Analyzing the Performance Comparing of Different SUI Channel and AWGN and Rayleigh Rician Fading Channel Models for Wimax Communication System

Md. Zahid Hasan and Mohammad Reaz Hossain
Department of Information and Communication Engineering,
Rajshahi University, Rajshahi-6205, Bangladesh

Abstract: Ubiquitous broadband Internet access is an important requirement to satisfy user demands and support a new set of real time services and applications. Worldwide Interoperability for Microwave Access (WiMAX) system has emerged as a strong candidate for providing mobile broadband wireless service to users. In this study we conduct simulation studies for different fading communication channel models to verify its effectiveness and the correctness of the channel performance analysis. We also compare adaptive digital modulation techniques (QPSK, 16-QAM and 64-QAM) performance. And the Wimax system incorporates Reed-Solomon (RS) encoder with Convolutional encoder with ½ rated codes in FEC channel coding. The simulation results of estimated Bit Error Rate (BER) displays that the implementation of interleaved RS code (255,239,8) with ½ rated Convolutional code under BPSK modulation technique is highly effective to combat in the Wimax communication system.

Key words: OFDM, convolution coding, reed-solomon coding additive, white gaussian noise, fading channel, wimax

INTRODUCTION

In the fast-changing field of wireless communications, researchers regularly try to come up with new technologies that satisfy the ongoing demand for faster data rates with longer transmission ranges and that are thus suitable for new applications. One of the newest technologies to join the fray is mobile WiMax, a version of traditional WiMax (worldwide interoperability for microwave access), which enables high-speed fixed wireless communications. Mobile WiMax proponents hope their approach will compete with cellular, Wi-Fi and last-mile Internet-access technologies such as DSL and cable. WiMAX will bring a standards-based technology to a sector that otherwise depended on proprietary solutions.

WiMax uses scalable ODFM, which increases bandwidth by splitting a data-bearing radio signal into smaller signal sets, modulating each onto different subcarriers spaced orthogonally to minimize interference and assigning subsets of subcarriers to individual base stations. In Wimax Physical layer generally the transmitted bit stream is divided into many different sub streams and sent over many different sub channels. Typically the sub channels are orthogonal under ideal propagation conditions. The data rate on each of the sub channels are much less than the total data rate and the corresponding sub-channel bandwidth is much less than the total system bandwidth. The number of sub streams is chosen to insure that each sub channel has a bandwidth less than the coherence bandwidth of the channel, so the sub channels experience relatively flat fading with insignificant amount of ISI effect (Vaughan-Nichols, 2008; Abichar et al., 2006).

In almost all applications of multi-carrier modulation, satisfactory performance cannot be achieved without the addition of some form of channel coding. In wireless systems subjected to fading, extremely high SNR ratios are required to achieve reasonable error probability. In addition, interference from other wireless channels is frequently severe. On wire-line systems, large constellation sizes are commonly employed to achieve high bit rates.

Coding in this case is essential for achieving the highest possible rates in the presence of crosstalk and impulsive and other interference. Channel coding in Wimax systems can be implemented in time and frequency domain such that both dimensions are utilized to achieve better immunity against frequency and selective fading. A concatenated coding scheme constituted form

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Corresponding Author: Md. Zahid Hasan, Department of Information and Communication Engineering, Rajshahi University, Rajshahi-6205, Bangladesh

a combination of two 8-bi channel codes (Goldsmith, 2005; Stuber *et al.*, 2004). However in the present study, an effort has been made merely to concatenate the various channel encoding codes to improve the reliable reception performance of a Wiamx wireless communication system under different digital modulation schemes such as QPSK, 16-QAM and 64-QAM.

In short, WiMAX delivers a wireless signal much farther with less interference than competing technologies. However, the higher the number of bits per symbol, the more susceptible the scheme is to Intersymbol Interference (ISI) and noise. Intersymbol interference occurs due to time dispersion when in a multipath environment, the time delay between the various signal paths is a significant fraction of the transmitted signal's symbol period and a transmitted symbol may arrive at the receiver during the next symbol period and cause Intersymbol Interference (ISI). Modulation technique and fading channel environment is an important role of WiMAX systems. Generally the Signal-to-Noise Ratio (SNR) requirements of an environment determine the modulation method to be used in the environment. QPSK is more tolerant of interference than either 16-QAM or 64-QAM (Andrews *et al.*, 2007).

