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Performance Evaluation of Physical Layer of 802.16e WiMAX Using Reed Solomon Code and Convolutional Code under Different Modulation Techniques and Communication Channels

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Abstract— An evergreen listening Radio spectrum system informs that future demands must be met using more data throughput wireless technologies. Since system bandwidth is limited and user request goes on to grow. This problem could be solved by WiMAX (Worldwide Interoperability for Microwave Access) technology. WiMAX is proposed 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. Since WiMAX provides good quality of services. In this paper the performance of WiMAX system is analyzed with the help of Convolutinal code and Reed Solomon code with Convolutional code over different channels like Additive White Gaussian Noise (AWGN) channel and fading channels (Rayleigh and Rician channels) with different modulation techniques such as BPSK, QPSK and QAM (Both 16 and 64) to find out the best performance of physical layer for 802.16e WiMAX. And the performance of each channel is compared. OFDM has been used to achieve high data rate necessary for intensive application. The performance has been concluded based on BER and SNR output through MATLAB Simulation.

Keywords- **WiMAX, AWGN, OFDM, BER, SNR**

I. INTRODUCTION

WiMAX is called the upcoming broadband wireless technology, which proposes high speed, secure, refined and last mile broadband services along with a cellular back haul and Wi-Fi hotspots. The growth of WiMAX began a few years ago when scientists and engineers felt the requirement of having a wireless Internet access and other broadband services which works well everywhere especially in the rural areas or in those areas where it is hard to establish wired infrastructure and economically not practicable. Mobile broadband wireless access (BWA) gives a flexible and inexpensive solution to these problems [1]. WiMAX is a global broadband wireless access standard which can offer high speed voice, video and data service to fixed users as well as portable and mobile ones over a large geographical area. WiMAX will use for other broadband technologies competing in the same segment and it will become a very good solution for the getting of the solution . In this way, WiMAX will attach rural areas in evolutive countries as well as underserved urban areas and can be used to deliver backhaul for carrier structures, enterprise campus, and Wi-Fi hot-spots. WiMAX gives a proper solution for these challenges as it provides an inexpensive, expeditiously deployable solution [2]. WiMAX also provides quality of service (QoS) for video, voice, real time video conferencing and other services upto 280 Mbps. Mobile WiMAX standard defined under the IEEE 802.16e standard that provides high speed mobile data, true broadband for roaming users and facilitate access to broadband internet connection for laptops and PDAs with integrated WiMAX technology. Industry specialists are forecasting that WiMAX will strengthen business competition between Telecomm industries (GMS, CDMA) and cable broadband companies. Moreover, WiMAX hotspots (IEEE 802.16e) are suitable to replace WiFi hotspots. IEEE 802.16 is also known as IEEE Wireless-MAN used for both licensed and unlicensed spectrum of 2-66 GHz, which is standard for fixed wireless broadband and included mobile broadband application. WiMAX forum was formed in June 2001 to adjust the components and evolve the appliance those will be compatible and inter operable. After several years in 2007, Mobile WiMAX appliance 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 is based on Orthogonal Frequency Division Multiple Access (OFDMA) which main motive is to provide better performance in non-line-of-sight environments. IEEE 802.16e proposed Multiple Input Multiple Output (MIMO), scalable channel

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bandwidth up to 20 MHz and Adaptive Modulation and Coding enabled 802.16e technology to support peak Downlink data rates up to 63 Mbps in a 20 MHz channel through Scalable OFDMA (S-OFDMA) system. IEEE 802.16e uses Extensible Authentication Protocol for mutual authentication due to this it has strong and powerful security architecture.

The paper is organized as follows: section II deals with the simulation model. Simulation results are given in section III while section IV concludes the paper.

II. SIMULATION MODEL

The block diagram of WiMAX Physical layer system is shown in figure 1.The description of each block is given one by one in detail.

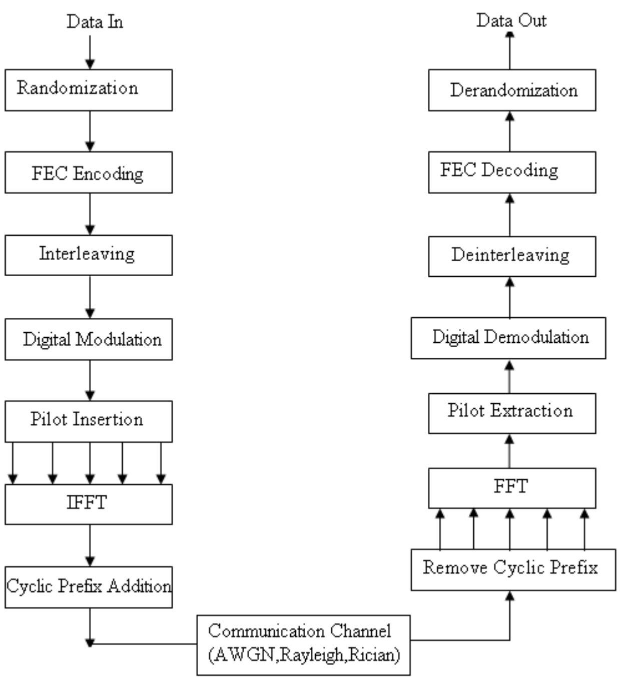

Fig.1: Block diagram of WiMAX System

A. Randomization

Randomizer performs the randomization of input data. It is basically scrambling of data to generate random sequence. Randomizer works on a bit by bit basis. The motive of the scrambled data is to modify long sequences of zero's or one's in a random sequence to improve coding performance and data integrity [7].

