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A Robust and Efficient Color Image Transmission over OFDM Fading Channels with Power Saving Approach

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ABSTRACT:

In many applications retransmission of lost packets is a very important aspect. Here In this thesis we introduced an efficient approach to transmission of discrete wavelet transformation based compressed color images over the OFDM channels. We analyzed the performance of the proposed system, supported by MATLAB simulations; we demonstrate the usefulness of our proposed scheme in terms of system energy saving without compromising the received quality in terms of peak signal-noise ratio.

I.INTRODUCTION :

It is always desired to increase the data rate over wireless channels. But high rate data communication is significantly limited by Inter Symbol Interference (ISI) and frequency selective fading nature of the channel. Rayleigh fading channel is an example of frequency selective and time varying channel. Multi-carrier modulation is used for such channels to mitigate the effect of ISI. OFDM is a multi-carrier modulation scheme having excellent performance which allows overlapping in frequency domain. In OFDM, individual sub channels are affected by flat fading, so for a period of time, condition of the sub channels may be good, or they might be deeply faded. The packets which are transmitted through these faded sub channels are highly prone to be lost at the receiver due to non-acceptable errors. OFDM system provides an opportunity to exploit the diversity in frequency domain by providing a number of subcarriers, which can work as multiple channels for applications having multiple bit streams. There are three types of source coding techniques: non progressive coding, which is designed purely for compression efficiency but it requires retransmissions; progressive coding, which also requires retransmissions but it offers scalability; and multiple description coding (MDC), where no retransmission is required but it sacrifices some compression efficiency. For still image transmission, most common way is progressive (or layered) encoding technique. State-of-the-art image or video compression techniques, layered coding is performed. In this technique, layers should reach in a predefined order for processing the data and reconstructing the image at the receiver. Lost layers are retransmitted to complete the processing at the receiver. This process introduces unpredictable latency, thereby restricting the performance of the system.

Layered coding produces data of unequal importance and hence one has to put a higher protection for more 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 lossless transmission system, in the event of errors reconstruction of image can be stalled due to retransmission of lost coefficients, which is not acceptable in real time content delivery applications.

MDC is used for the applications which do not allow latency in the reception. In MDC, source contents, such as DWT coefficients, are divided into multiple bit streams (called descriptions) which are transmitted through different channels. MDC receiver is able to decode with a low but acceptable quality even if a fewer descriptions are received. In comparison with the layered coding with no error protection in both, MDC always outperforms in delay sensitive applications. This is because; MDC gives an opportunity to estimate the lost descriptions from the correctly received descriptions without the need for retransmissions.

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However, if some channel state information (CSI) (e.g., binary indication, like 'good' or 'bad') is available at the transmitter, then MDC performance in the delay sensitive applications is no more superior with respect to the layered coding. 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. So, rather than unnecessarily increasing complexity by using MDC, the DWT compressed data could be directly transmitted over the error-prone sub channels, with the coefficients having lower variances (i.e., with lower importance levels, high pass coefficients) mapped onto 'bad' sub channels.

Thus, the more important coefficients are protected from likely losses in the transmission process. The lost coefficients in DWT image would still introduce lesser distortion than what it would have been in the MDC scheme. A key observation is that, the unequal importance level of the compressed image coefficients can be combined intelligently with the binary channel state feedback to achieve an improved transmission performance in delay-sensitive applications. This feedback can also be used further for energy saving in the transmission process with little or no trade-off in transmission performance.

In this paper, we explore the possibility of transmitting DWT images through the block fading OFDM channels with binary channel state feedback, where, unlike in conventional layered coded frame transmission, retransmission of lost packets are not allowed. Depending on the binary channel feedback and a predefined acceptable received power threshold, the 'good' and 'bad' (deeply faded) channels are sorted, and the coefficients in order of their importance levels are mapped to the sub channels belonging to the good ones. As an energy saving measure, if a coefficient is mapped onto a 'bad' sub channel, we propose that, it is discarded at the transmitter itself. Since our mapping scheme ensures that the discarded coefficients are of rather lesser importance, in most cases the transmitted frame could be reconstructed at the receiver with some distortion, without needing retransmissions. An application scenario of our proposed scheme could be real-time image/video transmission in peer-to-peer broadband communication systems.