MATERIALS AND METHODS

This structure corresponds to the physical layer of the WiMAX/IEEE 802.16 WirelessMAN-OFDM air interface. In this setup, the input binary data stream is ensured against errors with Forward Error Correction Codes (FECs) and interleaved. The complementary operations are applied in the reverse order at channel decoding in the receiver end. The complete channel encoding setup is shown in Fig. 1.

FEC techniques typically use error-correcting codes (e.g., RS, CC) that can detect with high probability the error location. These channel codes improve the bit error rate performance by adding redundant bits in the transmitted bit stream that are employed by the receiver to correct errors introduced by the channel. Such an approach reduces the signal transmitting power for a given bit error rate at the expense of additional overhead and reduced data throughput (even when there are no errors (Yorozu *et al.*, 1987). The Forward Error Control (FEC) consists of a Reed-Solomon (RS) outer code and a rate-compatible Convolutional Code (CC) inner code. A block Reed Solomon (255, 239, 8) code based on the Galois field GF (2^8) with a symbol size of 8 bits is chosen that processes a block of 239 symbols and can correct up to 8 symbol errors calculating 16 redundant correction
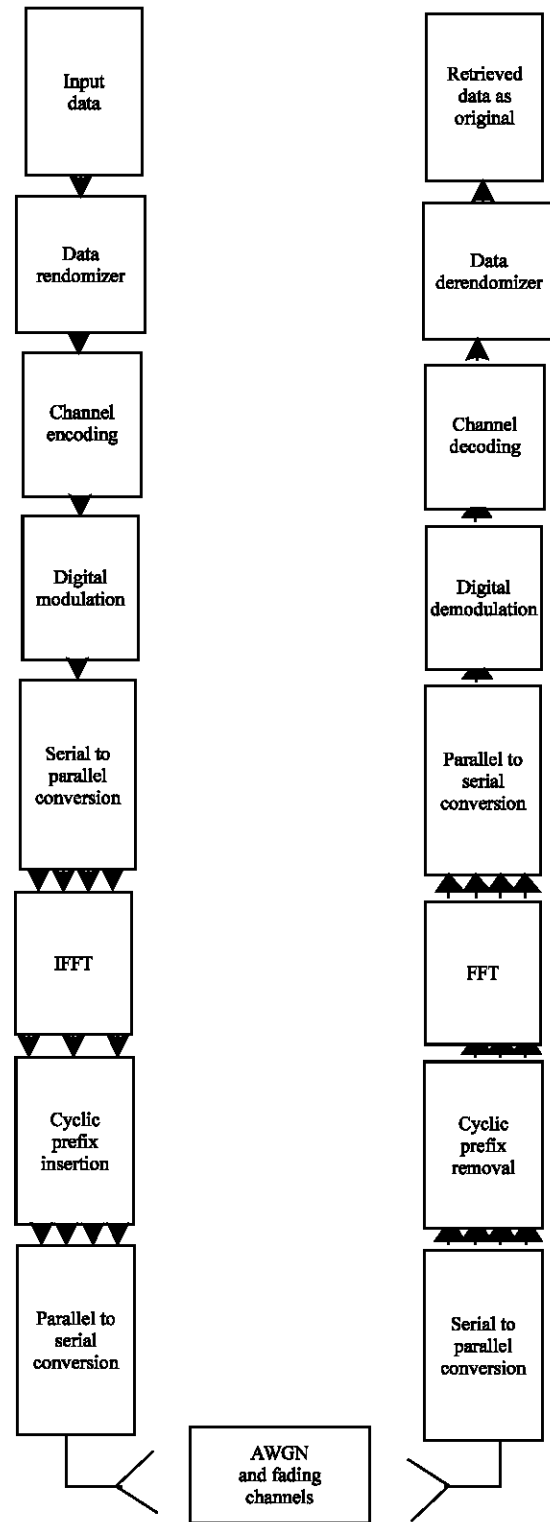

Fig. 1: Wimax communication system model based with interleaved concatenated channel coding

symbols. Reed Solomon Encoder that encapsulates the data with coding blocks and these coding blocks are helpful in dealing with the burst errors (Young, 1989). The block formatted (Reed Solomon encoded) data stream is passed through a convolutional interleaver. Here a code rate can be defined for convolutional codes as well. If there are k bits per second input to the convolutional encoder and the output is n bits per second, the code rate is k/n.

