Analysis of Effect of Coding on Performance of Fixed WiMAX Physical Layer

Rajesh Chauhan,
M.Tech Student
Department of Electronics and communication
Swami Devi Dayal Institute of Engineering and Technology, Barwala (Panchkula), Haryana, INDIA

Er Sukhvinder Kaur
Head of Department
Swami Devi Dayal Institute of Engineering and Technology, Barwala (Panchkula), Haryana, INDIA

***Abstract*—Wimax (Worldwide Interoperability for Microwave Access) is an emerging broadband wireless technology for many last few years. The basic need of the next generation of wireless communications technologies (4G) will be multimedia services such as speech, audio, video, image, Internet services, and data at high data rates and with high mobility, high capacity and high QoS. The key features of WiMAX including higher bandwidth, wider range and area coverage, its robust flexibility on application and Quality of Services (QoS) attract the investors for the business scenarios. Many techniques are used to fulfill these requirements. The WiMAX technology has been standardized under IEEE 802.16d for fixed WiMAX technology and Orthogonal Frequency Division Multiplexing (OFDM) is the core of this technology It delivers the maximum range (50 km) and higher data rates (up to 75 Mbps) than Wi-Fi, etc. The aim of this paper is to analyze the effect of FEC(Forward error correction) (an error control mechanism)in channel encoding part of physical layer of fixed WiMAX technology with various modulation techniques in the form of bit-error-rate (BER) Vs E_b/N_o(Bit energy to noise ratio) performance under reference channel models. A MATLAB codes used to simulate for Fixed WIMAX standard.**

Keywords (forward error correction, WiMAX, physical layer, coding)

I. INTRODUCTION

Broadband Wireless Access (BWA) has emerged as a promising solution for last MILE ACCESS technology to provide high speed internet access in the residential as well as sized enterprise sectors. The IEEE WiMAX/802.16d is FIXED WiMAX standard for broadband wireless metropolitan area networks (WMANs) can deliver high throughput over long distances, support different qualities of services, offers a wireless backhaul network that enables high speed internet access to residential, and medium business customers. The basic two layers in IEEE 802.16 are the MAC and the physical (PHY) layers. The PHY layer Combines OFDM Orthogonal Frequency Division Multiplexing and uses multiple inputs multiple output antenna technology with an adaptive coding and Modulation schemes. WiMAX standard that supports fixed non-line of sight (NLOS) wireless internet services thus forming a point to multipoint deployment scenario. The IEEE 802.16d standard operates on 2-11 GHz frequency band for non line of sight (NLOS). The scale for bandwidth channel flexibility starts from 1.25 MHz up to 20 MHz with channel bandwidth(can be integer multiple of 1.25MHz). Four schemes to modulate the transmitted bits have been used are *BPSK, QPSK, 16-QAM, 64-QAM*. The aim of this paper is to analyze the effect of Error control mechanism which able us to transmit the data in WIMAX with low bit error rate and high efficient data under noisy area using Forward Error Correction method as Reed Solomon code and Convolution code. A suitable selection of FEC coding will make sure the robustness of the channel to the random errors. Effect of FEC is analyzed by comparing the (Bit error rate) BER Vs E_b/N_o (Bit energy to noise ratio) curves. According to the growth of multimedia services and the demand of Internet is to increasing interest in high speed communications. The requirement of wide bandwidth and flexibility improve the use of efficient transmission methods which fits the features of wideband channels basically in wireless environment in which the channels are very challenging. BWA is used due to its wireless nature, it is faster, easier to scale and more flexible.

II. SIMULATION MODEL

The baseband transmitter/Receiver having major parts as shown below:

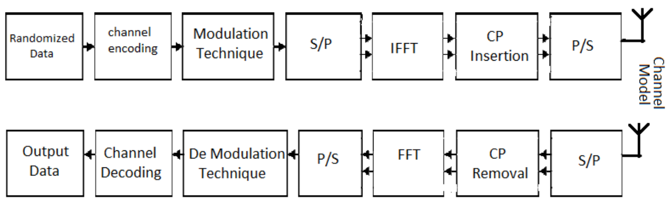
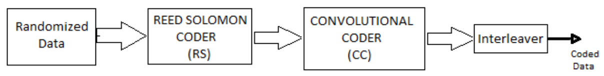
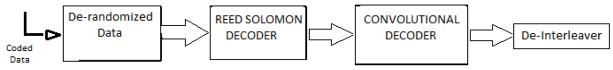


Figure 1: WiMAX Transmitter and Receiver.

