BER An Alysis through WIMAX PHY Layer Over An AWGN Flat Fading Channel

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Abstract

WIMAX (worldwide interoperability for microwave access) is an emerging global broadband wireless system based on IEEE 802.16 standard. The emergence of WIMAX has attracted significant interest from all the fields of wireless communications including students, researchers, system engineers and operators. Developing an understanding of the WIMAX system can be best achieved by looking at the model of the WIMAX system. This paper discusses the model building of the WIMAX physical layer using Matlab 7.9 version. This model is useful tool for BER performance evaluation for data communication by the WIMAX physical layer under convolution coding with ½ and 2/3 rates and transmitting with the OFDM technique. Convolution coding is used to improve the system performance. The performance evaluation of the system modulation schemes BPSK, QPSK, 16 QAM with ½ and 2/3 encoding rate. The simulation result on BER over Additive White Gaussian Noise (AWGN) and flat fading channel. The primary issue in implementation of PHY layer is robust performance in multipath fading environments. In this paper, the performance of Wimax PHY layer with convolution coding mechanisms is investigated and compared with the existing mechanisms. The results obtained show that convolution coding offers lower BER and enhance the performance of the PHY layer (multipath) environments.

Keywords

World Wide Interoperability for Microwave access (WIMAX), Bit Error Rate (BER), Additive White Gaussian Noise (AWGN), Physical Layer (PHY), Orthogonal Frequency Division Multiplexing (OFDM).

1. Introduction

IEEE 802.16, is Worldwide Interoperability for Microwave Access (WiMAX), is a recent wireless broadband standard that has promised high bandwidth over Long-range transmission. The standard specifies the air interface, including the medium access control (MAC) and physical (PHY) layers, of broadband wireless access (BWA). Worldwide Interoperability for Microwave Access (WiMAX) provides specifications for both fixed Line of sight (LOS) communication in the range of 10-66GHz (802.16c), and fixed, portable, Non-LOS communication in the range of 2-11GHz (802.16a & 802.16d). In addition, it defines wireless communication for mobiles, moving at a speed of 125 KMPH, in the range of 2-6 GHz (802.16e). Support for both time division duplex (TDD) and frequency division duplex (FDD) SS is provided, both using a burst transmission format whose framing mechanism supports adaptive burst profiling in which transmission parameters, including the modulation and coding schemes, may be adjusted individually to each SS on a frame-by-frame basis, thus providing high data rates. The key development in the PHY layer includes Orthogonal Frequency-Division Multiplexing (OFDM), in which multiple accesses are achieved by assigning a subset of sub carriers to each individual user. [1]

In recent years, orthogonal frequency-division multiplexing (OFDM) has emerged as the standard of choice in a number of important high-data-rate applications. In OFDM, instead of using a single wide-band carrier to transmit information, a large number of parallel narrow-band sub-carriers are used. OFDM is very effective in dealing with multipath fading. But it is very sensitive to frequency offset and phase noise. In an OFDM system, the data is divided into multiple parallel sub streams at a reduced data rate, and each is modulated and transmitted on a separate orthogonal subcarrier. This increases symbol duration and improves system robustness. OFDM is achieved by providing multiplexing on users' data streams on both uplink and downlink transmissions. OFDM is achieved by providing multiplexing on users' data streams on both uplink and downlink transmissions. First published in 2001, the IEEE 802.16 standard specified a frequency range of 10–66 GHz with a theoretical maximum bandwidth of 120 Mb/s and maximum transmission range of 50 km. However, the initial standard only supports line-of-sight (LOS) transmission and thus does not seem to favor deployment in urban areas. A variant of the standard, IEEE 802.16a-2003, approved in April 2003, can support non-LOS (NLOS) transmission and adopts OFDM at the PHY layer. It also adds support for the
2–11GHz range [5]. One of the main problems in the earlier draft of IEEE 802.16 is that it covers too many profiles and PHY layers, which can lead to potential interoperability problems.

The WiMAX standard 802.16e provides fixed, nomadic, portable and mobile wireless broadband connectivity without the need for direct line-of-sight with the base station. It is different from the previous versions of the

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standard in the sense that 802.16e adds the feature of mobility to the wireless broadband standard [2].

