ISSN : 2278 – 1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 1, Issue 6, August 2012

Performance Analysis of Wimax System by Increasing Capacity Using Various Compression Techniques

Anuradha.R.kondelwar[1], Dr.K.D.Kulat[2]

Assistant professor, Priyadarshini College of Engineering, Nagpur, India[1]

Professor& HOD, Dept. Of Electronics, Visvesvaraya National Institute of Technology, Nagpur, India[2]

Abstract*—With the tremendous increase in wireless technology and wireless services in the last few decades has put forward the need of an efficient wireless technology that provides high data rates. WiMAX is a promising wireless transmission technology that offers both fixed and mobile broadband wireless accesses, based on methods defined in 802.16 IEEE standards. IEEE 802.16 (WiMAX) standard presents specifications for fixed Line of sight (LOS) communication in the range of 10-66GHz (802.16c), as well as for fixed, portable, Non-LOS communication in the range of 2-11GHz (802.16a, 802.16d). This paper presents an extensive study of WiMAX system. For increasing the capacity in proposed wimax system different data compression techniques are used.The proposed modification to the WiMAX system is tested under AWGN channel. The results show that the proposed modifications in the system increases the SNR, channel capacity, better link reliability and throughput of the system.

Keywords—**Fixed broadband wireless access point, Physical layer, MAC Layer, WAN, MAN, BWA, WiMAX, Quality of Service(QoS), OFDM**

I. INTRODUCTION

WiMAX (Worldwide Interoperability for Microwave Access) was defined by the WiMAX Forum, formed in June 2001 to promote conformance and interoperability of the IEEE 802.16 standard, officially known as Wireless MAN [1]. WiMAX is an access technology that allows higher data rates of about 1Gbps or more over long distances, efficient bandwidth use and lessened interference.

IEEE 802.16 Working Group began developing technologies for wireless metropolitan networks in 2000, published their first standard in 2002 for line-of-sight connectivity in 10-66 GHz frequency band (IEEE 802.16c). Applications of this standard included includes point to point (PPP) and point to multi point (PMP) microwave communication, interconnection between remote locations and backhaul services. This group then extended the standard for use in the lower frequency range of 2-11 GHz which allowed for non-line-of- sight (NLOS) connectivity (IEEE 802.16a). This was updated in 2004 (IEEE 802.16d) for lower frequencies of 2-11 GHz range, targeted to provide a broadband internet connection to indoor users.

In 2005 an amendment to 802.16-2004 was made to address mobility. This WiMAX[1] 802.16e standard in the range of 2-6 GHz implemented a number of enhancements to 802.16-2004, including better support for Quality of Service and the use of Scalable OFDMA (orthogonal frequency-division multiple access) as opposed to the OFDM, and is often referred to as Mobile WiMAX[5].

The 802.16 standard effectively standardizes two characteristics of the air interface - the PHY (physical) layer and the MAC (Media Access Control) layer.

1. MAC Layer

The main focus is to efficiently handle resources of the airlink. This layer further consists of three sub-layers:

- Service specific convergence sub-layer (SSCS) – It provides an interface to upper layer entities through a CS service access point (SAP).
- The MAC common part sub-layer (CPS) - It serves the core MAC functions. This sub layer further includes uplink scheduling, bandwidth request and grant, connection control, and automatic repeat request (ARQ).

ISSN : 2278 – 1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 1, Issue 6, August 2012

- Privacy sub-layer (PS) – It provides the key feature of data encryption and authentication.\

2. PHY Layer

- This standard specifies the air interface for a fixed point-to-multipoint broadband wireless access (BWA) system, thus catering multiple services in a wireless MAN. In addition it defines optional mesh topology enrichment to the MAC layer.
- For 10–66 GHz air interface this standard specifies a single-carrier modulation, known as WirelessMAN-SC air interface.
- For below 11 GHz frequencies, the WirelessMAN-SCa, WirelessMAN-OFDMA & Wireless-MAN-OFDM air interfaces are specified.

