BER IMPROVEMENT IN OFDM USING CODING TECHNIQUES

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ABSTRACT

In the last decade, Orthogonal Frequency Division Multiplexing (OFDM) based communication systems have been identified as one of the key transmission techniques for next generation wireless communication systems. The main objective is to transmit the OFDM signal with low bit error rate in the noisy environment. A cyclic prefix acts as a buffer region where delayed information from the previous symbols can get stored. Different modulation technique with respect to bit-error rate and SNR ratio is analyzed using MATLAB software. Here the performance of OFDM signal is analyzed by comparing the BER results of coding technique such as convolution [1]. As well various modulation methods are also used. Two decoding methods are used to analyze the signal. One is soft decoding and other is hard decoding with convolution code. Three types of modulation methods are used with normal OFDM to analyze the system performances which are Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK), and Quadrature Amplitude Modulation (QAM)[2]. The goal of this paper is to improve system performance by the mean of low bit error rate. Finally bit error rate of these three methods are analyzed by comparing SNR versus BER plots. Soft decoding method in convolution with high code rate gives better BER performance.

Keywords: OFDM, Convolution Code, Error detection, Error correction code, cyclic prefix, SNR, QPSK, BPSK, QAM, and BER

I INTRODUCTION

OFDM belongs to a family of transmission schemes called multicarrier modulation, which is based on the idea of dividing a given high-bit-rate data stream into several parallel lower bit-rate streams and modulating each stream on separate carriers often called subcarriers. Orthogonal frequency division multiplexing (OFDM) system has been proposed as a technique for broadcasting digital signals and for wireless communication. The bit-error-rate (BER) performance of the OFDM system is severely affected by the nonlinearity of the high power amplifier and by the impairments like noise. To reduce these effects caused by impairments, error rate of signal should be low and that can be obtained by FEC technique. Moreover, simulation results are presented to validate the analysis. It is shown that the resulting inter-carrier interference (ICI) due to noise generated by these impairments becomes very significant in a multi-hop relaying communication system, and severely degrades the BER performance of the system. Practical results show perfect agreement with those obtained by simulation. Three types of modulation methods with and without FEC techniques are used to analyze the system performances which are Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK) and Quadrature Amplitude Modulation (QAM). Out of two scenarios i.e. with FEC and without FEC, both the methods are analyzed by using three modulation techniques. In this paper bit error rate of three modulation methods without FEC is compared to achieve the goal. This paper is organized as follows. In section II a whole system is described. Out of that implemented results are described in section IV. OFDM system using the BPSK, QPSK, QAM modulation method is described. Then, its exact BER performance is investigated based on the channel noise for OFDM system without FEC. Numerical results are plotted to analyze an OFDM with Convolution Code and finally, conclusions are provided in Section V.

II OFDM WITH AND WITHOUT FEC

Coding techniques is used for providing reliable information through the transmission channel to the user. In coding techniques the number of symbols in the source encoded message is increased in a controlled manner in order to facilitate two basic objectives at the receiver one is Error detection and other is Error correction.[2] 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 (SNR). In digital communication, coding techniques is a broadly used term mostly referring to the forward error correction code. The advantage of forward error correction is that a feedback-channel is not required, or that retransmission of data can often be avoided, at the cost of higher bandwidth requirements on average. This project is useful to get less number of errors in OFDM by using convolution coding scheme for different modulation technique with respect to bit-error rate and SNR ratio. In order to improve the error performance of the OFDM system forward error correction scheme can be utilized. In telecommunication, information theory, and coding theory, forward error correction (FEC) or channel coding 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 (ECC). The American mathematician Richard Hamming pioneered this field in the 1940s and invented the first error-correcting code in 1950: the Hamming code. Many FEC schemes for multicarrier systems have been proposed in orthogonal FDM. Convolution is popular coding schemes for FEC. Convolution codes are binary code and it can operate on desired constraint length. One of the reasons that why CC-OFDM popular is that the same higher performance as Turbo code.[4] Turbo code is implemented using the structure of parallel concatenation of different FEC code and which may leads to high complexity. Convolutional codes are easy to implement and low complexity compared to Turbo code. Convolution codes are implemented with different code rates for improving the error performance of OFDM system. The BER performance of convolution coded OFDM is evaluated for various code rates in an AWGN channel.