In OFDM serial-to-parallel transmitter converts the incoming high-rate data stream into low-rate streams, and then transmits each low-rate data stream over a unique orthogonal carrier. The data rate of each transmitted stream is effectively reduced by a factor of from the original data rate. Utilizing this strategy, OFDM drastically reduces intersymbol interference (ISI) .In this paper, a model of an OFDM system with IEEE 802.16 implementation is developed using simulation in Matrix laboratory language (MATLAB) on which BER calculations for various digital modulation schemes like BPSK, QPSK, 16QAM with convolution coding rate ½ and 2/3. The convolution coding and interleaving is applied to improve BER performance of OFDM system. The OFDM signal is transmitted over the AWGN channel for various signal-to-noise ratio (SNR) values. To evaluate the performance, for each SNR level, the received signal was demodulated and the received data was compared to the original information. The result of the simulation is shown in the plot of the bit error rate versus Eb/No, which provides information about the system's performance. In the transmitter, binary input data sequence is taken. Forward Error-Correction Coding (FEC) and interleaving is done to provide frequency diversity. The sequence is encoded by a convolution encoder. Then Interleaving is applied to randomize the occurrence of bit errors prior to increase performance. After interleaving, the binary values are converted to symbol values, on which digital modulation scheme is applied. Previously, multi-carrier systems were implemented through the use of separate local oscillator. This was both inefficient and costly.

The paper is organized follows: in Section I, description of physical layer of the WiMAX is introduced. Detailed description of simulated environment is presented in Section II. Simulation results are detailed in Section III. Finally conclusions future implementation is reflected in Section IV and Section V.

2. PHY LAYER OF WIMAX

The primary function of WiMAX PHY is the actual physical transport of data. To achieve maximum performance for high data rate transmission (both in fixed and mobile environments) and high spectral efficiency with diverse QoS requirements it supports variety of PHY mechanisms.

The WiMAX physical layer is based on orthogonal frequency division multiplexing. OFDM is the transmission scheme of choice to enable high-speed data, video, and multimedia communications and is used by a variety of commercial broadband systems, including DSL, Wi-Fi, Digital Video Broadcast-Handheld (DVB-H), and Media FLO, besides WiMAX. OFDM is an elegant and efficient scheme for high data rate transmission in a non line-of-sight or multipath radio environment.

The physical (PHY) layer of WiMAX is based on the IEEE 802.16-2004 and IEEE 802.16e-2005 standards and was designed with much influence from Wi-Fi, especially IEEE 802.11a. Although many aspects of the two technologies are different due to the inherent difference in their purpose and applications, some of their basic constructs are very similar. Like Wi-Fi, WiMAX is based on the principles of orthogonal frequency division multiplexing (OFDM) as previously introduced in above which is a suitable modulation/access technique for non–line-of-sight (LOS) conditions with high data rates. In WiMAX, however, the various parameters pertaining to the physical layer, such as number of subcarriers, pilots, guard band and so on, are

The IEEE 802.16 suite of standards (IEEE 802.16-2004/IEEE 802-16e-2005) [3, 4] defines within its scope for PHY layers, any of which can be used with the media access control (MAC) layer to develop a broadband wireless system. The PHY layers defined in IEEE 802.16 are

•WirelessMAN SC, a single-carrier PHY layer intended for frequencies beyond 11GHz requiring a LOS condition. This PHY layer is part of the original 802.16 specifications.

•WirelessMAN OFDM, a 256-point FFT-based OFDM PHY layer for point-to-multipoint operations in non-LOS conditions at frequencies between 2GHz and 11GHz. This PHY layer, finalized in the IEEE 802.16-2004 specifications, has been accepted by WiMAX for fixed operations and is often referred to as fixed WiMAX.

• WirelessMAN OFDMA, a 2,048-point FFT-based
OFDMA PHY for point-to-multipoint operations in NLOS conditions at frequencies between 2GHz and 11GHz. In the IEEE 802.16e-2005 specifications, this PHY layer has been modified to SOFDMA (scalable OFDMA), where the FFT size is variable and can take any one of the following values:
128, 512, 1,024, and 2,048. The variable FFT size allows for optimum operation/implementation of the system over a wide range of channel bandwidths and radio conditions. This PHY layer has been accepted by WiMAX for mobile and portable operations and is also referred to as mobile WiMAX
[5].