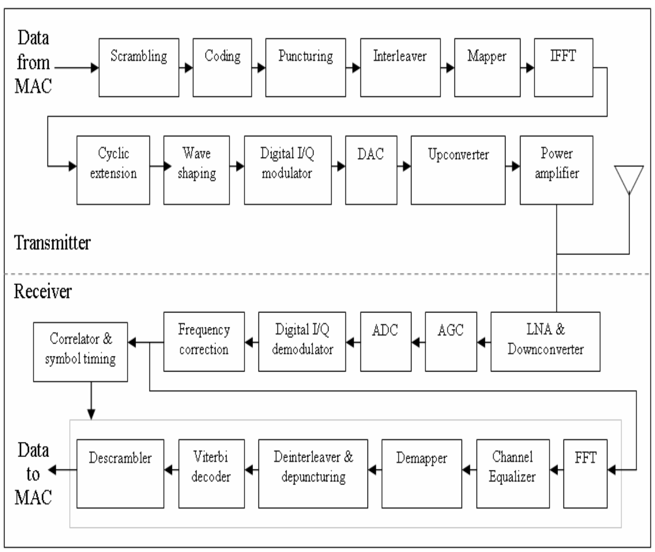


Figure 1: OFDM transceiver block diagram

IEEE 802.16m is under development as the future amendment of IEEE 802.16-2004 and IEEE802.16e-2005. This standard amends the IEEE 802.16 Wireless MAN-OFDMA specification to provide an advanced air interface for operation in licensed bands with data rates reaching 1Gbps for fixed applications and 100Mbps for mobile applications. IEEE 802.16m will be backward compatibility to previous WiMAX standards[2][6].

II. WIRELESSMAN-OFDM SYSTEM

OFDM (Orthogonal Frequency Division Multiplexing) is a multi-carrier transmission scheme where the information is transmitted on multiple subcarriers, with a lower data rate, instead of one high data rate carrier. Further the subcarriers are orthogonal to each other resulting in saving of bandwidth.

General OFDM transceiver[7] comprises two main blocks, transmitter and receiver, which are separated by a duplexer (TDD, FDD or half-duplex) as in Figure 1. At transmitter end the information goes through channel coding composed of randomization, forward error correction (FEC), and interleaving. The randomizer pseudorandomly scrambles the transmitted bit sequence thus generating a pseudorandom bit sequence (PRBS) which eliminates any possibility of transmitting series of all ones or zeros for a long period of time, facilitating automatic gain control. FEC helps to correct the errors in subcarriers to some extent by concatenating an outer Reed–Solomon encoder with an inner rate compatible convolutional encoder. The interleaver rearranges the subcarriers so as to uniformly distribute the burst errors at the demodulation input, by taking dual permutation. After channel coding, data bits are mapped and modulated onto the allocated subcarriers by QPSK, 16–QAM and 64–QAM modulation. Subsequently, data are transmitted by OFDM method. At the receiver side, the operations carried out at transmitter side are carried out in a reverse order.

An OFDM symbol consists of a series of subcarriers (in frequency domain). In Wireless MAN–OFDM PHY specification there are 256 subcarriers, categorized into three types as: 192 data subcarriers carrying payload, 8 pilot subcarriers mainly for channel estimation, and 56 null subcarriers for guarding purpose as shown in Figure 2 below. The pilot subcarriers distribute evenly among the data subcarriers which gives the standard symbol in frequency domain.

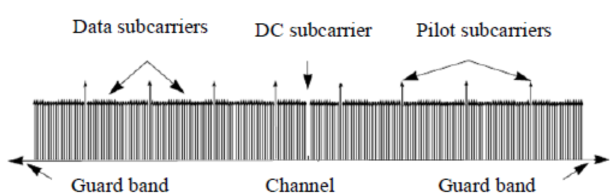


Figure 2: OFDM symbol frequency domain representation [3]

An ‘N’ point inverse discrete fourier transform (IDFT) of ‘X(k)’is defined as below, which is equivalent to generation of OFDM symbol

$$x(n) = \frac{1}{N}\sum_{n=0}^{N-1} X(k)\, e^{j\frac{2k\pi n}{N}} \qquad (1)$$

ISSN : 2278 – 1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 1, Issue 6, August 2012