2.1 OFDM

Simulation analysis gives the comparison of OFDM with and without FEC. OFDM system performance can be improved by using various kinds of modulation methods also. Three types of modulation methods without FEC techniques are used to analyze the system performances which are binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), and quadrature amplitude modulation (QAM). Finally bit error rate of these three methods are analyzed by comparing SNR versus BER plots. QPSK gives better BER performance for low SNR value whereas QAM results are better for high SNR value.

2.2 CC-OFDM

The redundancy allows the receiver to detect a limited number of errors that may occur anywhere in the message, and often to correct these errors without retransmission. FEC gives the receiver the ability to correct errors without needing a reverse channel to request retransmission of data, but at the cost of a fixed, higher forward channel bandwidth. FEC is therefore applied in situations where retransmissions are costly or impossible, such as one-way communication links and when transmitting to multiple receivers in multicast. FEC information is usually added to mass storage devices to enable recovery of corrupted data, and is widely used in modems.FEC processing in a receiver may be applied to a digital bit stream or in the demodulation of a digitally modulated carrier. For the latter, FEC is an integral part of the initial analog-to-digital conversion in the receiver. The Viterbi decoder implements a soft-decision algorithm to demodulate digital data from an analog signal corrupted by noise. Many FEC coders can also generate a bit-error rate (BER) signal which can be used as feedback to fine-tune the analog receiving electronics. The maximum fractions of errors or of missing bits that can be corrected are determined by the design of the FEC code, so different forward error correcting codes are suitable for different conditions. Evaluation of BER for OFDM without FEC reached to 10^{-1} and evaluation with CC-OFDM reached to 10^{-6}. Obviously CC-OFDM is the prominent solution to improve system performance. In CC-OFDM various decoding schemes are also. Hard decoding and soft decoding are two popular decoding methods. Then Performance analysis of CC-OFDM with hard decoding and soft decoding at different code rates have been analyzed. Hence, the BER performance of the CC-OFDM with higher code rate and soft decoding method with BPSK modulation has found to be best than the normal OFDM system. Hence the burst of errors has been reduced when CC-OFDM is used. Orthogonal Frequency Division Multiplexing has been employed in numerous wireless standards. However, the performance of OFDM systems is degraded by both the Inter Carrier Interference (ICI), Inter symbols Interference (ISI) and the channel noise. Hence new exact closed-form system model is designed for calculating the average BER of OFDM systems in the presence of both Interferences and channel noise in selective AWGN fading channels. By simulation results system model can be verified and the accuracy of our exact BER analysis is done. Consider an OFDM system having N subcarriers using the BPSK, QPSK, QAM modulation for communicating over frequency selective Additive white Gaussian noise channel.

1. FEC = Forward Error Correction
2. IFFT = Inverse Fast Fourier Transform
3. RF = Radio Frequency
4. FFT = Fast Fourier Transform

The transmitted sequence {bn} is obtained from the input information sequence {*an*} through an *N*-point inverse digital Fourier transform (IDFT). The {*an*} is created from the source data passed through a forward error correction (FEC) encoder, then interleaved and mapped into a constellation that can be Quaternary Phase Shift Keying (QPSK), 16-Quadrature Amplitude Modulation (QAM).

III OFDM MODEL WITH CC

In digital communication, coding techniques is a broadly used term mostly referring to the forward error correction code. The advantage of forward error correction is that a feedback-channel is not required, or that retransmission of data can often be avoided. Coding techniques is used for providing reliable information through the transmission channel to the user. In coding techniques the number of symbols in the source encoded message is increased in a controlled manner in order to facilitate two basic objectives at the receiver one is Error detection and other is Error correction. 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 (SNR).