To implement the OFDM transmission scheme, the whole design is divided into three sections–Transmitter, Channel and Receiver. In the transmitter, binary input data sequence is taken. Forward Error-Correction Coding (FEC) and interleaving is done to provide frequency diversity. The sequence is encoded by a convolution encoder. Then Interleaving is applied to randomize the occurrence of bit errors prior to increase performance.

After interleaving, the binary values are converted to symbol values, on which digital modulation scheme is applied. Previously, multi-carrier systems were implemented through the use of separate local oscillator. This was both inefficient and costly. With the advent of cheap powerful processors, the sub-carriers can now be implemented by the FFT which keep tones to orthogonal with each other. The symbol is modulated onto sub carriers by applying the Inverse Fast Fourier Transform (IFFT).

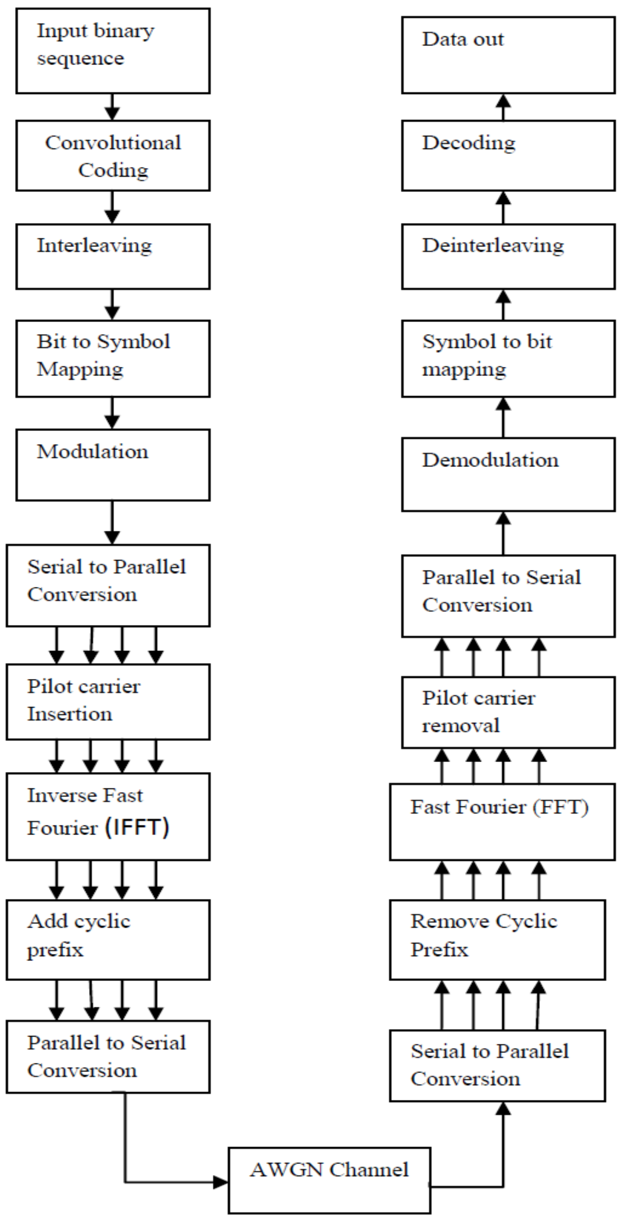

Fig.1 IEEE 802.16 physical layer

The output is converted to serial and a cyclic extension is added to make the system robust to multipath propagation. In channel, additive white Gaussian noise characteristics are taken. The receiver performs the reverse operations of the transmitter. After removing the cyclic extension, the signal can be applied to a Fast Fourier transform to recover the modulated values of all subcarriers. The modulated values are then demapped into binary values, and finally deinterleaving and Viterbi decoder decodes the information bits.