An efficient way of implementing IDFT is by inverse fast fourier transform (IFFT). Hence IFFT is used in generation of OFDM symbol. The addition of cyclic prefix is done on the time domain symbol obtained after IFFT. The SNR at the receiver in dB is calculated using:

$$SNR_r = P_r - log(B) - N_f - N_o \qquad (2)$$

where B is the effective channel bandwidth in Hz, N_f the noise figure in dB and No the thermal noise level in dBm. B in above equation represents the channel bandwidth specifically used for information transmission in an OFDMA system.

$$B = F_s\, N_{used} / N_{FFT} \qquad (3)$$

where F_s is the frequency sampling, N_{used} is the number of data sub-carriers, N_{FFT} is the FFT size.

III. PROPOSED WIMAX SYSTEM

We know that as we go on increase data rate BER increases.But in high data rate wireless transmissions we need to transmit huge data in less time for that we need to increase capacity. In our proposed system we are increasing capacity by compressing data so that more data can be transmitted in less time. The proposed WiMAX system is as shown in Figure 4(a) & (b).The input data sequence is encrypted using AES (Advanced Encryption Standard), then given to the compression block. Different compression algorithms are employed such as RLE, Huffman, DCT, DWT and Lempel–Ziv–Welch (LZW). This compressed data is then given to normal WiMAX transmitter. In this case two transmitting and two receiving antennas are used. The reverse is followed at the receiver side as in figure 4(b). The Encryption and different compression standards used are discussed below:

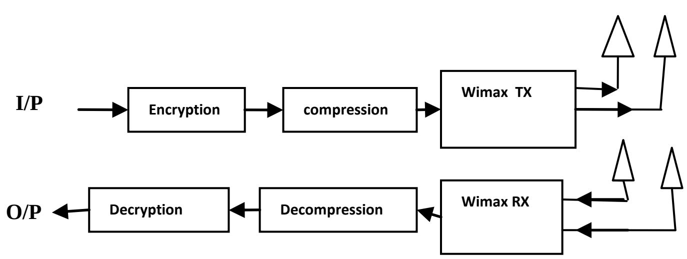


Figure 4(a) & 4(b): Proposed WiMAX Transmitter &receiver.

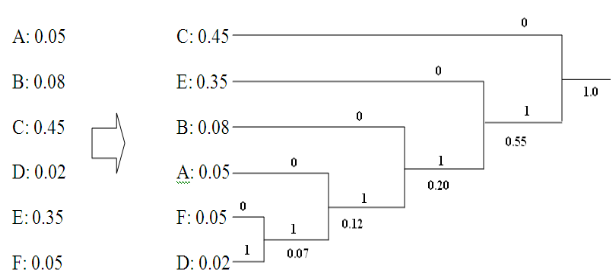
- ***Advanced Encryption Standard (AES)***

AES supersedes DES. AES is a symmetric-key algorithm i.e., it uses the same key is used for both encrypting and decrypting the data. AES has a fixed block size of 128 bits and a key size of 128, 192, or 256 bits. In AES first the round keys are derived from the cipher key using Rijndael's key schedule [4][8]. Then each byte of the state is combined with the round key using bitwise XOR. After this a non-linear substitution step is performed where each byte is replaced with another according to a lookup table. Followed by a transposition step where each row of the state is shifted cyclically a certain number of steps. Finally a mixing operation is performed which operates on the columns of the state, combining the four bytes in each column.

Compression Techniques:

- ***Huffman Encoding***

Huffman coding is an entropy encoding algorithm developed by David A. Huffman 1952, used for lossless data compression. In huffman coding a variable-length code table is first derived based on the estimated probability of occurrence for each possible value of the source symbol. Then this table is used to encode the source symbols. Consider an example[9] where source generates 6 symbols {A, B, C, D, E, F} with probabilities {0.05; 0.08; 0.45; 0.02; 0.35; 0.05} respectively.



