International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 5, May - 2013

DWT Image Transmission By OFDM System With Adequate Energy Saving

Ankit Emmenual Ram, Anil Kumar, Arvind Kumar Jaiswal
ECE Department SHIATS-DU Allahabad India 211007

Abstract

Resending of lost packets is not allowed in the field of communication as far as many applications are considered. Only some of the subset of carrier fulfils the criteria of data transmission. The data having least importance can be discarded at the receiver itself so that only good subcarriers can be transmitted over the channel, if the channel state information is available at the transmitter itself. In this paper, we present a system model which transmits any compressed image using DWT Image transmission by OFDM channels using QAM with an approach to save adequate energy. To achieve this bad subchannels are discarded at the transmitter itself with a usefulness of the proposed scheme in terms of peak signal-noise ratio.

1. Introduction

In communication, intersymbol interference (ISI) and frequency selective fading nature of the channel is a form of a distortion of a signal in which high rate data communication are significantly limited. Example of such channel is Rayleigh fading channel. Multi-carrier modulation (MCM) is a method of transmitting data by splitting it into several components, and sending each of these components over separate carrier signals which appease the effect of ISI. Orthogonal frequency division multiplexing (OFDM) is a special case of multicarrier transmission, where a single data stream is transmitted over a number of lower rate subcarriers which allows overlapping in frequency domain. A large number of closely spaced orthogonal sub-carrier signals are used to carry data on several parallel data streams or channels. Each sub-carrier is modulated with a conventional modulation scheme (such as quadrature amplitude modulation or phase-shift keying) at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth..

The three types of source coding which are being used in the world of transmission are non progressive coding, progressive coding and multiple description coding.

Layered coding is performed in State-of-the-art image or video compression techniques, such as JPEG2000 [1] (which uses Discrete Wavelet Transform DWT). In this technique, the base layer is sent first and then enhancement layers are added if the bandwidth is available. The Layers which gets lost are retransmitted to complete the processing at the receiver. This process introduces inactivity, thereby restricting the performance of the system. Layered coding produces data of unequal importance and hence special protection should be provided for important data. Scalability property of the layered coding approach allows that a fewer layers can be transmitted to reconstruct the image frame of an acceptable quality. However those layers should be received perfectly, which leads to the need for retransmissions. Thus, although progressive coding works well in loss-less system, but if errors are generated during reconstruction, the image can be hampered due to resending of lost coefficients.

To avoid the above mentioned technique MDC [2] is used for the applications which do not allow inactivity in the reception. MDC is source coding for multiple channels that a decoder which receives an arbitrary subset of the channels may produce a useful reconstruction. MDC always outperforms in delay sensitive applications [3]. MDC gives a chance to evaluate the lost information from the correctly received data without retransmission Since MDC distributes the importance equally among all the coefficients; it works against its recovery quality when CSI is known. It can be explained by the fact that, for a limited correlation among the descriptions produced by MDC, the distortion for even one description loss is more than the minimum variance of the input data streams [4]. So, not to unnecessarily increase complexity by using MDC, the DWT compressed data can be directly transmitted over the error-prone subchannels leading to more important coefficients are protected from likely losses in the transmission process.

In this paper, we propose a energy saving approach, where the compressed coefficients are arranged in descending order of priority and mapped over the channels starting with the good ones. The coefficients with lower importance level, which are likely mapped over the bad channels, are discarded at the transmitter to save power without significant loss of reception quality.

The paper is organized as follows. Section II gives the DWT-OFDM system model, followed by the proposed scheme. The analysis of distortion and energy saving is given in SECTION III. Simulation and analytical results are shown in Section IV. Finally the paper is concluded in Section V.

2. DWT-OFDM System Model

The OFDM implemented by using IFFT's and FFT's have some problems. Due to these problems we need to look at other type of modulation to generate the carrier. One of these is the wavelet transform. The wavelet transform is proposed by many authors, it has a higher degree of side lobe suppression and the loss of orthogonality leads to lesser ISI and ICI. In Wavelet OFDM the FFT and IFFT is replace by DWT and IDWT respectively. For the Wavelet transform we see that from the time-frequency plot that the basic Wavelet transform offers lesser flexibility than the wavelet packet transform. For the wavelet packet transform we can construct an algorithm to do the decomposition such that the effect due
to the noise (assuming that we know the frequency that is affected most by the noise and the time when it affected most).
An OFDM trans-receiver is shown in Figure 1[5]. The data generator used is a sine wave of bit stream d. It is processed using M-ary modulator to map the input data into symbols Xm. These symbols are now sent through IDWT block to perform IDWT operation to generate N parallel data streams. Its output in discrete time domain is given by,

$$X_{k(n)} = \frac{1}{\sqrt{N}} \sum_{i=0}^{N-1} Xm(i) e^{(j2\pi i/N)} \quad (1)$$