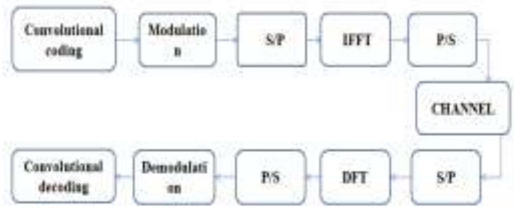

Fig.1. OFDM with Convolution Code

3.1 Code rates in CC-OFDM

Convolutional code can be generated at different code rates. Code rate is the ratio of number of input to the number of outputs. Following examples show the different code rate in convolutional code.1.The figure below is a rate 1/3 (*k*/*n*) encoder with constraint length (*L*) of 3. Generator polynomials $G_1 = (1,1,1)$ $G_2 = (0,1,1)$ $G_3 = (1,0,1)$. Output bits are calculated as follows $n_1 = m_1 + m_0 + m_{-1}$;

$n_2 = m_0 + m_{-1}$;

$n_3 = m_1 + m_{-1}$.

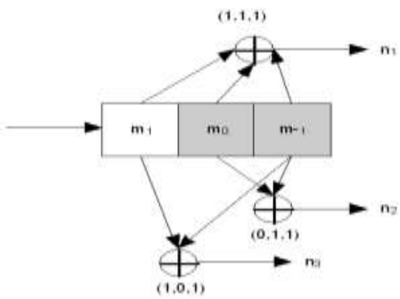

Fig 2. Rate 1/3 non-recursive CC-Encoder

The example of the encoder is systematic because the input data is also used in the output symbols. Codes with output symbols that do not include the input data are called non-systematic.

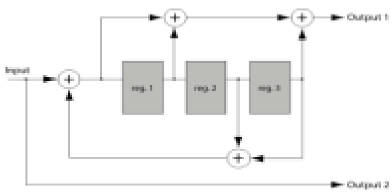

Fig.3. Rate 1/2 Recursive Systematic CC-Encoder

IV SIMULATION AND RESULTS

We have developed the simulator in Matlab™ using modular approach. Each block of the transmitter, receiver and channel is written in separate ´m´ file. The main procedure call each of the block in the manner a communication system works. The main procedure also contains initialization parameters, input data and delivers results. The parameters that can be set at the time of initialization are the number of simulated OFDM symbols, CP length, modulation and coding rate, range of SNR values. The input data stream is randomly generated. Output variables are available in Matlab™ workspace while BER values for different SNR are stored in text files which facilitate to draw plots. Each single block of the transmitter is tested with its counterpart of the receiver side to confirm that each block works perfectly.

4.1 BER Plots of an OFDM

In this section various BER vs. SNR plots have been described for all the mandatory modulation and coding profiles as specified in the standard on same channel models. The value of signal to noise ratio (Eb/No) can be changed by following parameter in function block set. As we increase the value of SNR, getting result of decrease in error rate. Equally-spaced orthogonal sub-carriers are used to carry data. Each sub-carrier is modulated with a conventional modulation scheme. Here by using BPSK (Binary Phase Shift Keying) and QPSK (Quadrature Phase Shift Keying) phase shift keying modulation and demodulation for all the simulations, OFDM system without FEC is analyzed. The constellation points are displayed on discrete time scatter plot. As SNR increases by 6 dB, there is decrease in error rate. BPSK is good one in OFDM system performance. Reversal Keying or 2PSK is the simplest form of phase shift keying (PSK). It uses two phases which are separated by 180° and so can also be termed 2-PSK. It is, however, only able to modulate at 1 bit/symbol and so is unsuitable for high data-rate applications. As a result, the data is often differentially encoded prior to modulation. Binary PSK is functionally equivalent to 2-QAM modulation. QPSK gives better BER performance for low SNR value. QPSK uses four points on the constellation diagram, equispaced around a circle. With four phases, QPSK can encode two bits per symbol, shown in the diagram with gray coding to minimize the bit error rate (BER). QAM results are better for high SNR value.