The redundancy is on not only the incoming k bits but also several of the preceding k bits. Preceding k bits used in the encoding process is the constraint length m that is similar to the memory in the system (Sakariya Sa-e *et al.*, 2007), where k is the input bits and n is the number of output bits is equal to ½ and the constraint length of 7 m.

The convolutionally encoded bits are interleaved further prior to convert into each of the either three complex modulation symbols in QPSK, 16-QAM, 64-QAM modulation and guard intervals is added to the data once the data is converted into time domain and ready to be transmitted. The simulated coding, modulation schemes and also noisy fading channels used in the present study are shown in Table 1.

The addition of guard interval to the data before it is actually transmitted helped the data to cater the problems related to the multipath propagation and provided a resistance against ISI. IEEE 802.16 allows the insertion of

guard time intervals is added to the WiMAX symbol before it is transmitted. Guard interval is a copy of the last part of OFDM symbol which is appended to the front of transmitted OFDM symbol (Nee and Prasad, 2000). The length of the guard interval must be chosen as longer than the maximum delay spread of the target multipath environment. The transmitted data is then fed into the SUI channel variations (1-4) and AWGN channels. At the receiver side, guard interval is removed before any processing starts. The simulation evaluated the performance of WiMAX for Bit Error Rate (BER) values equal to the rate of error of the transmission is verified. The simulation was initialized with an Eb/No = 0 dB. The

Table 1: Simulated coding, modulation schemes and noisy channels

| Parameters	Value
BW-This is the nominal channel Bandwidth	2.5 MHz
N_{used}-Number of used subcarriers	200
N_{FFT}	256
Modulation	QPSK, 16-QAM, 64-QAM
RS code	(255,239,8)
CC code	½
Noise channels	AWGN and SUI
SUI channel model parameters	
P (Power in each tap in dB)	[0-15-20]
	[0-12-15]
	[0-5-10]
	[0-4-8]
K (Ricean K-factor in linear scale)	[4 0 0]
	[2 0 0]
	[1 0 0]
	[0 0 0]
Tau (Tap delay)	[0 0.4 0.9]
	[0.0 0.4 1.1]
	[0.0 0.4 .9]
	[0.0 1.5 4.0]
Doppler (Doppler maximal frequency parameter)	[0.4 0.3 0.5]
	[0.2 0.15 0.25]
	[0.4 0.3 0.5]
	[0.2 0.15 0.25]
Ant_corr (Anteena Correlation)	0.7, 0.5, 0.4,0.3,
Fnorm (gain normalization factor)	-0.1771, -0.3930, -1.5113, -1.9218
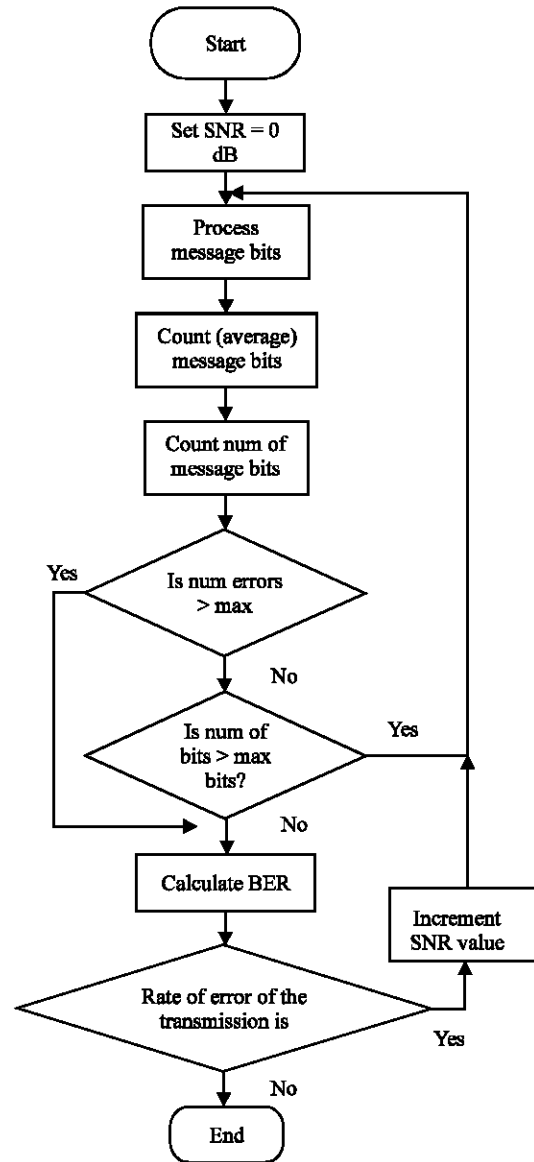
Fig. 2: Flowchart of the simulation processing chain

