

Performance Analysis of Mobile WiMAX System using Turbo Coding Technique for Different Modulation Schemes under AWGN and Rayleigh Channel

P. Samundiswary, Biswajit Sahoo

Abstract - In wireless communication, future demands must be met using more data throughput wireless technologies. Since bandwidth is limited and user demand continues to grow. This problem could be solved by WiMAX technology based on IEEE 802.16e specifications, which provides high data services on mobile environment. So, to support high data rate traffic, the error correction could be enhanced by incorporating a better channel coding technique in mobile WiMAX physical layer. Further, coding technique is used for providing reliable information through the transmission channel to the user. It is used to reduce the level of noise and interferences in electronic medium. The amount of error detection and correction required and its effectiveness depends on the signal to noise ratio. The advantages of Forward Error Correction (FEC) are that a back-channel is not required, or that retransmission of data can often be avoided, at the cost of higher bandwidth requirements on average. In this paper, the performance of mobile WiMAX system with convolutional turbo coding is determined and analyzed for various modulation schemes under different channels. The BER performance of mobile WiMAX system using convolutional turbo Coding is determined and compared with the existing concatenated Reed Solomon(RS) coding in the presence of AWGN and Rayleigh Channel. From the simulation results, it is verified that convolutional turbo coding provides better BER performance than concatenated RS coding.

Keywords – AWGN Channel, Rayleigh Channel, RS Coding, Turbo Coding, WiMAX.

I. INTRODUCTION

WiMAX is a new OFDM based technology and promises to combine high data rate services with wide area coverage in frequency range of 10 – 66 GHz (Line of sight) and 2-11 GHz (Non Line of Sight)) and large user densities with a variety of Quality of Service (QoS) requirements. WiMAX can provide Broadband Wireless Access (BWA) up to 30 miles (50 km) for fixed station and 3 to 10 miles (5-15 km) for mobile stations with data rates between 1.5 and 75 Mbps per channel [1]. The 802.16e standard is an amendment to 802.16d standard and adds new major specifications enabling full mobility at vehicular speed with increased QoS to it (below 6 GHz NLOS operation) [2]. To increase the spectral efficiency and data rate, FEC coding techniques are incorporated in the physical layer of wireless technologies. Many researchers have developed FEC techniques based on IEEE 802.16d and 802.16e specifications. The main objective of this paper is to analyze the performance of mobile WiMAX system using turbo coding and convolution coding.. Turbo coding and Convolution coding are the two powerful error correction and detection methods to reduce the noise. In order to increase the

performance of the coding technique, Cyclic Prefix and interleaving techniques are used with different modulation techniques like BPSK, QPSK, and 16-QAM modulation under AWGN and Rayleigh channel. The rest of the paper is organized as follows: Section 2 deals with the physical layer model of WiMAX system. Simulation model of mobile WiMAX system using convolutional turbo coding is explained in Section 3. In section 4, the simulation results are discussed and analysed .Conclusion is drawn in Section 5.

II. WiMAX PHYSICAL LAYER MODEL

The physical layer model of WiMAX system [3] is shown in figure 1. The various blocks of that model are explained below:

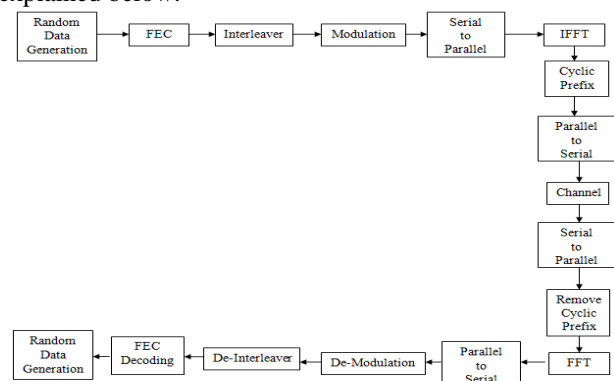


Fig.1. WiMAX physical layer model

A. Randomization

It is a simulink block that converts an input string into a seemingly random output string of the same length, thus avoiding long sequences of bits of the same value [4].

B. Forward Error Correction (FEC)

It is a technique used for controlling errors in data transmission over unreliable or noisy communication channels. The central idea is the sender encodes their message in a redundant way by using an error-correcting code.

The FEC block shown in Fig.1 consists of two blocks such as Reed-Solomon coding and Convolutional coding. Reed-Solomon coder is outer encoder and Convolutional encoder is inner encoder for WiMAX system [5] [6].

C. Interleaver

In interleaver data is written in one manner and read in different manner. It is used to increase the performance of coding.

D. Modulation

The interleaved and rearranged data are digitally modulated by different modulation schemes such as BPSK, QPSK and 16-QAM [7] [8].

E. Serial to parallel conversion

Data to be transmitted is typically in the form of a serial data stream. In OFDM, each symbol typically transmits 40 - 4000 bits, and so a serial to parallel conversion stage is needed to convert the input serial bit stream to the data to be transmitted in each OFDM symbol. The data allocated to each symbol depends on the modulation scheme used and the number of sub carriers. For example, for a sub carrier using modulation of 16 QAM, each sub carrier carries 4 bits of data, and so for a transmission using 100 sub carriers the number of bits per symbol would be 400. At the receiver the reverse process takes place, with the data from the sub carriers being converted back to the original serial data stream.