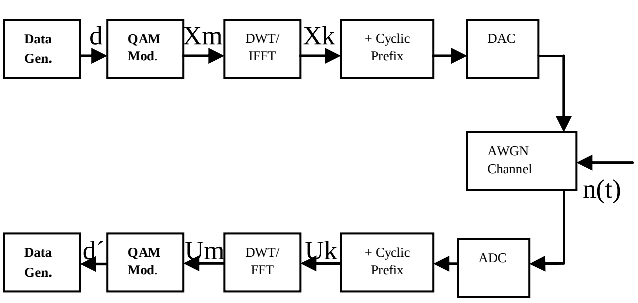

Figure 1. An OFDM transceiver of FFT/ DWT-OFDM

The transformed output (X_k) is now appended with cyclic prefix. The cyclic prefix (CP) is added before transmission, to mitigate ISI effect. It is usually 25% of the last part of the original OFDM symbol and this data is passed through AWGN channel with proper input power set. At the receiver, the reverse operation is done to obtain the original data back. The CP is removed and processed in the DWT block and finally passed through demodulator for data recovery.

In our proposed model, an image frame is compressed using DWT, and the compressed data is arranged in data vectors, each with equal number of coefficients. These vectors are quantized and binary coded to get the bit steams, which are then packetized and intelligently mapped to the OFDM system, such that poorer subchannels can only affect the lesser important data vectors. We consider only one-bit channel state information available at the transmitter, informing only about the subchannels to be 'good' or 'bad'. For a good subchannel, instantaneous received power should be greater than a threshold Pth. Otherwise; subchannel is in fading state and considered 'bad' for that batch of coefficients. Note that the data transmitted through deeply faded subchannels are highly sensitive to error and are likely to be discarded at the receiver. Thus, the binary channel state information gives an opportunity to map the bit streams intelligently and to save a reasonable amount of power. The brief explanation of model is under:

At first DWT is applied to any original image whether gray or coloured of size A × B pixels leading to four sub-images denoted as HL, LH, HH, and LL, each of the size (A/2)×(B/2) pixels, from these sub-images four coefficient vectors are generated, each of length (A.B)/2. Post this step uniform quantization of the coefficient vectors is done which are binary coded with L bits/coefficients to form four bit streams. These bit streams are packetized and traced on the OFDM system.

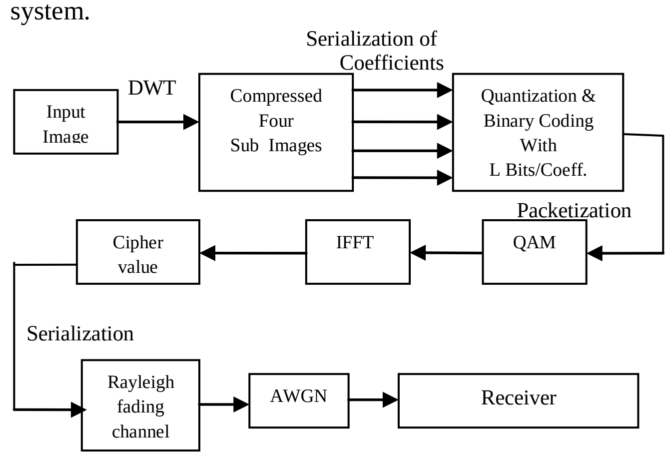

Figure 2. Proposed Model for DWT-OFDM

According to Figure 2, bit streams are packetized by chopping them into bit vectors of size *N´* bits. Four such vectors are contained in a packet. Cipher Bits are added to each vector to estimate the SNR of the subchannels at the receiver[7].The system is described by arranging 32 packets in parallel to get 128 bit streams making them m-ary modulated and being simultaneously transmitted via different subchannel set. Here only the feedback comes into role which takes the condition of selecting 'good' or 'bad' data with the help of a predefined threshold P_{th} and accordingly draft them to IFFT. We propose an outline which is adequate in terms of quality reception as well as energy saving. Packets are send via frequency selective, slow varying fading channel. Vice-versa is done at receiver with suitable measures due to 'bad' vectors.

In this study we use block fading channel model as in [8]. All sub-bands are independently faded with Rayleigh-distributed envelop, which corresponds to the block fading approximation in frequency domain [9], [10].