The huffman code: A - 1110, B - 110, C - 0, D - 11111, E - 10, F – 11110

Applications:

ISSN : 2278 – 1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 1, Issue 6, August 2012

Arithmetic coding can be viewed as a generalization of Huffman coding, in the sense that they produce the same output when every symbol has a probability of the form $1/2^k$; in particular it tends to offer significantly better compression for small alphabet sizes. Huffman coding nevertheless remains in wide use because of its simplicity and high speed. Arithmetic coding can offer better compression than Huffman coding because its "code words" can have effectively non-integer bit lengths, whereas code words in Huffman coding can only have an integer number of bits. Therefore, there is an inefficiency in Huffman coding where a code word of length k only optimally matches a symbol of probability $1/2^k$ and other probabilities are not represented as optimally; whereas the code word length in arithmetic coding can be made to exactly match the true probability of the symbol.

Huffman coding today is often used as a "back-end" to some other compression methods. DEFLATE (PKZIP's algorithm) and multimedia codec's such as JPEG and MP3 have a front-end model and quantization followed by Huffman coding (or variable-length prefix-free codes with a similar structure, although perhaps not necessarily designed by using Huffman's algorithm.

- ***Run-length Encoding***

Run-length encoding is a very simple data compression technique in which runs of data i.e., sequences in which the same data value occurs in consecutive data elements are stored as a single data value and count, rather than as the original run. Consider a 15-character string with four different character runs as shown below. This string without RLE would require 15 bytes to represent the string.

BBBBBBBaaaaXXXy

After applying RLE we get,

7B4a3X1y

Thus, after run-length encoding, the 15-byte string would require only 8 bytes to represent the string yielding a compression ratio of almost 54%.

Applications:

Run-length encoding performs lossless data compression and is well suited to palette-based iconic images. It does not work well at all on continuous-tone images such as photographs, although JPEG uses it quite effectively on the coefficients that remain after transforming and quantizing image blocks.

Common formats for run-length encoded data include Truevision TGA, PackBits, PCX and ILBM.This technique is based on fourier transform.

Run-length encoding is used in fax machines (combined with other techniques into Modified Huffman coding). It is relatively efficient because most faxed documents are mostly white space, with occasional interruptions of black.

- ***Lempel–Ziv–Welch (LZW)***

Lempel–Ziv–Welch[8] is a lossless data compression algorithm created by Abraham Lempel, Jacob Ziv, and Terry Welch in 1984. It encodes sequences of 8-bit data as fixed-length 12-bit codes. In LZW a dictionary is initialized to contain the single-character strings corresponding to all the possible input characters. Then the longest string W in the dictionary is found that matches the current input. The dictionary index for W is given as output and W is removed from the input. Then add W followed by the next symbol in the input to the dictionary. Then the process is repeated.

Applications:

LZW compression became the first widely used universal data compression method on computers. A large English text file can typically be compressed via LZW to about half its original size.

LZW was used in the public-domain program compress, which became a more or less standard utility in Unix systems circa 1986. It has since disappeared from many distributions, both because it infringed the LZW patent and because gzip produced better compression ratios using the LZ77-based DEFLATE algorithm, but as of 2008 at least FreeBSD includes both compress and uncompress as a part of the distribution. Several other popular compression utilities also used LZW, or closely related methods.

LZW became very widely used when it became part of the GIF image format in 1987. It may also (optionally) be used in TIFF and PDFfiles. (Although LZW is available in Adobe Acrobat software, Acrobat by default

ISSN : 2278 – 1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 1, Issue 6, August 2012

uses DEFLATE for most text and color-table-based image data in PDF files.)

- ***Discrete cosine transform(DCT):***

A **discrete cosine transform** (**DCT**) expresses a sequence of finitely many data points in terms of a sum of cosine functions oscillating at different frequencies. DCTs are important to numerous applications in science and engineering, from lossy compression of audio (e.g.MP3) and images (e.g. JPEG) (where small high-frequency components can be discarded), to spectral methods for the numerical solution of partial differential equations. The use of cosine rather than sine functions is critical in these applications: for compression, it turns out that cosine functions are much more efficient (as described below, fewer functions are needed to approximate a typicalsignal), whereas for differential equations the cosines express a particular choice of boundary conditions.