Prior work on DWT-OFDM system in studied the transmission of DWT compressed still frame over OFDM multipath channels. In that approach, the high pass coefficients were simply discarded before transmission. In contrast, in our approach, we consider the possibility of transmitting the low pass as well as high pass coefficients. We also explore the possibility of energy saving in transmission process over fading channel environment by discarding the coefficients of lower importance level through an informed decision process. Note that, as an alternative approach, adaptive modulation and coding (AMC) may prove to be a good solution for the OFDM system with full channel feedback. But it has a higher complexity in terms of optimization, and full channel feedback information is also less reliable in fast-changing environment due channel estimation error.

On the contrary, under such fast fading channel conditions, the binary channel state information at the transmitter could be available more reliably and at a much lower overhead. This is because, in our approach, binary feedback corresponds to the comparison of the received signal strength with the threshold without resorting to any channel estimation technique. In our proof of concept study, we generate four coefficients, after the first level DWT. Each coefficient in the form of a data vector is mapped on to a sub channel. We compare the energy saving and reception quality performance, by sending all coefficients over the mapped sub channels versus.

A.DWT-OFDM System:

The proposed model is for transmission of DWT compressed data over OFDM channels in fading environment and illustrated in Fig. 1. The steps involved are as follows:

• In the first step of proposed system initially we read the input image into the MATLAB

• Then DWT is applied on a video frame of original size S1 ×S2 pixels, producing four discarding the ones that are mapped on to the bad channels. Our results show that, up to 60% energy saving is possible at the low fading margins with a considerably high gain in the quality (PSNR) of the received image.

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II.SYSTEM MODEL :

In our system model, input color image 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 sub channels can only affect the lesser important data vectors. We consider only one-bit channel state information available at the transmitter, informing only about the sub channels to be 'good' or 'bad'. For a good sub channel, instantaneous received power should be greater than a threshold Pth. Otherwise, the sub channel is in fading state and considered 'bad' for that batch of coefficients. Note that the data transmitted through deeply faded sub channels are highly prone 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. Below, we described the DWTOFDM system model in details.

sub-images: HL, LH, HH, and LL, each of the size S_1/2×S_2/2 pixels.

• From these sub-images four coefficient vectors are generated, each of lengths1.s2/2.
• The coefficient vectors are uniformly quantized and binary coded with L bits/coefficient to form four bit streams.
• The bit streams are packetized and mapped on the OFDM system.

B.Packetizing and mapping onto the OFDM system :

As described in Fig. 1, bit streams are packetized by chopping them into bit vectors of size N_ bits. Four such vectors are contained in a packet. Training bits are added at the front of each bit vector to estimate the SNR of the sub channels at the receiver. We illustrate the system by taking an example of OFDM system with IFFT size 128. For this system 32 packets are arranged in parallel to get 128 bit streams (see Fig. 1).

