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BER EVALUATION OF LOW-DENSITY PARITY-CHECK CODED OFDM SYSTEM UNDER DIFFERENT MODULATION SCHEMES

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ABSTRACT

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In this paper, the impact of low-Density Parity-Check code (LDPC) on the performance of an Orthogonal Frequency Division Multiplexing (OFDM) system under various digital modulations (QPSK, 8PSK,QAM and 8QAM) over an Additive White Gaussian Noise (AWGN) and other fading (Raleigh and Rician) channels is investigated. The study is made with the development of a computer program and its application on the processing of a black and white (monochrome) digital image. Numerical results show that Bit error rate (BER) performance of LDPC coded OFDM system with QAM modulation technique is highly effective to combat inherent interference in the communication system. Due to constraint in data handling capability of the program editor, a black and white image in JPEG is converted into a monochrome BMP format and is used for analysis. The transmitted image is found to have retrieved effectively under noisy and fading situations.

Keywords: Low-Density Parity-Check code, Bit error rate, Digital Modulation, Image Transmission.

INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is a very attractive technique for high bit-rate-data transmission required for high quality communications in multipath environments. In OFDM system, the wide signal bandwidth is divided into many narrowband subchannels transmitted in parallel. In multipath environments, the intersymbol interference (ISI) is eliminated by adding a guard interval in OFDM. Generally, under such environments, some of the OFDM subcarriers may be completely lost because of the deep fades and most subcarriers may be detected without errors, the overall bit error rate (BER) will be largely dominated by a few subcarriers with small amplitudes. To avoid this domination by the weakest subcarriers, forward-error correction coding is essential. Many error-correcting codes such as convolutional codes, Reed-Solomon codes, Turbo codes etc have been applied to OFDM. Recently, low-density parity-check (LDPC) codes have attracted much attention particularly in the field of coding theory. LDPC codes were proposed by Gallager in 1963 (Gallager, 1963) and the performance is very close to the Shannon limit with practical decoding complexity like Turbo codes. LDPC codes have been applied to BPSK and 8PSK, and their fundamental performance has been evaluated on an additive white Gaussian noise (AWGN) channel .The performance of LDPC codes has also been evaluated on a block fading channel, and it has been shown that the LDPC codes achieve a large gain with respect to convolutional codes for large packet length (Hisashi, et al. 2002, C. Berrou, et al. 1996).

LDPC codes are linear block codes specified by a sparse parity-check matrix with the number of 1's per columns (column weight) and the number of 1's per row (row weight) both of which are very small compared to the block length (D.J.C.MacKay, 1999). LDPC are classified into two groups, regular and irregular LDPC codes. . Regular LDPC codes have a uniform column weight and row weight and irregular LDPC codes have a nonuniform column weight. Irregular LDPC codes have better performance than regular codes. In case of block length relatively greater than 1000, irregular LDPC codes outperform Turbo codes (T.Richardson, et al. 2000). An irregular LDPC code defined by 32400 X 64800 parity check matrix as (64800, 32400) LDPC with a code rate of ½ generated in the Matlab has been preferred to be used in the present simulation study. The parity-check matrix has 6 and 7 nos. of 1's in its 1st and 2nd to 32400th rows. The no. of 1's in its 1st to 12960th columns is 8 and from 12961th to 32400th columns, its 1's no is 3.In this paper , we evaluate the bit error rate(BER) of a low-density parity-check coded Orthogonal Frequency Division Multiplexing (LDPC-COFDM) system working under each of four types of digital modulation such as QPSK, 8PSK,QAM and 8QAM on the AWGN and Rician fading channels.

MATERIALS AND METHODS

We assume a low-density parity-check coded Orthogonal Frequency Division Multiplexing (LDPC-COFDM) system as shown in Figure 1. A black and white digital image in Joint Photographic Experts Group (JPEG) format has been taken and resized. Its matrix size is 180 X 180 X 3. This image file is reconverted into a Binary image in Monochrome Bitmap (BMP) format containing 180 X 180 pixels. The pixels with the values of 0 and 1 are displayed as black and white respectively. Each pixel value of the image is multiplexed column wise into serial unipolar binary bit stream. The binary bits are encoded at the LDPC encoder and modulated at the modulator. In multicarrier OFDM modulator, the digitally modulated information 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 intersymbol interference (ISI) caused by channel time spread, each block of IDFT coefficients is typically preceded by a cyclic prefix (T. Kratochvil, 2003, L. J. Cimini, Jr. 1985). At the receiving section, after the serial to parallel conversion with removal of cyclic prefix, the OFDM sub-channel demodulation is implemented by using a fast Fourier transform (FFT). The received OFDM symbols generated by the FFT are demodulated at the demodulator. The demodulated bits are decoded with each LDPC block and eventually; the transmitted image is retrieved with restoration of unipolar binary bits. The model parameters used in the simulation study are shown in Table 1.