B. Forward Error Correction (FEC)

The bits come from the randomizer are then applied to the FEC encoder. FEC techniques typically use error-correcting codes that can detect with high probability the error location. FEC channel codes enhance the bit error rate performance by adding redundant bits in the transmitted bit stream which are used by the receiver to correct errors introduced by the channel. This reduces the signal transmit power for a given BER. In this paper, Convolutional codes and RS codes are used.

I) Convolutional codes

After randomizer data is passed onto the FEC Encoder. Convolutional codes are used primarily for real-time error correction and can convert an entire data stream into one single codeword. The Viterbi algorithm provided the basis for the main decoding strategy of convolutional codes. The encoded bits depend not only on the current informational *k* input bits but also on past input bits. Convolutional code is used to add the redundant bits to the data sequence. The addition of these redundant bits helps to correct the errors; these errors are occurred at the time of transmission [6].

II) Reed Solomon codes

Reed-Solomon codes are block-based error correcting codes with a wide range of applications in digital communications and storage. The Reed-Solomon encoder takes a block of digital data and adds extra "redundant" bits. The Reed-Solomon decoder processes each block and attempts to correct errors and recover the original data. The number and type of errors that can be corrected depends on the characteristics of the Reed-Solomon code. A Reed-Solomon code is specified as RS (n, k) with s-bit symbols. This means that the encoder takes k data symbols of s bits each and adds parity symbols to make an n symbol codeword. There are $n-k$ parity symbols of s bits each. A Reed-Solomon decoder can correct up to t symbols that contain errors in a codeword, where $2t = n-k$.

C. Interleaving

Interleaving is applied to protect the transmission against long sequences of successive errors, which are very hard to correct and these long sequences of error may cause burst losses in transmitted data.

D. Modulation

The function of the modulator is to map the digital information into analog form in a manner to send the data over the channel. This can be done by changing the amplitude, frequency or phase. In this analysis various digital modulation techniques (BPSK, QPSK, 16-QAM and 64-QAM) are used. Inverse process is called demodulation, which is done by the receiver to recover the transmitted digital information.

E. Pilot Insertion

The pilot subcarriers are used for various estimation and synchronization purposes. Pilot carriers are inserted whose magnitude and phase is known to the receiver. The pilots carriers are used in tracking of the remaining phase error if it is present after frequency correction. Without this correction, the constellation points

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start rotating either positive/negative angle. It is very much sensitive at higher constellation.

F. Inverse Fast Fourier Transform (IFFT)

It converts the frequency domain data to time domain data as the channel is in time domain. IFFT is useful for OFDM because it generates samples of a waveform with frequency component satisfying orthogonality condition. Similarly the functions of FFT are apposite to IFFT. It converts the time domain data to frequency domain data. By calculating the outputs simultaneously and taking the advantage of the cyclic properties of the multipliers Fast Fourier Transform (FFT) techniques it reduce the number of computations to the order of $N\log_2 N$. The FFT is most efficient when N is a power of two. The result of the FFT contains the frequency data and the complex transformed result.

G. Cyclic Prefix

Cyclic prefix is added in OFDM signals to preserve the frequency orthogonality and decrease the delay due to multipath propagation, To do so, before transmitting the signal, it is added at the beginning of the signal. In wireless transmission the transmitted signals might be distort by the effect of echo signals due to presence of multipath delay. The ISI is totally removed by the design when the CP length is greater than multipath delay. After performing Inverse Fast Fourier Transform (IFFT) the CP will be added with each OFDM symbol.

H. Communication Channel

In wireless communication, the data are transmitting by the wireless channel with related bandwidth to obtain higher data rate and maintain quality of service. In this paper AWGN, Rayleigh and Rician channels are used for the analysis.

III. SIMULATION RESULTS

In this section, we have presented various BER vs. SNR plots for all the essential modulation techniques.