F. IFFT (Frequency to time domain conversion)

After the subcarrier modulation stage each of the data sub carriers is set to amplitude and phase based on the data being sent and the modulation scheme. All unused sub carriers are set to zero. This sets up the OFDM signal in the frequency domain. An IFFT is then used to convert this signal to the time domain, allowing it to be transmitted. In the frequency domain, before applying the IFFT, each of the discrete samples of the IFFT corresponds to an individual sub carrier. Most of the sub carriers are modulated with data. The outer sub carriers are unmodulated and set to zero amplitude. These zero sub carriers provide a frequency guard band before the Nyquist frequency and effectively act as an interpolation of the signal and allows for a realistic roll off in the analog anti-aliasing reconstruction filters.

G. Cyclic prefix

It refers to the prefixing of a symbol with a repetition of the end. Although the receiver is typically configured to discard the cyclic prefix samples, the cyclic prefix serves as a guard interval; it eliminates the inter-symbol interference from the previous symbol [9].

H. AWGN Channel

Additive white Gaussian noise (AWGN) is a channel model in which the only impairment to communication is a linear addition of wideband or white noise with a constant spectral (expressed as watts per hertz of bandwidth) and a Gaussian distribution of amplitude. The model does not account for fading, frequency selectivity, interference, nonlinearity or dispersion. However, it produces simple and tractable mathematical models which are useful for gaining insight into the underlying behavior of a system before other phenomena are considered [10].

In the study of communication systems, the classical (ideal) AWGN channel, with statistically independent Gaussian noise samples corrupting data samples free of inter-symbol interference (ISI), is the usual starting point for understanding basic performance relationships. An AWGN channel adds white Gaussian noise in the signal that passes through it.

I. Rayleigh Channel

Rayleigh fading is a statistical model for the effect of a propagation environment on a radio signal such as that used by wireless devices. It assumes that the power of a signal that has passed through such a transmission medium (also called a communications channels) will vary

randomly or fade according to a Rayleigh distribution, the radial component of the sum of two uncorrelated Gaussian random variables. It is reasonable model for tropospheric and ionospheric signal propagation as well as the effect of heavily built up urban environment on radio signals. Rayleigh fading is most applicable when there is no line of sight between the transmitter and receiver.

In a multipath propagation environment, the received signal is sometimes weakened or intensified. The signal level of the received wave changes from moment to moment. Multipath fading raises the error rate of the received data.

III. SIMULATION MODEL

In the simulation model, convolutional turbo coding is used as FEC channel coding instead of concatenated Reed-Solomon coding. The channels considered for simulation are Rayleigh and AWGN channel. The simulation model is shown in Fig.2.

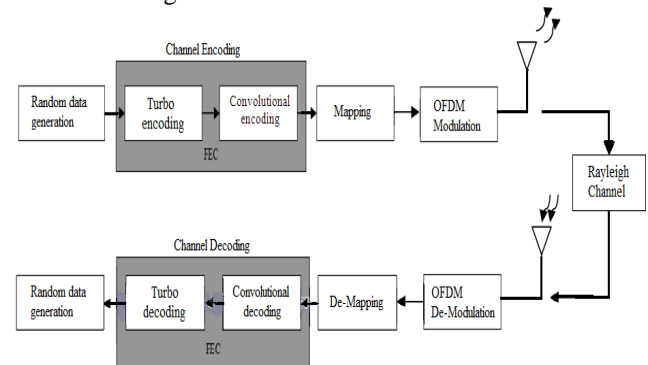


Fig.2. Simulation model of mobile WiMAX system with turbo coding

A. Turbo Encoding

The Turbo encoder is shown in figure 3. Turbo codes are basically convolutional codes concatenated in series or in parallel and are generally known as convolutional turbo codes (CTC). The basic idea of turbo codes is to use two convolutional codes in parallel with some kind of interleaving in between them. Convolutional codes can be used to encode a continuous stream of data, but in this case it is assumed that data is configured in finite blocks corresponding to the interleaver size. The frames can be terminated i.e. the encoders are forced to a known state after the information block. The termination tail is then appended to the encoded information and used in the decoder.