3. Arithmetic and Simulation Result

A. Distortion involved for various loss events

As the proposed scheme gives an opportunity to reduce the distortion as much as possible for a given channel condition; only a few loss events can take place. Let x_1, x_2, x_3, and x_4 are the data vectors corresponding to the four sub-images obtained from original frame using DWT compression. Also, let σ^2_{x1}, σ^2_{x2}, σ^2_{x3} and σ^2_{x4} are the respective variances. Without any loss, assume that the variances σ^2_{x1} to σ^2_{x4} are in descending order of magnitude. Thus, the corresponding importance levels are also in descending order. These data vectors are drafted over different subchannels in such a way that only a few specific loss events are possible. The corresponding likelihood of loss events would be: only x_4 is lost; x_3 and x_4 are lost; x_2, x_3, and x_4 are lost; and all x_1, x_2, x_3, and x_4 are lost. Thus, according to our mapping strategy only four combinations of the loss events are possible and each individual distortion can be calculated as:

$$D_i = \begin{cases} \frac{i\Delta^2}{12} & if\ i = 4. \\ \sum_{i+1}^{4} \sigma^2_{x_i} + \frac{i\Delta^2}{12}, & Otherwise \end{cases} \quad (2)$$

B. Block fading channel behavior:

The performance of the proposed scheme depends on probability of the loss events. In this section, the probabilities of loss events are determined with respect to the channel fading parameter. In our interleaved coefficient mapping scheme, all the four subchannels per group of four coefficients are from different sub-bands. Thus, p will also be the probability of a subchannel to be bad. Let P_i = probability associated with the loss event i, for i = 0, 1, 2, 3, 4, which produces distortion Di. Thus, for an arbitrary received packet we can write:

$$P_i = \binom{4}{i} p^{4-i}(1-p)^i \quad (3)$$

Then, the average distortion of the proposed scheme can be written as:

$$\bar{D} = \sum_{i=0}^{4} D_i P_i \quad (4)$$

B. Energy *saving measure:*

In the proposed scheme the less important data vectors are discarded at the transmitter to save power if corresponding subchannel is in fading state. Denoting the percentage of data not transmitted in a packet as a measure of the percentage of energy saving, using (3) we can write energy saving expression as:

$$\%Energy\ Saving = 100 \times \sum_{i=0}^{4} i\, P_i/4 \quad (5)$$

Simulations are carried out in Matlab to validate the proposed schemes. In our proposed scheme we can use any image for transmission but here we have used the coloured image of baboon. We simulated the OFDM system with 128 subcarriers. In this way, 32 packets can be transmitted simultaneously through the OFDM system. The modulation scheme used for the transmission can be any one from the two i.e. QPSK or QAM but here we have taken QAM for simulation purpose. This Modulation scheme gives the best of its results when it comes to the transmission of data. The results are as follows:

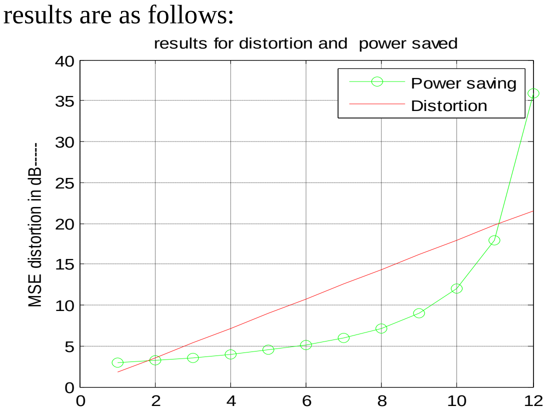

Figure 3. Distortion and power saved

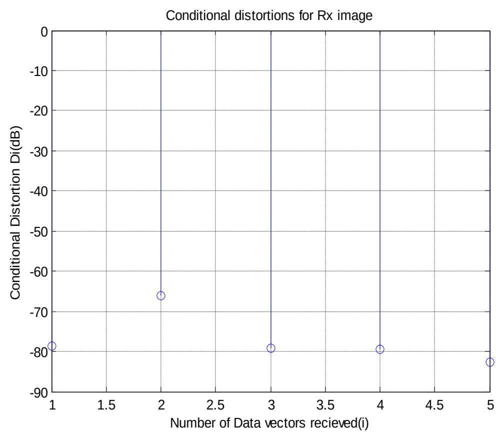

Figure 4. Conditional Distortion for Rx Image

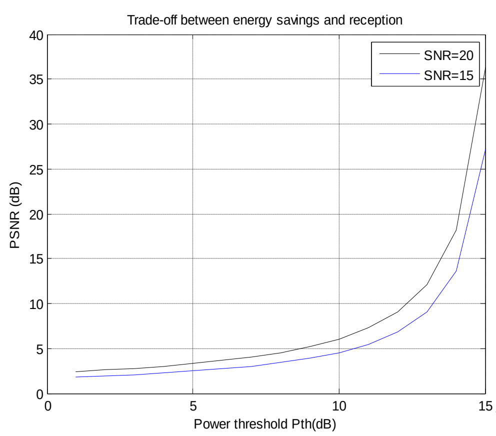

Figure 5. Trade-off between energy savings and reception

To show the effect of fading we have not considered Gaussian Noise in our analysis and simulation. From Figure 3, it is noted that the distortion depends on the threshold value P_{th} and on transmitting the image of coloured baboon a adequate amount of energy of about 65 percent is saved.