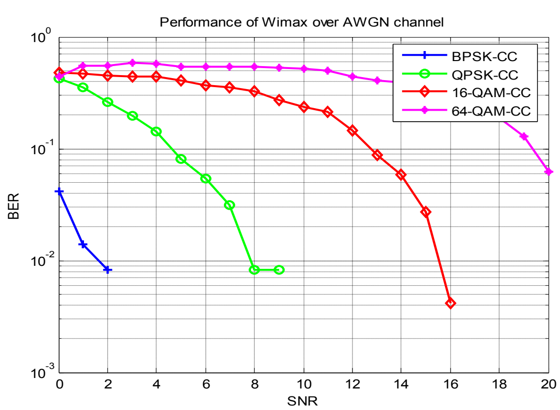

Fig.2: System performance in AWGN channel for CC code

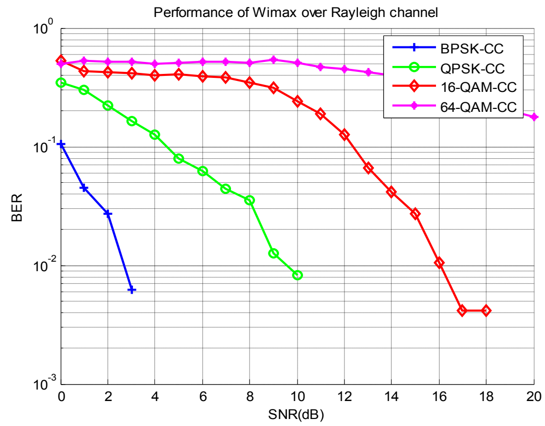

Fig.3: System performance in Rayleigh channel for CC code

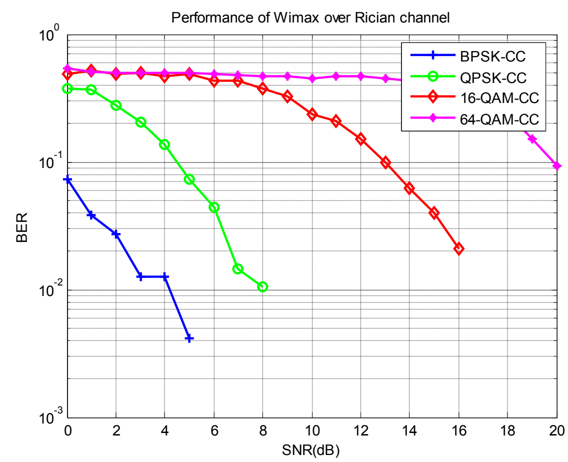

Fig.4: System performance in Rician for CC code

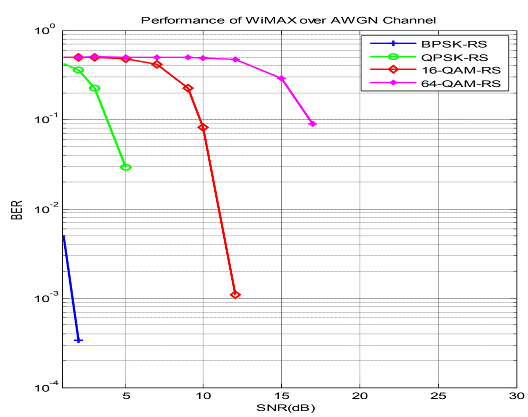

Fig.5: System performance in AWGN channel for RS code

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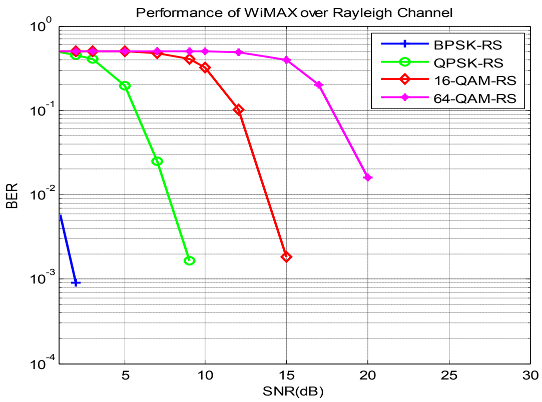

Fig.6: System performance in Rayleigh channel for RS code

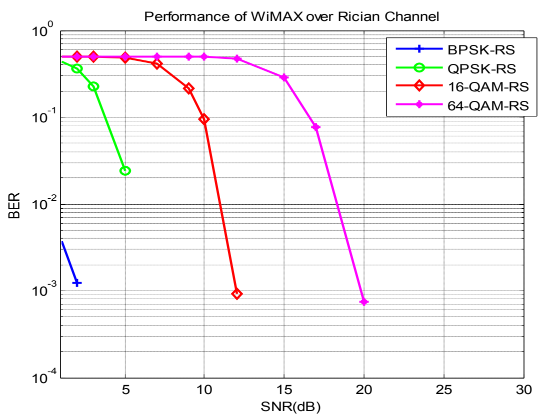

Fig.7: System performance in Rayleigh channel for RS code

IV. CONCLUSION

A performance analysis of Wimax (Worldwide Interoperability for Microwave Access) system with convolutional code and RS code has been carried out. The BER vs SNR curves were used to compare the performance of different modulation techniques over AWGN, Rayleigh and Rician channels. The SNR performance of Convolutinal code and RS code defines at the highest SNR value. At the higher SNR value the 64-QAM is preferred because at the higher SNR value it gives high capacity. At the lower SNR 16-QAM gives high BER. BPSK modulation gives the lowest SNR values and the lowest BER but the channel capacity is very low By comparing the results of Convolutional code and RS code it is concluded that RS code gives lowest BER in BPSK modulation (10^{-3}) and Convolutional code gives highest SNR value in 64-QAM modulation (26 dB).

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