The design of the simulated transmitter and receiver for the WiMAX OFDM based PHY layer. This design is based on the physical layer of the IEEE 802.16d WIMAX OFDM air interface. In the physical layer of the IEEE 802.16d, the channel coding is done in three steps namely (i) data randomization, (ii) Forward Error Correction (FEC) and (iii) interleaving. The FEC is done in two phases: the outer phase is implemented by using a Reed-Solomon (RS) coder and the inner phase is implemented by a convolutional coder (CC) as shown in firure1.1 below



(i) Channel Encoding



(ii) Channel Decoding

Figure 2: Channel Coding and Decoding.

The input data is generated using a pseudo random binary sequence generator and information bit length is according to the type of modulation scheme used. The randomized data after arranging in blocks format passed through Reed Solomon encoder and make them able for application where error accurs in brust. The Reed Solomon error correction is coding technique which takes the input data in form blocks and then first construct a polynomial from data and then send an over sampled version of that polynomial. A Reed Solomon code specified as RS(N,K,T). Where, k is no. of data symbol taken is the no. of data bytes that can correct and N is no. of data bytes after encoding (length of codeword). The encoder support shortened and punctured code to facilitate variable block sizes and variable error correction capability. Convolutional codes are proves good for random error correction. A convolutional code is a type of FEC code that is specified by CC (m, n), in which each m-bit information symbol to be encoded is transformed into an n-bit symbol, where m/n is the code rate (n>m) and the transformation is a function of the last k information symbols, where k is the constraint length of the code .The block sizes and code rates used in the modulations in WiMAX systems as specified in IEEE 802.16 standard are shown

Table 1 Coding Block size for different modulation schemes

modulation	Uncoded block size (bytes)	Coded block size (bytes)	Overall code rate	RS Code (RS)	CC code rate
BPSK	12	24	1/2	(12,12,0)	1/2
QPSK	24	48	1/2	(32,24,4)	2/3
QPSK	36	48	3/4	(40,36,2)	5/6
16-QAM	48	96	1/2	(64,48,8)	2/3
16-QAM	72	96	3/4	(80,72,4)	5/6
64-QAM	96	144	2/3	(108,96,6)	3/4
64-QAM	108	144	3/4	(120,108,6)	5/6

The Interleaver provides two steps. The first step is that adjacent coded bits are mapped into nonadjacent sub carriers. The second is that adjacent coded bits are mapped alternately onto less or more significant bits, which avoiding long runs of unreliable bits. The Matlab function matintrlv performs for interleaving and matdeintrlv performs for de-interleaving. IFFT produce a time domain signal, where the symbols obtained after modulation is used as amplitudes of a certain range of sinusoids. A cyclic prefix (CP) is added to the time domain samples to combat the effect of multipath. Four different interval of CP is available in that standard. At the receiver where receives the data by using FFT in which it converts the signal into the frequency domain and then demodulated according to the block diagram. Then cyclic prefix is removed and receive the original signal for further processing of FFT. The FFT transforms is a cyclic time domain signal of its equivalent frequency spectrum. The pilot carrier is removed to use the retrieved signal in parallel form. Now for demodulation these are converted into serial bit stream and passed to the demodulator. The output of demodulator received in the form of symbols. So it is converted into original bits. The interleaved data also regain in its original order and the deinterleaved data is further passed on to Viterbi decoder. Then the received output signal used for computing BER from the simulations and comparing various techniques. The BER is calculating by the received bits which are altered due to noise and distortion, divided by the transferred bits during a time interval. We have implemented and conducted the simulations in MatLab. The main program contains initialization parameters and input data. The parameters that can be set at the time of initialization are the number of simulated OFDM symbols, CP length, modulation, the range of SNR values, and SUI-1 channel model for simulation. Some of the simulation parameters are listed in Table2

Table 2 Initial Parameters

Parameters	Values
No. of Symbols	192
Bandwidth	5 MHz
Cyclic Prefix	1/8
Modulation	BPSK, QPSK,16-QAM,64-QAM
Channels	SUI-1
Coding	With FEC, Without FEC

II.SIMULATION RESULTS

The WIMAX model based on simulated using BPSK, QPSK, QAM 16, QAM 64, modulation techniques. The graphs between bit error rate (BER) and bit energy to noise ratio (E_b/N_o) are plotted in each case. Our aim is to show how much system performance will degrade without using FEC. The graphs are plotted under two conditions (i) with FEC, means by using forward error control coding mechanism and (ii)NO FEC, means without using FEC i.e. data is directly mapped without coding. The following graph shows the simulated results of WIMAX based OFDM system with various modulation and coding profiles. The simulations implemented are all done in MATLAB.