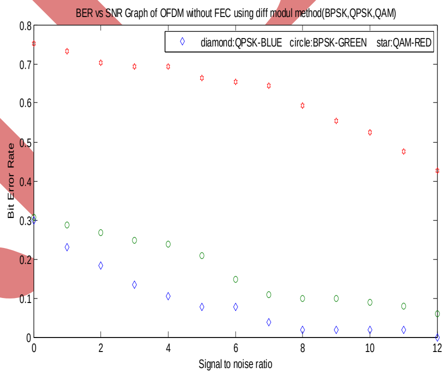

Fig 4. OFDM with Different Modulation Methods

Above graph as shown in fig.9 is obtained when all methods are combined. Arbitrarily high spectral efficiencies can be achieved with QAM by setting a suitable constellation size, limited only by the noise level and linearity of the communications channel. This paper is useful for analysis of physical layer of WIMAX[3] with different modulation techniques like BPSK, QPSK, QAM and comparison of these modulations with and without Forward Error Correction methods. 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 small and medium sized enterprise sectors. IEEE 802.16 standard for BWA and its associated industry consortium, Worldwide Interoperability for Microwave Access (WIMAX) forum promise to offer high data rate over large areas to a large number of users where broadband is unavailable.

4.2 BER Plots Of CC-OFDM

The figure shows the convolution coding FEC scheme in OFDM. First figure is the result of simulated plot of Convolutional code with using four modulation methods QAM, QPSK, DBPSK, and BPSK. Black diamond gives rate of QAM whereas black stars give information about QPSK modulation. Green is for DBPSK and blue stars are of BPSK. Convolution code with BPSK modulation is found to be best which gives less number of errors as SNR increases.

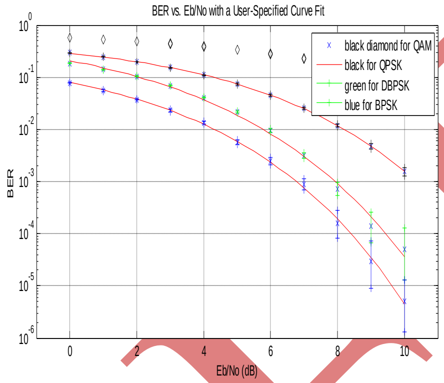

Fig.5. CC-OFDM at different modulation

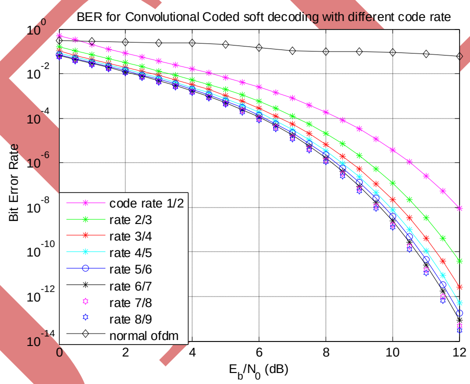

Fig.6. CC-OFDM at different code rates

The figure indicates comparison of eight code rates in CC-OFDM and BER of OFDM without FEC using BPSK modulation method. Higher code rate in convolution code i.e.8/9 code rate gives the best performance as SNR increases.

V CONCLUSION

Error detection and correction techniques are essential for reliable communication over a noisy channel. In this paper, a comparison of BER performance analysis of CC-OFDM and normal OFDM over AWGN channel has been presented. It has been found that the error performance of the OFDM system over AWGN and fading channel can be significantly improved by using Convolution codes for FEC. The improvement in the BER performance of the coded OFDM system increases by increasing the code rate (r). The BER performance of convolutionally coded OFDM system is found to be better than OFDM system.

Convolution codes are one of the most powerful and essential binary error correcting codes for detecting and correcting burst errors. The effect of errors occur during transmission is reduced by adding redundancy to the data prior to transmission. The redundancy is used to enable decoder in the receiver to detect and correct errors. CC-OFDM is an efficient code to correct the errors by using code rates. It can reduce the bit-error in noisy environment and provide the efficient data through subscriber.CC-OFDM gives the all requirements required in wireless communication. It achieves the required channel capacity which leads to high data rate. Quality of an OFDM system is improved because it minimizes the probability of Error. It solves real life issues e.g. system complexity, cost of implementation, low transmission power required (SNR), minimum bandwidth etc. Performance analysis of BER evaluation of normal OFDM is poor than that of CC-OFDM. Obviously CC-OFDM is the prominent solution to improve system performance. BER performance of the CC-OFDM with higher code rate and soft decoding method with BPSK modulation has been found to be best than the normal OFDM system. Hence the burst of errors has been reduced when convolutional code with soft decoding method is used.