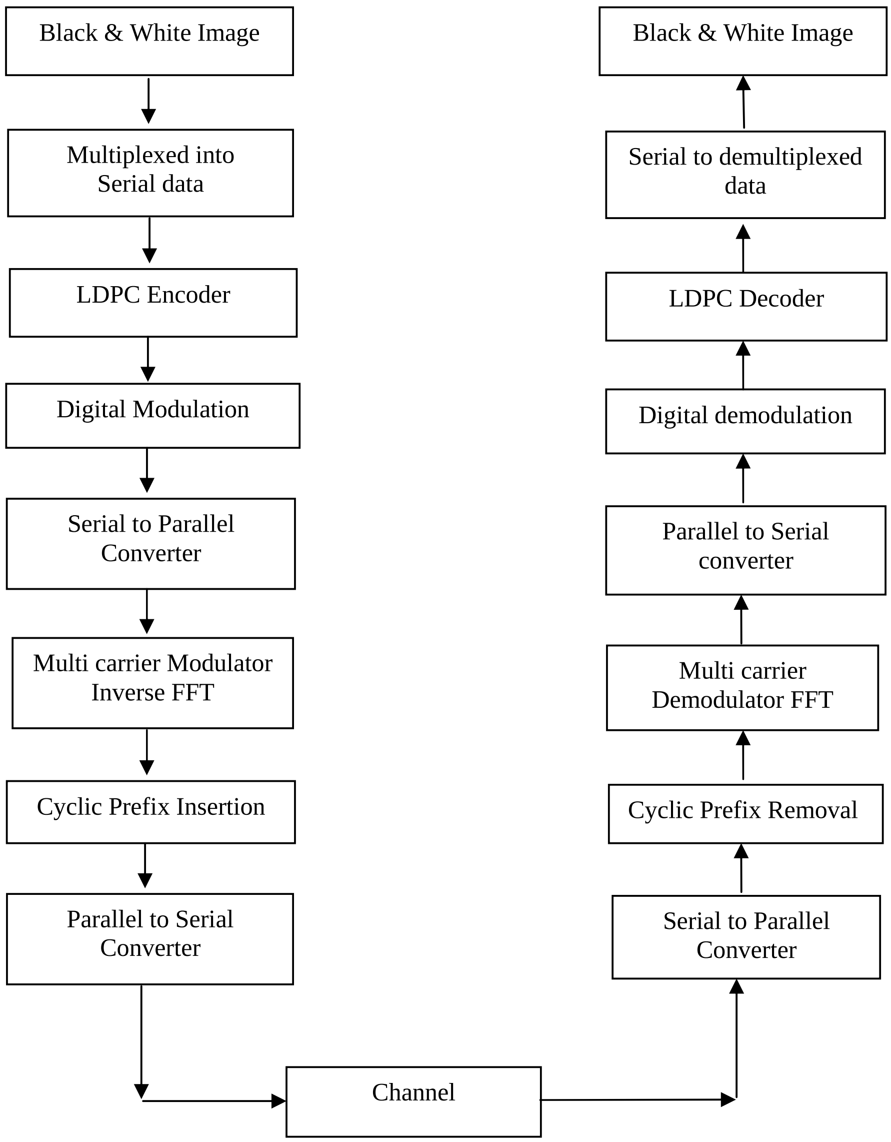

Figure 1. Block diagram of LDPC coded Orthogonal Frequency Division Multiplexing (OFDM) system

Table 1. Model parameters used in simulation study

Size of Black and white image	180 X 180 pixels
Number of binary bit (0/1) for a pixel	1
No. of bits used for image transmission	32400
Signal to noise ratio per sample	0 dB -15 dB
Sample time (period of each bit) in Rician/ Rayleigh fading	1/32400 sec.
Maximum Doppler frequency shift in Rician/ Rayleigh fading	100Hz
Doppler frequency shift in Rician fading	100Hz
K- factor parameter in Rician fading	10
Size of Parity-check matrix of the LDPC code	32400 X 64800
Total number of bits in a codeword.	64800
Number of information bits in a codeword.	32400
Number of parity bits in a codeword	32400

Simulation Results

We present results of our computer simulation on the BER performance of the LPDC coded OFDM system with different types of digital modulations on both AWGN and fading channels. We use the (64800, 32800) irregular LDPC code with a code rate of ½ .The maximum number of iterations in decoding was set to 500.Figure 2 through Figure 4 show the bit error rates (BERs) for different values of energy per bit to noise ratio (Eb /N).