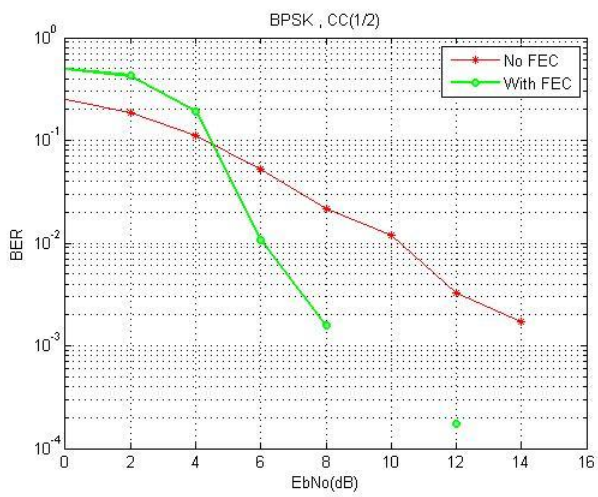


Figure3: BER Vs E_b/N_o for BPSK.

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It is clear from the figure 3 that in case of BPSK effect of using FEC, bit error is reduced to a significant value at 8 dB level of E_b/N_o.

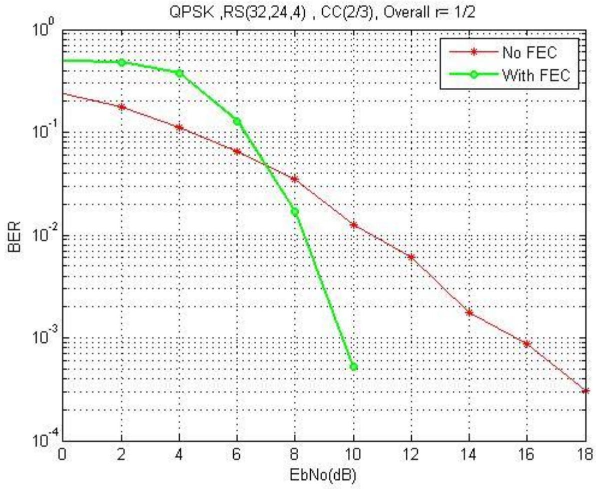

Figure 4: BER Vs E_b/N_o for QPSK,RS(32,25,4),CC(2/3),Overall r=1/2.

Also in the case of QPSK as shown in figure 4 and figure 5 there is better performance of the system if we use forward Error correction mechanism in comparison of without using FEC. The figure 6 and figure 7 shows the result of BER curves for 16 – QAM at the difference of RS , convolutional code CC and overall code rate, we observe that bit error is reduced at the high E_b/N_o level. Figure 8 and figure 9 shows that there is significant reduction in bit error rate due to FEC, at higher value of Eb/N_o .

Table 3 shows the values of bit error rate at the different Bit energy to noise ratio levels for all modulation techniques and coding profiles as shown in table 1, by which we are able to analyze the effect of forward Error mechanism.

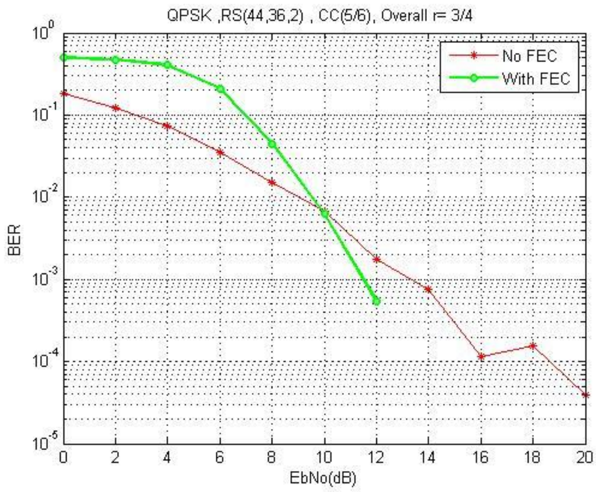

Figure 5: BER Vs E_b/N_o for QPSK,RS(34,36,2),CC(5/6),Overall r=3/4.

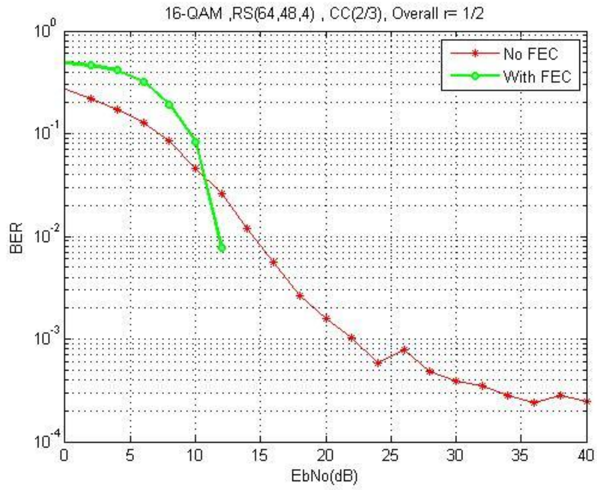

Figure 5: BER Vs E_b/N_o for 16-QAM,RS(64,48,4),CC(2/3),Overall r=1/2.