Eb/No value was incremented by 1 dB when a predefined number of errors were measured or a predefined number of message bits were sent. The simulation processing chain is illustrated by the process flow diagram is shown in Fig. 2.

As long as the length of guard interval is larger than maximum expected delay spread, all reflections of previous symbols are removed and orthogonality is restored. The orthogonality is lost when the delay spread is larger than length of guard interval. In OFDM modulator, the digitally modulated symbols are transmitted in parallel on subcarriers through implementation as an Inverse Discrete Fourier Transform (IDFT) on a block of information symbols followed by an Analog-to-Digital Converter (ADC).

To mitigate the effects of Inter-symbol Interference (ISI) caused by channel time spread, each block of IDFT coefficients is typically presented by a different length of guard intervals. At the receiving side, a reverse process (including deinterleaving and decoding) is executed to obtain the original data bits. As the deinterleaving process only changes the order of received data, the error probability is intact. When passing through the CC-decoder and the RS-decoder, some errors may be corrected, which results in lower error rates (Xiao, 2008).

RESULTS AND DISCUSSION

Here an attempt has been made to evaluate the performance of the Wiamx systems by varying the modulation techniques and AWGN and SUI and Rayleigh, Rician fading channels. To complete this performance analysis in Wimax based systems, a segment of audio signal is used for analysis shown in Fig. 3. The transmitted audio message is found to have retrieved effectively under noisy situation. Here uses 8 bits per
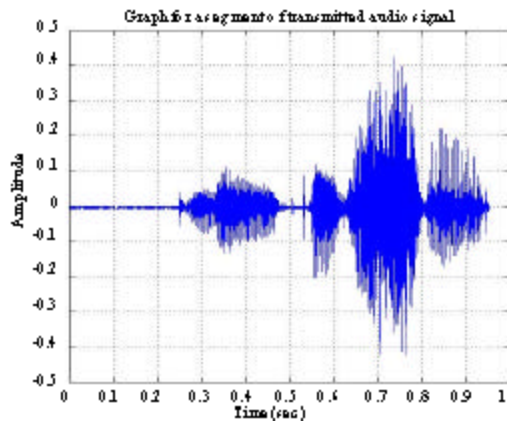
sample at a sampling frequency of 8 kHz. In Fig. 4, the bit error rate performance under QPSK modulation technique over AWGN channel performance is better with 3 dB SNR value is 0.030435 which is much more less than other fading channels SUI and Rayleigh and Rician fading environments. And SUI (1,3) channel performance has almost the same performance of Rayleigh and Rician channel. The bit error rate performance of SUI (3, 4) channel gives better performance to increase SNR value.