In Figure 2, it is seen that the BERs of the present communication system with QAM modulation is about 5.94 dB better that that of the system with 8QAM modulation for a typical value of energy per bit to noise ratio (Eb /N) of 8 dB on the Additative White Gaussian channel. In comparison of the 8QAM with 8PSK modulation, it is found that system performance is improved by 13.76 dB in case of 8QAM. Figure 3 shows the BER performance of the LDPC coded OFDM system on a Rayleigh fading channel. Due to fading channel effect, system performance degrades and its performance imp roves with QAM modulation. In Figure 3, the system with 8QAM is more influenced by the Doppler frequency shift and its performance degrades. At (Eb /N) of 10 dB, system peformance is improved by 8.19 dB in QAM modulation as compared with 8QAM. Figure 4 shows the BER performance of the LDPC coded OFDM system on a Rician fading channel. The system provides satisfactory performance with QAM modulation. In comparison of the 8QAM with QAM modulation for a Eb /N value of 10 dB, it is found that system performance is improved by 11.15 dB in case of QAM. In such a fading channel, the system with 8PSK is more influenced by the Doppler frequency shift with degradation of system performance.

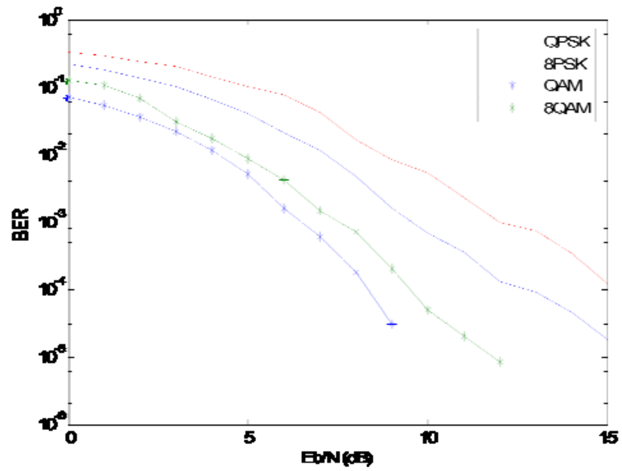

Figure 2. BER of the (64800, 32400) LDPC coded OFDM system with different modulation schemes on an AWGN channel

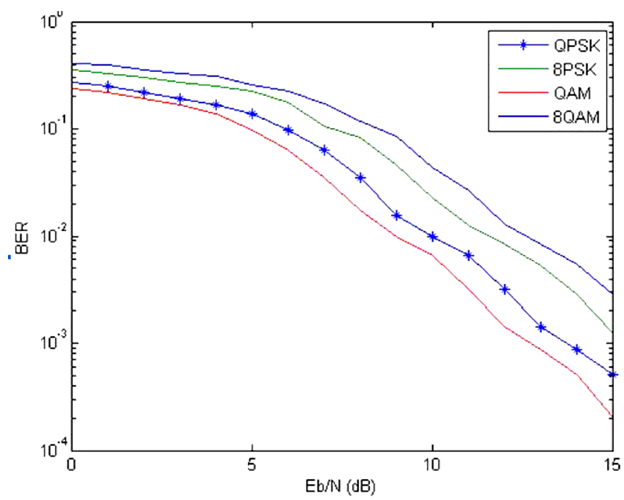

Figure 3. BER of the (64800, 32400) LDPC coded OFDM system with different modulation schemes on a flat Rayleigh fading channel

In this paper, we evaluated the performance of the low-Density Parity-Check coded Orthogonal Frequency Division Multiplexing system under various digital modulations. We showed that the system achieves good error rate performance on both an AWGN and frequency-selective fading channels. On the basis of results obtained in the present study, it can be concluded that the low-Density Parity-Check coded Orthogonal Frequency Division Multiplexing system with deployment of QAM modulation is very much effective in proper identification and retrieval of transmitted digital image in noisy and fading environment

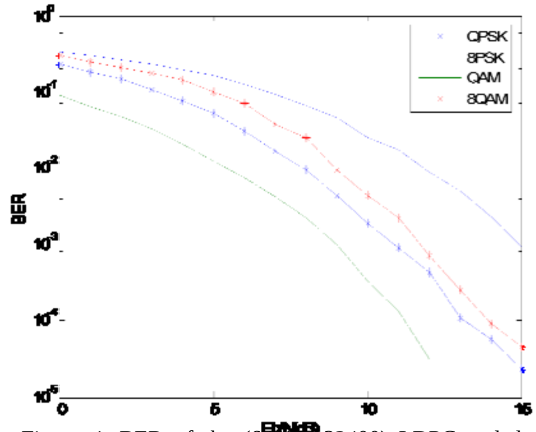

Figure 4. BER of the (64800, 32400) LDPC coded OFDM system with different modulation schemes on Rician fading channel

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