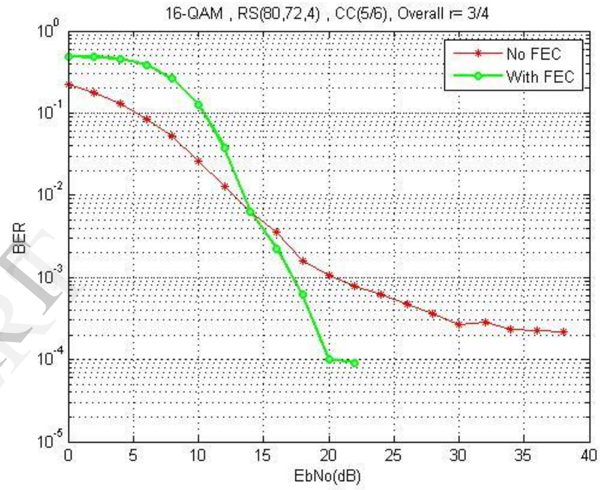

Figure 6: BER Vs E_b/N_o for 16-QAM,RS(80,72,4),CC(5/6),Overall r=3/4.

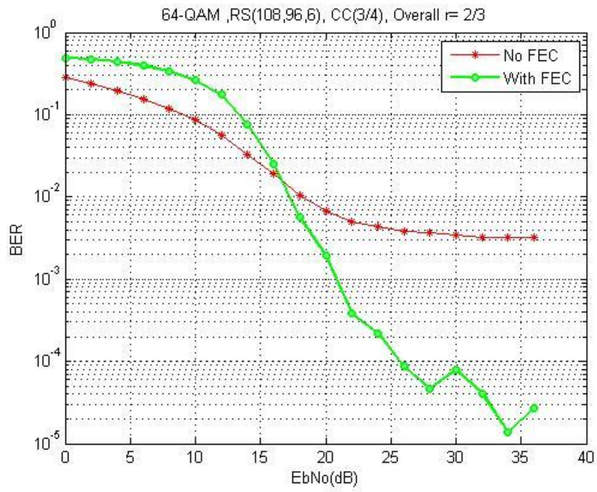

Figure 7: BER Vs E_b/N_o for 64-QAM,RS(108,96,6),CC(3/4),Overall r=2/3.

Table 3: comparison of BER Values

Modulation and Coding Scheme	No FEC	With FEC	Reduction In BER Value
BPSK CC(1/2) BER Values at 8db level of E_b/N_o.	0.02604	0.00034	0.02564
QPSK ,RS(32,24,4) , CC(2/3), Overall r= ½ BER Values at 10db level of E_b/N_o.	0.0124	0.00052	0.12348
QPSK ,RS(44,36,2) , CC(5/6), Overall r= 3/4 ER Values at 12db level of E_b/N_o.	0.00540	0.00173 6	0.0036
16-QAM ,RS(64,48,4) , CC(2/3), Overall r= 1/2 BER Values at 12db level of E_b/N_o.	.02635	0.0076	0.2559
16-QAM , RS(80,72,4) , CC(5/6), Overall r= 3/4 BER Values at 20db level of E_b/N_o.	0.00107 5	0.00101 3	.00006
64-QAM ,RS(108,96,6), CC(3/4), Overall r= 2/3 BER Values at 20db level of E_b/N_o.	0.00617	0.00196 1	0.0042

It is observed from the above table analysis that as the Modulation Level and coding rate increases the effect of error control coding is less significant. That is higher the modulation less is forward error control mechanism effective. Also to have the advantage of forward error control mechanism for higher modulation level large bit energy to noise ratio (E_b/N_o) is required as shown in table.

IV.CONCLUSION

In this paper the IEEE 802.16d physical layer has been investigated under different modulation schemes and also under different SUI-1 channel conditions. Both cases coded with FEC and without FEC coding systems have been investigated in this paper. In general the simulation results show that a coded system outperforms without coding system above a certain level of E_b/N_o. But, this level depends on the modulation scheme and coding profile used conditions. It has also been shown that a coded system may not outperform an uncoded system even at a very high E_b /N_o. For example, 16-QAM and 64-QAM do not show any improvement in coded system compared to without coded system. But, BPSK and QPSK modulation does.

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