II SIMULATION ENVIRONMENT AND ANALYSIS OF OUTPUT

Figure 2 and 3 shows the BER performance of audio data communication through WiMAX-PHY layer under various types of digital modulation schemes on both AWGN and flat fading channels. In all the cases, the proposed system provides degraded performance in 8 PSK and satisfactory performance in BPSK modulations. In Figure 2, the BER performances of data propagation through WiMAX PHY using ½ rated convolutionally coded system under various digital modulations in AWGN channel. For a typical SNR value of 4 dB, the BER values for BPSK and 16PSK modulations are 0.002035 and 0.5086 respectively viz. the system performance is improved by 23.97 dB. Similarly, in Figure 3, the system performance with 2/3-rated Convolution coding is improved by 15.33 dB for a typical SNR value of 4 dB and the corresponding BER values are 0.0189 and 0.5086. It is mentionable here that the BER for BPSK modulation approaches zero above the SNR values of 5 and 9dB in case of 1/2-rated and 2/3-rated Convolution coding, respectively. The system shows almost flat degraded

Performance for a wide value of SNR (0-10dB using ½ rated coding and 0-12dB for 2/3-rated coding) with implemented 16PSK modulation. Also comparing the two outputs shows the BER vs SNR ratio for BPSK is better than other modulation schemes. Typical results shows that the better modulation schemes shows better outcomes.

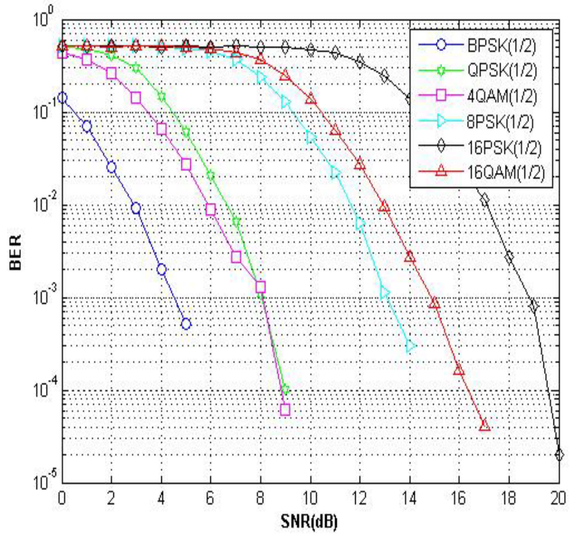

Figure 2 BER simulations of an audio data through WiMAX-PHY layer using ½-rated Convolutionally encoded system for different modulation schemes over an AWGN channel

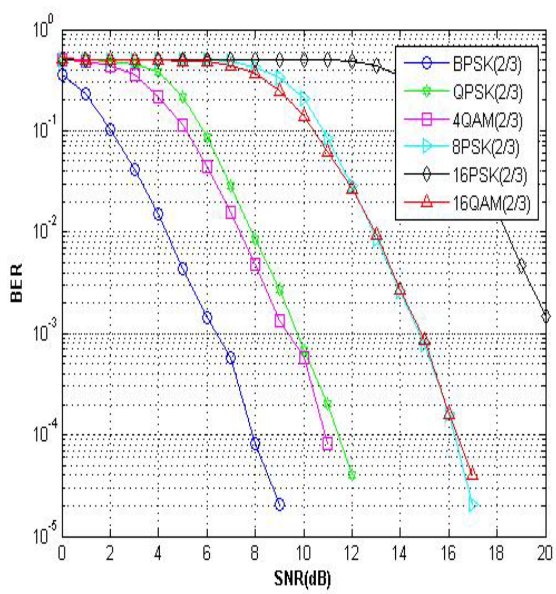

Figure 3. BER simulations of an audio data through WiMAX PHY layer using 2/3-rated Convolutionally encoded system for different modulation schemes over an AWGN channel.

IV. CONCLUSIONS

The performance of IEEE 802.16d/e based PHY layer is investigated by implementing its various key aspects in mobile environments. The investigations are carried further with the implementation of the optional feature of turbo coding in the PHY layer of the WiMax system. The BER performance of the real audio data communication through broadband WiMAX-PHY layer based wireless communication system adopting the Convolutional channel coding and several digital modulation schemes. The system performance reflects the impact of digital modulations under Convolutional coding, AWGN flat fading channels. In the context of system performance, it can be concluded that the implementation of BPSK modulation with half (½) rated channel coding technique provides satisfactory result among the digital modulation schemes with limited SNR.

V. Future enhancements

Our paper focuses basically on improvement of WiMAX PHY layer performance for a single mobile user with the introduction of convolution coder in the PHY layer of the system. The OFDM-convolutionally coded PHY layer has been found to outperform the OFDM-FEC based PHY layer with the only constraint of increased delay owing to increased memory states and complexity of the system the decoder. The improved interleaver design and memory efficient decoding algorithms can further be implied to overcome these delay

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