with Different Modulation Schemes

Sr. No.	Modulation Scheme	Total Number of Bits	Error Bits	Bit Error rate
1.	4 – QAM	191808	143902	0.7502
2.	16 – QAM	190656	178683	0.9372
3.	32 – QAM	189888	183937	0.9686
4.	QPSK	550000	274700	0.4996

So, it is clear that QPSK modulation has less bit error rate as compare to other modulation schemes. Now by using QPSK modulation analyze the different encoding schemes for the Wimax system such as Cyclic Redundancy Code and Reed – Solomon encoding. Now compute the bit error rate by using these encoding schemes. Table 2. shown the BER of Wimax system different encoding schemes.

Table 2. BER of Wimax with Different Encoding Schemes

Sr. No.	Encoding Scheme	Total Number of Bits	Error Bits	Bit Error rate
1.	RS Encoding	28260	8730	0.3089
2.	CRC Encoding	28260	14110	0.4994

From this table it is clear that while analyzing the different encoding schemes of Wimax system with QPSK modulation, the Reed – Solomon encoding is well suited for it.

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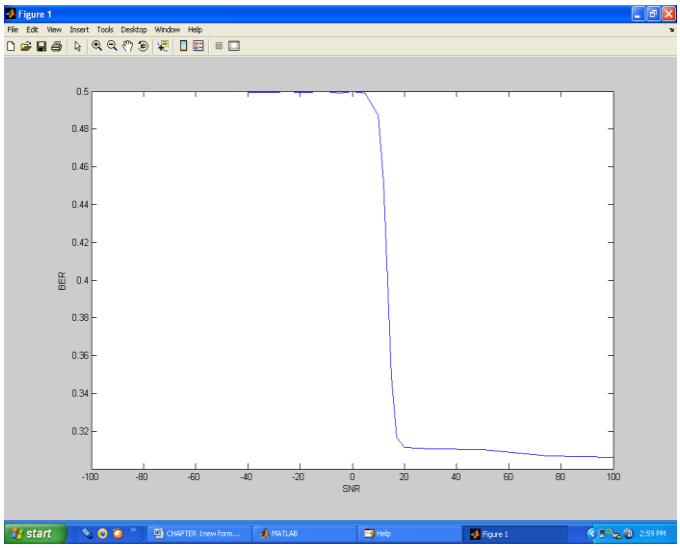

Figure 8. BER Plot of WiMAX system with RS Encoding

Figure 8 shows BER plot of WiMAX system with RS encoding. As clear from graph BER is decreasing as SNR increases.

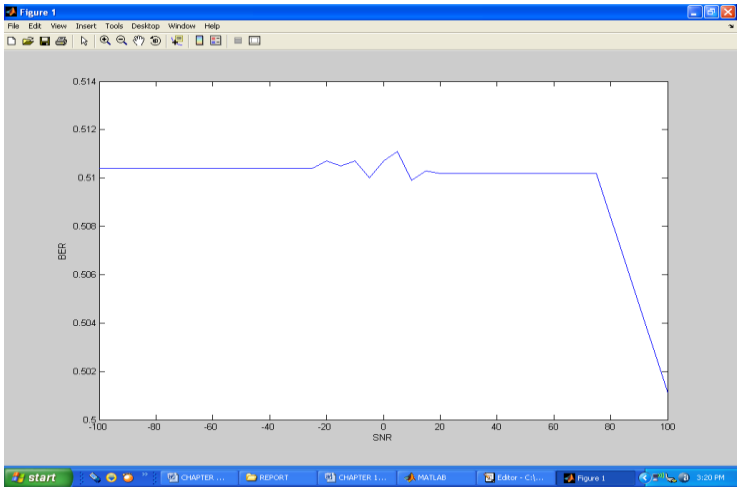

Figure 9. BER Plot of WiMAX system with CRC Encoding

Figure 9 shows BER plot of WiMAX system with CRC encoding. As clear from graph BER is constant as SNR increases. By analyzing the Wimax system with different Signal to Noise Ratio, the bit error rates are calculated. Now plot these bit error rates with respect to various signal to noise ratio. By comparing two plots it is clear that RS encoding scheme is better than CRC. Now from these results it is clear that from the different modulation schemes of Wimax, the QPSK modulation is best with 6.245% error without encoding scheme. Analysis of different encoding schemes of Wimax with QPSK modulation shows that RS encoding is well suited for Wimax system with 3.86% error.

V. CONCLUSION

A performance analysis of WiMAX system in selective channel has been presented. The analysis proceeds in two steps. First, simple WIMAX system has been modeled. A comparable bit rate is transmitted over system and different waveforms and scatter plots has been studied. On analyzing the waveform of transmitted signal of the WIMAX it is clear that the system has approximately very high transmission bandwidth. As the bandwidth of transmission is very high in WIMAX but in terms of transmission performance the Bit Error Rate of WIMAX is very small as compare to other systems. If we make every effort to improve the BER in each system, there is no difference in the attainable BER as long

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as the same channel is used. On comparing the scatter plot of WIMAX it is clear that WIMAX can effectively combine all the received signal energy scattered in the channel. In the received signal of WIMAX more fading effects results in more errors in WIMAX. But due to the use of CRC code Generator in WIMAX which acts as an error check code the BER of WIMAX is very small. On comparing the waveform of transmitted signal and received signal of the WIMAX system the Bit Error Rate of the system has been studied. On comparing the received signals the distortion in the signal can be calculated. From scatter plots of the received signals fading of the signal can be measured. The system having more fading has more noise. But a system is efficient if it has less bit error rate. On comparing the BER of the system the best encoding and modulation can be choose. In a communication system there are two main features one is efficiency of the system and other is data transmission rate of the system. WIMAX is a system which has high transmission rate and Bit Error Rate of WIMAX with QPSK is 0.4996 and with QAM Modulation BER is very high. So QPSK modulation is best for WIMAX. On basis of modulation scheme and encoding schemes CRC, RS have used. CRC encoding scheme is best. In WIMAX with CRC encoding the Bit Error Rate is 0.3089.

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