In Fig. 5, the Bit Error Rate performance under 16-QAM modulation technique over AWGN channel performance is also better with 7 dB SNR value is 0.00071809 which is much more less than other fading channels SUI and Rayleigh and Rician fading environments. SUI (1,3), SUI (2,4) and Rayleigh and Rician
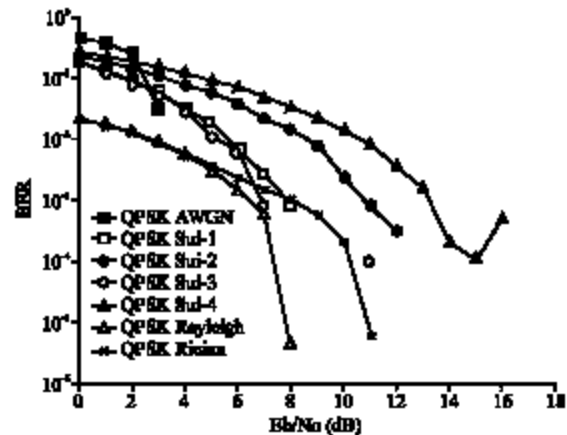

Fig. 4: Bit error rate performance between AWGN and different fading channel models of a ½-rated RS-CC coded under QPSK modulation technique

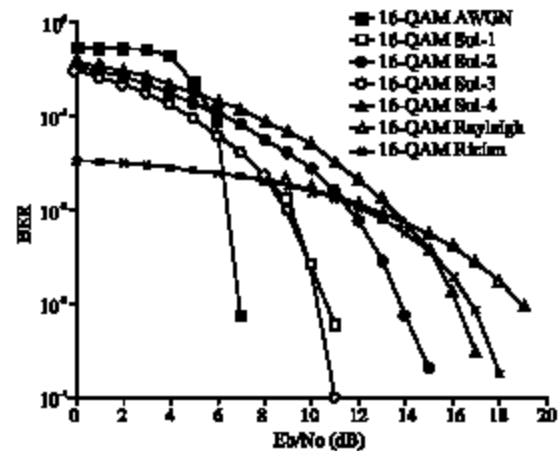Fig. 5: Bit Error Rate Performance between AWGN and different fading channel models of a ½-rated RS-CC coded under 16-QAM modulation technique
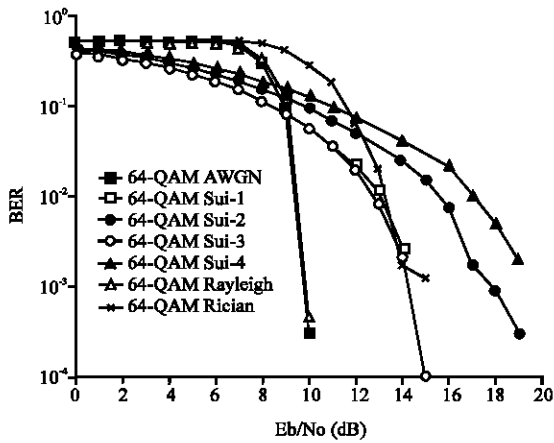

Fig. 3: A segmented of transmitted audio signal

Fig. 6: Bit Error Rate Performance between AWGN and different fading channel models of a ½-rated RS-CC coded under 64-QAM modulation technique

shows almost the same Bit Error Rate performance. In Fig. 6, the Bit Error Rate performance under 64-QAM modulation technique over AWGN channel performance is always better with 10 dB SNR value is 0.00028947. SUI (1, 3) has the same bit error rate performance. The bit error rate performance of SUI-2 is better than SUI-4 channel model. Rician shows the better performance after increasing the Signal to Noise Ratio value.

CONCLUSION

In this study, the performance of the Wimax system in digital audio signal transmission over AWGN channel is comparatively better as compared to Rayleigh and Rician and the variations of SUI fading channels. And it is also observed from the above discussion, the Bit Error Rate performance of QPSK modulation technique is the better than 16-QAM and 64-QAM. In absence of any fading effects, the Quadrature Phase Shift Keying based modulation/demodulation over AWGN scheme shows unique performance in proper identification and retrieval of transmitted audio signal.

The IEEE 802.16 standard comes with many optional PHY layer features, which can be implemented to further improve the performance. The optional Block Turbo Coding (BTC) can be implemented to enhance the performance of FEC. Space Time Block Code (STBC) can be employed to provide transmit diversity.

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