REFERENCES

[1] Ashish Goel, Manoj Kumar Garg, Dept.of ECE Jaypee Institute of Technology.,"Comparative Performance Evaluation of Convolutionally Coded and LDPC Coded OFDM System Over AWGN and SUI-5 Fading Channel",International Conference on Computer and Communication Technology 2012

[2] Prabhakar Telagarapu, G.B.S.R.Naidu, K.Chiranjeevi, Dept.of.ECE GMR Institute of Technology.,"Analysis of Coding Techniques in WiMAX", International Journal of Computer Applications (0975 – 8887) Volume 22– No.3, May 2011

[3] Arunabha Ghosh and David R. Wolter, SBC Laboratories Inc. Jeffrey G. Andrews and Runhua Chen, The University of Texas at Austin"Broadband Wireless Access With Wimax/8o2.16: Current Performance Benchmarks And Future Potential" by., IEEE Communications Magazine. February 2005.

[4] Alok Joshi, Davinder S. Saini.ECE Department JIIT, Noida.," Performance Analysis Of Coded-OFDM with RS-CC and Turbo codes in Various Fading Environment", Proceedings of the 5th International Conference on IT & Multimedia at UNITEN (ICIMU 2011) Malaysia .November 2011

Journal Papers:

1] IEEE 802.162004," IEEE Standard for Local and Metropolitan Area Networks Part 16: Air Interface forFixed Broadband Wireless Access Systems", 1 October,2004

2] J. G. Andrews, "Interference Cancellation in Cellular Systems: A Contemporary Overview," to appear, IEEE Wireless Commun.., Apr. 2005.

3] Israel Koffman, Runcom Technologies Vincentzio Roman, Paradise Consulting,"Broadband Wireless Access Solutions Based on OFDM Access in IEEE 802.16",IEEE Communications Magazine April 2002.

4] Dr.Kurt R.Matis (Director of Systems Research.,Visual System Simulator2002.,"Simulation of Convolutional Codes in VSS

5]"Signal Coding and Estimation Theory"by RanjanBose;"Digital Communication" by Simon Haykin.

6] Yun Hee Kim, Student Member, IEEE, Iickho Song, Senior Member, IEEE, Hong Gil Kim, Student Member, IEEE, Taejoo Chang, and HyungMyung Kim, Member, IEEE.,"Performance Analysis of a Coded OFDM System in Time-Varying Multipath Rayleigh Fading Channels", IEEE Transactions on vehicular technology, vol. 48, no. 5, September 1999

7] Shraddha Bansal, Raksha Upadhyay, Department of ECE,, IET-DAVV, Indore.," Performance Improvement of Wi-Max IEEE 802.16e in Presence of Different FEC Codes", First International Conference on Computational Intelligence, Communication Systems and Networks.2009.

8] Mario Huemer,Christian Hofbauer,Johannes B. Huber, .,"Non-Systematic Complex Number RS Coded OFDM by Unique Word Prefix ",IEEE transactions on Signal Processing, Vol. 60, No. 1, January 2012.

9] Tanaporn Payommai, Wichupong Wiboonjaroen ,SomsinWangkhuntod department of Electronic Engineering Rajamangala University of Technology Isan Nakhonrat chasima, Thailand .," Study on Sub-block Encoder of LDPC Code with OFDM for Image Transmission, 2012 IEEE.

10] HakanDo˘gan, HakanYıldız, Graduate Member, IEEE, TodorCooklev, Senior Member, IEEE,YusufAcar.," Coded OFDM Wireless Systems with Generalized Prefix, 2012 IEEE

11] Ding-Bing Lin, Member, IEEE, Ping-Hung Chiang, Student Member, IEEE, and Hsueh-Jyh Li, Senior Member, IEEE.," Performance Analysis of Two-Branch Transmit Diversity Block-Coded OFDM Systems in Time-Varying Multipath Rayleigh-Fading Channels, IEEE transactions on vehicular technology, vol. 54, no. 1, January 2005.