Transmission through OFDM shows PSNR and energy saving quality in Figure 5, which also include the effect of AWGN. The figure also gives the optimal value of P_{th} about 8 dB. For lower values of P_{th} AWGN dominates, producing a higher distortion even if the coefficients are accepted at the receiver due to a low P_{th}. Therefore for higher values of P_{th}, i.e., at $P_{th} > 8$ dB, the effect of AWGN diminishes. But, as more subchannels are considered in fading state the quality suffers while providing a higher energy saving.

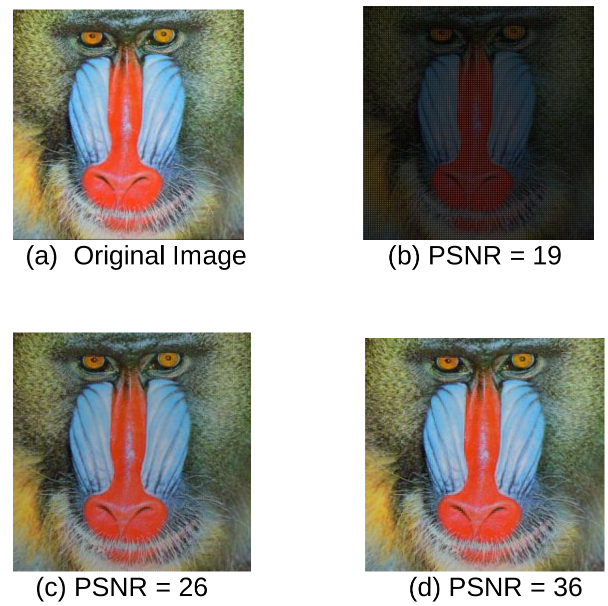

Figure 6. Transmitted Baboon Image and its received counterpart at different PSNR's.

It should be noted that we halt the transmission depending upon instantaneous received power if the subchannels, and a decision is made based on the value P_{th}. Thus, the amount of power saved and the corresponding degradation in quality for a higher P_{th} can be controlled. The received baboon image at different PSNR is shown in figure.

4. Conclusion

Reducing distortion in transmission of data is at top priority. So, in this paper an efficient scheme is proposed in which the coefficients with lower importance are discarded at the transmitter itself leading to saving of power without much loss in reception quality.

As a future work, the current study can be extended to adaptive modulation and moderating the scheme for video transmission as well.

5. References

[1] Athanassios Skodras, Charilaos Christopoulos, and Touradj Ebrahimi "The JPEG 2000 Still Image Compression Standard," IEEE Signal Processing Magazine, Sep. 2001.

[2] R. Puri and K. Ramchandran, "Multiple description source coding through forward error correction codes," IEEE Proceedings Asilomar Conference on Signals, Systems, and Computers, Asilomar, CA, October, 1999.

[3] J. Chakareski, S. Han, and B. Girod, "Layered Coding vs. Multiple Descriptions for VideoStreaming over Multiple Paths," ACM, November 2.8, 2003.

[4] V. K. Goyal and J. Kovacevic, "Optimal multiple description transform coding of Gaussian vectors," in *Proc.*

IEEE data Compression Conf., Snowbird, UT, Mar. 1998, pp. 388–397.

[5] Khaizuran Abdullah and Zahir M. Hussain, "Studies on DWT-OFDM and FFT-OFDM Systems," International Conference on Communication, Computer And Power (Icccp'09) Muscat, February 15-18, 2009.

[6] Ye Geoffrey Li, Gordon L. Stuber, "*Orthogonal frequency division multiplexing for Wireless Communications"*, Amazon, 2006.

[7] Y. Li, "Pilot-symbol-aided channel estimation for OFDM in wireless systems," *IEEE Trans. Veh. Techn.*, vol. 49, no. 4, pp. 1207–215, June 2000.

[8] Y. S. Chan, P. C. Cosman, and L. B. Milstein, "A cross-layer diversity technique for multi-carrier OFDM multimedia networks," *IEEE Trans. Image Proc.*, vol. 15, no. 4, pp. 833–847, Apr. 2006.

[9] R. J. McEliece and W. E. Stark, "Channels with block interference," *IEEE Trans. info. Theory*, vol. 30, no. 1, pp. 44–53, Jan. 1984.

[10] R. Knopp and P. A. Humblet, "On coding for block fading channels," *IEEE Trans. info. Theory*, vol. 46, no. 1, pp. 189–205,Jan.2000.