In particular, a DCT is a Fourier-related transform similar to the discrete Fourier transform (DFT), but using only real numbers. DCTs are equivalent to DFTs of roughly twice the length, operating on real data with even symmetry (since the Fourier transform of a real and even function is real and even), where in some variants the input and/or output data are shifted by half a sample. There are eight standard DCT variants, of which four are common.

The most common variant of discrete cosine transform is the type-II DCT, which is often called simply "the DCT", its inverse, the type-III DCT, is correspondingly often called simply "the inverse DCT" or "the IDCT". Two related transforms are the discrete sine transform (DST), which is equivalent to a DFT of real and *odd* functions, and the modified discrete cosine transform (MDCT), which is based on a DCT of *overlapping* data.

Applications:

The DCT, and in particular the DCT-II, is often used in signal and image processing, A related transform, the modified discrete cosine transform, or MDCT (based on the DCT-IV), is used in AAC, Vorbis, WMA, andMP3 audio compression. DCTs are also widely employed in solving partial differential equations by spectral methods, where the different variants of the DCT correspond to slightly different even/odd boundary conditions at the two ends of the array. DCTs are also closely related to Chebyshev polynomials, and fast DCT algorithms (below) are used in Chebyshev approximation of arbitrary functions by series of Chebyshev polynomials,

- ***Discrete wavelet transform(DWT):***

In numerical analysis and functional analysis, a **discrete wavelet transform**(DWT) is any wavelet transform for which the wavelets are discretely sampled. As with other wavelet transforms, a key advantage it has over Fourier transforms is temporal resolution: it captures both frequency *and* location information (location in time).

Applications:

The discrete wavelet transform has a huge number of applications in science, engineering, mathematics and computer science. Most notably, it is used for signal coding, to represent a discrete signal in a more redundant form, often as a preconditioning for data compression. Practical applications can also be found in signal processing of accelerations for gait analysishttp://en.wikipedia.org/wiki/Discrete_wavelet_transform_-_cite_note-5, in digital communications and many others.

It is shown that discrete wavelet transform (discrete in scale and shift, and continuous in time) is successfully implemented as analog filter bank in biomedical signal processing for design of low-power pacemakers and also in ultra-wideband (UWB) wireless communications[3].

IV.RESULTS

The proposed system for WiMAX is analyzed using AES encryption algorithm, different compression techniques in Gaussian noise (AWGN) channel environment. Figure 5 below shows the results of the proposed system under AWGN channel. It can be seen that the proposed system has better SNR as compared with the normal WIMAX system, for example as in figure 5(a) for AES+DWT in AWGN channel, the BER of the proposed system is 0.6 for 5dB SNR, whereas for normal WiMAX system it is 1.5 approximately. The same can be observed from figure 5(b) 5(c), 5(d), 5(e).The Table 1 shows the comparison of results obtained for different combinations.

ISSN : 2278 – 1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 1, Issue 6, August 2012

V. CONCLUSION

An extensive study of WiMAX system has been presented in this paper. The proposed modification to the normal WiMAX system includes encryption ,compression. The reverse is used at the receiver end. The proposed system is tested under AWGN channel. It is concluded from the results that the proposed modified WiMAX system provides good SNR,channel capacity, reliability and throughput as compared to the normal WiMAX system.