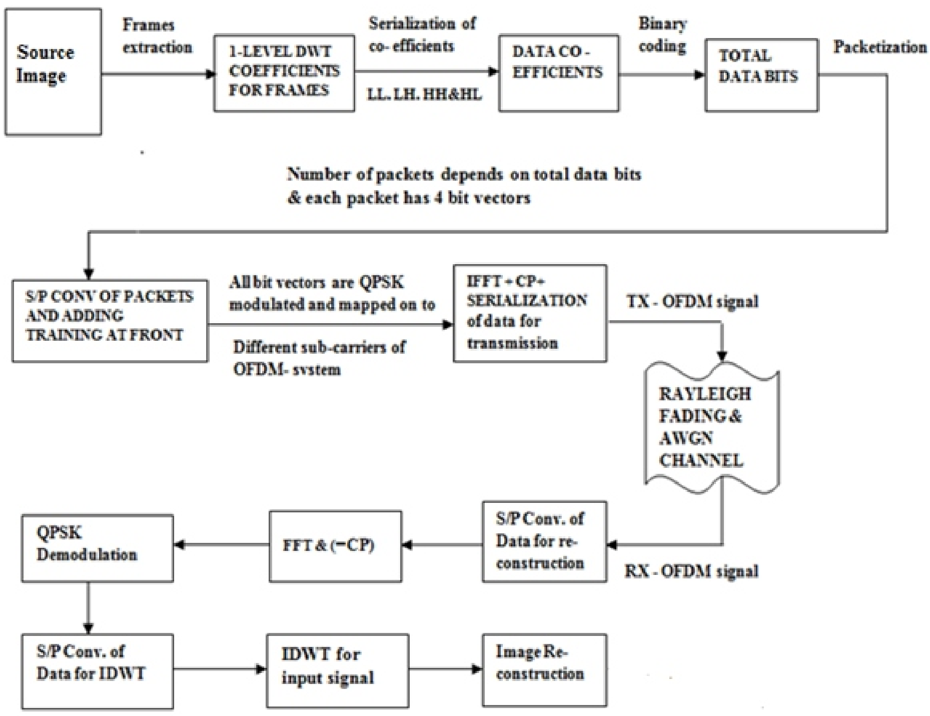


Fig1. Proposed DWT OFDM BASED Block Diagram

Each bit vector in a packet is m-ary modulated, and 32 packets are simultaneously transmitted through different sub channels set. Here we use the feedback to decide the sub channel condition ('good' or 'bad'), and accordingly re-arrange the data vectors to map them to the IFFT module. We propose a mapping scheme, which is proved to be efficient in terms of quality reception as well as energy savings. Packets are sent through frequency selective, slowly varying fading channel. The reverse process is done at the receiver with suitable treatments due to the discarded or lost data vectors.

C.Channel Model :

In this study we use block fading channel model as in. The channel model is illustrated in Fig. 3, where M is the coherence bandwidth in terms of number of sub channels. In a block fading environment, M consecutive sub channels will simultaneously be either bad or good. Each such set consisting M sub channels is called a 'sub-band'. We denote total number of such sub-bands in the OFDM system as N. Thus, the total number of sub channels in the system is N × M. All sub-bands are independently faded with Rayleigh-distributed envelop, which corresponds to the block fading approximation in frequency domain. Our proposed mapping scheme generates a situation of subcarrier assignment for each data vector in a packet.

III.FORMULATION :

We now formulate the average distortion and energy savings in our proposed transmission scheme. We measure the system performance by probabilistic analysis of the average distortion in a block fading environment. In our interleaved coefficient mapping scheme, all the four sub channels per group of four coefficients are from different sub-bands. Thus, p will also be the probability of a sub channel to be bad. Let Pi = probability associated with the loss event i, for i = 0, 1, 2, 3, 4, which produces distortion Di.

Energy Saving Approach :

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

$$\%\text{Energy saved}=100\times\sum_{i=0}^{4} iP_i/4$$

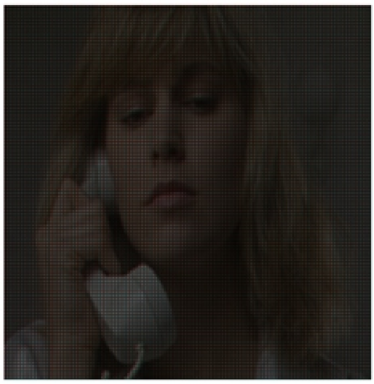
SIMULATION RESULTS:

Simulation results have been done in MATLAB 2011a version and tested for various color images. The source image has been shown in fig2. In fig3 we showed the received images with different PSNR values i.e., 21, 28 and 38 in which the reception quality will increase while increasing the PSNR value.

source image

Fig.2 Source image

Received image with PSNR 21



(a)

Received image with PSNR 28

(b)

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(c)

Fig3. Output received images with different PSNR values after transmitting through OFDM channel

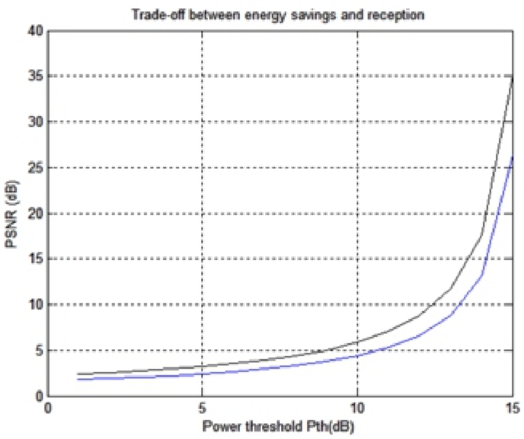

Fig4 Tradeoff between Pth and PSNR values

In fig4 we had shown the tradeoff between the PSNR and the power threshold value. We can see that the PSNR has increased while increasing the threshold power value.

V.CONCLUSION:

To conclude, we present a case of DWT compressed video transmission over OFDM channels where binary channel state information is available at the transmitter, but retransmission is not allowed. 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. Our analytic observations on reception quality and energy saving performance are validated by extensive MATLAB simulations.

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