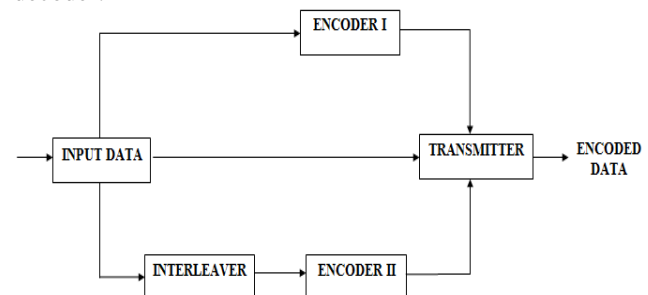


Fig.3. Turbo Encoder

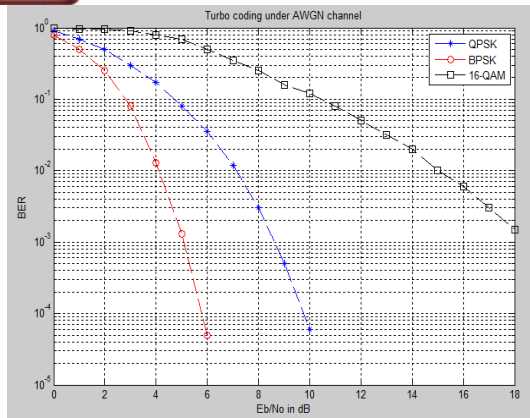


Fig.7. Turbo coding under AWGN channel

It is concluded from figure 8 that mobile WiMAX system using convolutional turbo coding achieves BER of about 10^{-4} at 11 dB of Eb/No for BPSK modulation and 10^{-2} at 21 dB of Eb/No for 16-QAM modulation under Rayleigh channel.

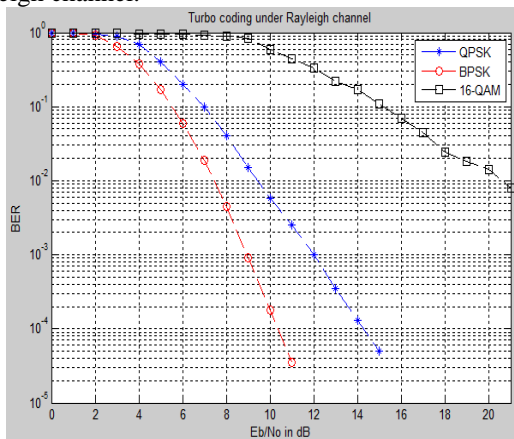


Fig.8. Turbo coding under Rayleigh channel

The simulation result shown in figure 9 infers that mobile WiMAX system using convolutional turbo coding provides BER between 10^{-4} and 10^{-5} which is better than concatenated RS coding by providing BER of about 10^{-3} at Eb/No of 10 dB for QPSK modulation scheme in the presence of AWGN channel. It is also observed through the figure 9 that the BER of mobile WiMAX system using convolutional turbo coding is lesser than BER using concatenated RS coding for QPSK modulation under AWGN channel.

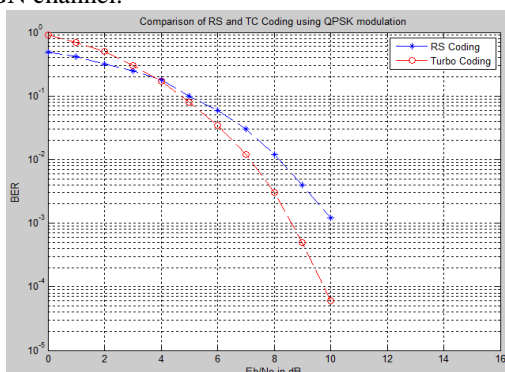


Fig.9. Comparison of Reed-Solomon and Turbo coding under AWGN channel

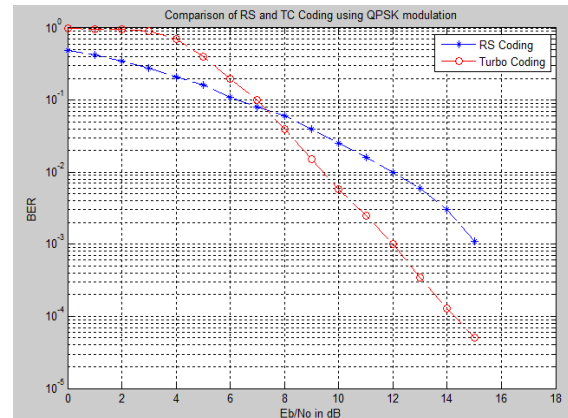


Fig.10. Comparison of Reed-Solomon and Turbo coding under Rayleigh channel

The Fig.10 shows that mobile WiMAX system using convolutional turbo coding provides BER lower than 10^{-4} which is better than concatenated Reed-Solomon coding by providing BER of near about 10^{-3} at Eb/No of 15 dB for QPSK modulation scheme in the presence of Rayleigh channel.

V. CONCLUSION

Mobile WiMAX system using concatenated RS and convolutional turbo coding for various modulation schemes under different channels is simulated by using MATLAB. From the simulation results, it is concluded that convolutional turbo coding gives better BER performance than reed-solomon coding. In RS coding the BER is near about 10^{-3} at 10 dB of Eb/No for BPSK modulation under AWGN channel and 10^{-3} at 15 dB of Eb/No under Rayleigh channel. BER of mobile WiMAX system using Turbo Coding is 10^{-4} at 6 dB of Eb/No for BPSK modulation under AWGN channel and 10^{-4} at 11 dB of Eb/No under Rayleigh channel.

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AUTHOR'S PROFILE



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