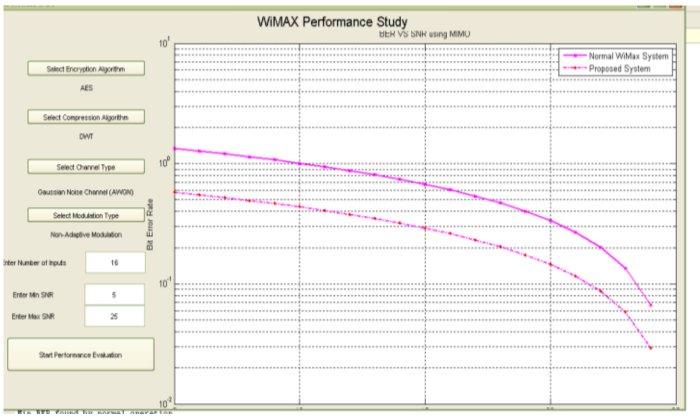


Figure 5(a): AES+DWT under AWGN channel

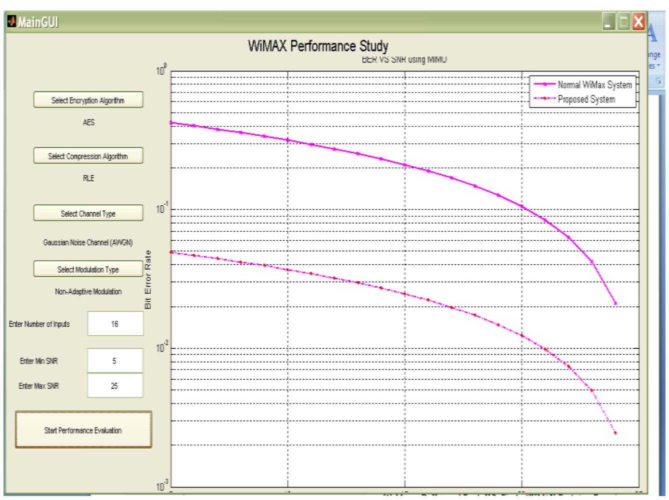


Figure 5(b): AES+RLE under AWGN channel

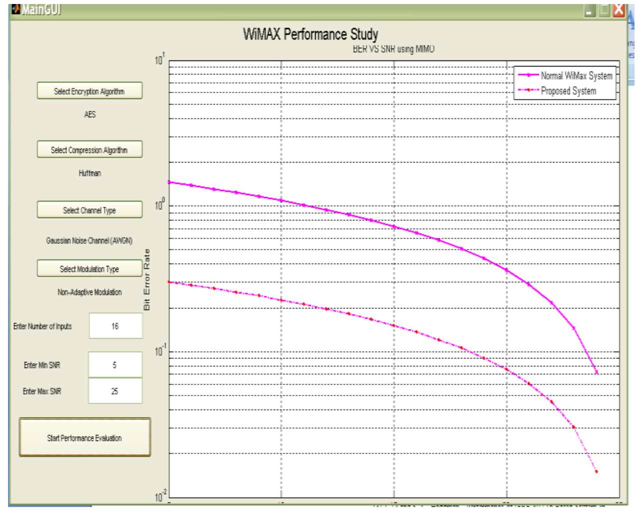


Figure 5(c): AES+Huffman under AWGN channel

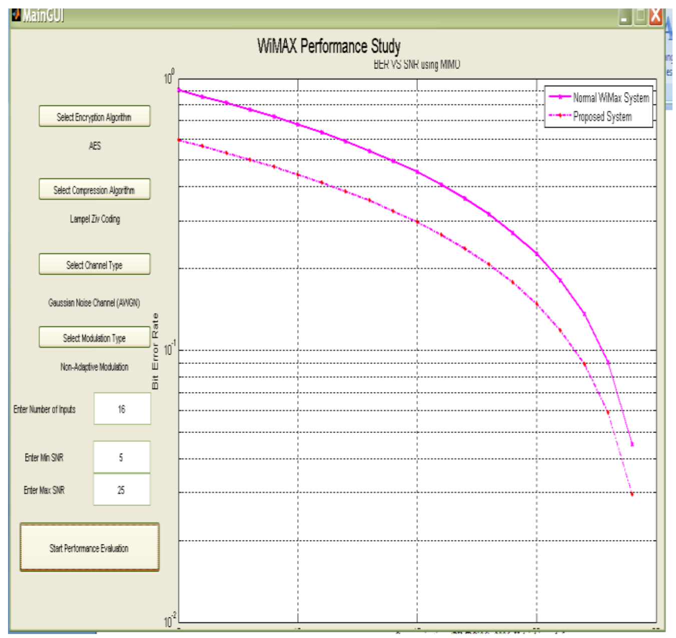


Figure 5(d): AES+ LZW under AWGN channel

ISSN : 2278 – 1021

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 1, Issue 6, August 2012

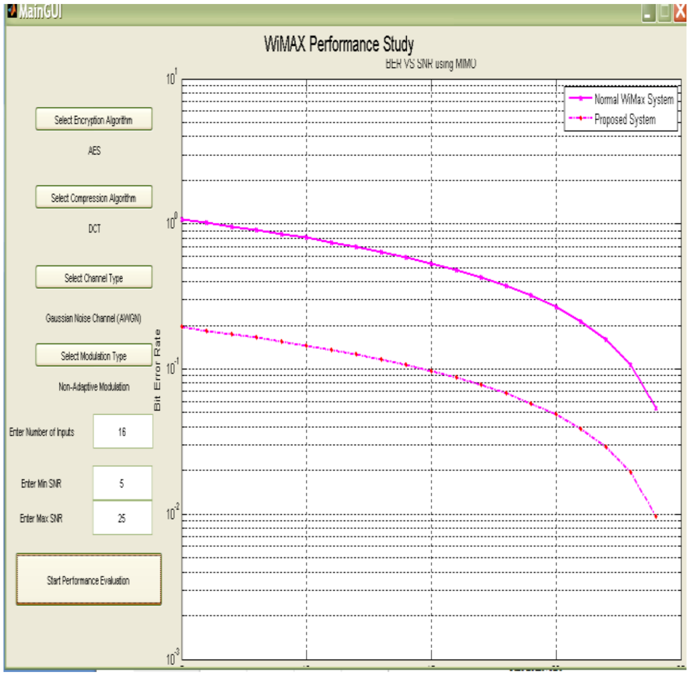


Figure 5(e): AES+DCT under AWGN channel

Table 1: Comparison of BER results at 5 db SNR

AWGN Channel			
Wimax System		Proposed	Normal
Encryption + compression	AES+DWT	0.6	1.5
	AES+RLE	0.05	0.425
	AES+ Huffman	0.3	1.5
	AES+LZW	0.6	0.9
	AES+DCT	0.2	1.1

REFERENCES

[1] Shaffatul Islam, Mamunur Rashid and Mohammed Tarique, "Performance Analysis of WiMax/WiFi System under Different Codecs", International Journal of Computer Applications (0975 – 8887) Volume 18–No.6, March 2011

[2] R. Kumar Jha, Dr U. D. Dalal "A Journey on wimax and its security issues," (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 1 (4) , 2010, 256-263Electronics and Communication Engineering Department, SVNITSurat, Gujarat, India.

[3] A.N. Akansu, W.A. Serdijn, and I.W. Selesnick, Wavelet Transforms in Signal Processing: A Review of Emerging Applications, Physical Communication, Elsevier, vol. 3, issue 1, pp. 1-18, March 2010.

[4] Christof Paar, Jan Pelzl, "The Advanced Encryption Standard", Chapter 4 of "Understanding Cryptography, A Textbook for Students and Practitioners". (companion web site contains online lectures on AES), Springer, 2009

[5] Marcos D. Katz and Frank H.P. Fitzek, "WiMAX Evolution: Emerging Technologies and Applications", 2009 John Wiley & Sons Ltd

[6] J. G. Andrews, A. Ghosh and R. Muhamed, "Fundamentals of WiMAX Understanding Broadband Wireless Networking," Prentice-Hall, Upper Saddle River, 2007.

[7] S. H. Ali, K.-D. Lee, and V. C. Leung, \Dynamic resource allocation in OFDMA wireless metropolitan area networks [radio resource management and protocol engineering for IEEE 802.16]," IEEE Wireless Communications, vol. 14, pp. 6{13, February 2007.

[8] http://en.wikipedia.org/wiki/Advanced_Encryption_Standard

[9] David Salomon, *Data Compression – The complete reference*, 4th ed., page 209,212

Biography

Anuradha.r.Kondelwar is working as Asst. professor at Priyadarshini college of engineering,Nagpur, Maharashtra. She is pursuing PhD on the research topic "Wimax system performance studies" under the guidance of Dr.K.D.Kulat,Professor,VNIT,Nagpur.

Dr.K.D.Kulat is working as Professor at VNIT ,Nagpur, Maharashtra.He is HOD of electronics department. Many students are doing PhD under his valuable guidance.