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Transmission of DWT Image over OFDM Fading Channel with Channel State Feedback

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Abstract

In OFDM system the transmission in fading channel is the challenging issue. Due to this fading, subset of carriers may be affected and they are cancelled at the receiver and it is also not possible to retransmit the lost packet. If the channel state information is available at the transmitter it is easy to retransmit the data by mapping and give the description effectively onto the good sub carrier and eliminate the bad sub carries which produces high channel error at the receiver. This paper describes the saving of energy approach for transmission of first level discrete wavelet transformed (DWT) based compressed image over fading channel. With the availability of channel state information at the transmitter and the description based on the descending order priority. This will reduce the consumption of power in the system, by dropping the data onto the bad subcarriers with mapped description at the transmitter. The parameter that were analyzed for system power consumption without effecting the data are in terms of peak signal-noise ratio(PSNR), distortion, Bit error rate(BER) are simulated using MATLAB. It gives 60% of energy saving.

Keywords: *DWT-OFDM system, fading broadcast channel, Channel state feedback, energy saving***.**

1. Introduction

In the modern wireless communication systems data rate increases and if data rate increases it leads to inter symbol interference (ISI) and noise will be effect information which is caused due to frequency selective fading. Rayleigh fading is a type of frequency selective fading and time varying behavior of channel. To reduce the effect of ISI multi carrier modulation is used. OFDM is the best multi-carrier modulation which shows the good performance and over lapping is possible in the frequency domain. In the OFDM system sub carrier is affected by the flat fading for period of time, sub channel may be good or effected by the fading. The packets which are transmitted through the fading channel are heavily affected by fading which leads to error that cannot be accepted at the receiver. One of the advantages in OFDM system is that, it provides the diversity in the frequency domain by providing number of sub carriers and work for the multiple bit streams by multiple sub channels for application.

In general three types of source coding techniques are used one is non -progressive coding that was designed for compression efficiency but it need retransmission. Another one is progressive coding technique it also requires the retransmission and it offers scalability. And the third one is multiple descriptions coding (MDC), it requires no retransmission but it sacrifices some compression efficiency. In still image transmission most common way is that is progressive coding technique. In the transmission of image or video compression techniques, such as JPEG2000 layered coding technique is performed which uses discrete wavelet transform (DWT). In this technique it was designed such that layers are predefined order process data and reconstruction of the image at the receiver. This process produces delay which is unpredicted. Therefore system performance will be reduced. Layered coding produces data of unequal importance and hence one has to put a higher protection for more important data. To overcome this effect it requires scalability in the layer coding approach. This will reconstruct the image with acceptable quality. Even though these layers should reach perfectly, but this requires retransmission. Although progressive coding woks effectively in the loss-less transmission system, and while reconstruction of image can leads to retransmission in the error, which is not possible in the real time content delivery application. To overcome the above problem MDC is used this will not allow any delay in reception. In this, the contents are divided into DWT coefficients, which are divided into multiple bit streams called description, and these are transmitted in different channels MDC receiver is able to decode with a low but acceptable quality even if a fewer descriptions. MDC always outperforms in delay sensitive applications when compared with the layered coding technique. MDC provides an opportunity to estimate the lost packet and description from the correctly received without the need of retransmission. 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. Even CSI is known MDC distributes the importance equally to coefficients, 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 transmission process. Compared to MDC the lost coefficients in DWT image would still introduce lesser distortion.

With the binary channel state feedback a key observation is that, the unequal importance level of the compressed image coefficients can be combined to achieve an improved transmission performance in delay-sensitive areas. By providing feedback it can also be used further for energy saving in the process of transmission with little or no trade-off in transmission performance. In this paper, it explore the possibility of transmitting JPEG2000 compressed (DWT) image frames through the block fading OFDM channels with *one bit channel state feedback*, like layered coded frame transmission, it is not possible retransmission of lost packets. In the binary channel state feedback with predefined threshold power acceptable at the receiver and we can decide whether the channel is good or bad in the deeply fading channel by the mapped scheme in the transmission of sub channel which belongs to good ones.

As an *energy saving measure*, if a coefficient is mapped onto a 'bad' sub channel, it is discarded at the transmitter itself. In this mapping scheme it ensures that the discarded coefficients are of rather lesser importance. In point to point communication systems it is required retransmission of the packets without distortion for image/video transmission and frames can be reconstructed Prior work on DWT-OFDM system in studied the In OFDM system transmission of DWT image in multipath channel. For this case it is desirable to consider the high pass confidents and discard the low pass coefficients. This leads to the energy saving approach in the fading channel environment. 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 DWT. All coefficients in the form of a data vector is mapped on to a sub channel. It compares the energy saving and reception better performance on transmitting all coefficients over the mapped sub channels versus discarding the ones that are mapped on to the channels which are affected. Our results show that, up to 60% energy saving is possible at the low with a consideration fading margins high gain in the quality (PSNR) of the received image. In the following Section II describes the DWT-OFDM system model, followed by the proposed mapping and energy saving scheme. Section III presents the analysis of distortion and energy saving in the proposed approach. Section IV contains the simulation and analytical results and discussions about the results. Finally the paper is concluded in Section V

2. System Model

In the proposed model the input image is compressed into the frame by using DWT. These compressed images are arranged data coefficient vectors. The coefficients are quantized to produce the binary stream of bits, mapped intelligently and packetized. By four bits each. In this paper only one bit channel state is considered for OFDM transmission over different fading channel condition. If they under goes in the fading it leads to the poorer reception the image, so one bit CSI is considered at the transmitter that gives whether the channel is 'good' or 'bad' for the transmission of the signal. By setting the power level based on the fading margin which gives the threshold power. For the optimized transmission good sub channels are taken such that power is greater than the threshold power. Otherwise the sub channels are affected by fading. If the sub channels are deeply affected by fading they will be canceled at the receiver. In fading environment, channel noise (say AWGN) can lead to wrongly declaring a 'good' as bad channel especially when the received signal power lies near the threshold. In this paper it ignored because of their lower probability of occurrence. So in this paper shows the better results and an opportunity to map the bit stream intelligently to save the power.

In the Fig 3. it was given the explanation OFDM based transmission of the image over the different channel. The image is decomposed into first level DWT. It produces four sub image and if the size of the image is $H \times W$. Each sub image as described in the fig after the quantization is done the binary bit streams are packetized into four vector bits in the packet. This packet will be added with the training bits sequence at front of the each vector these will estimates SNR of the sub channel at receiver.

Header information provides error free at the receiver. In the fig shown it has IFFT of the size 128. And number packets generated are 32 which simultaneously arranged parallel 128 bit stream. All sub carrier in the entire OFDM channel are used for the point-to-point content delivery purpose, and hence a sub channel implies the frequency band corresponding to a given sub carrier. Thus, in this context, we propose a mapping scheme on to the IFFT module to decide the sub carrier are 'good' or 'bad', such that date vectors are rearranged. Here, the number sub channels are equal to number of sub carriers. The packets generated are sent through the frequency selective fading channel, slow varying channel. This will gives the energy saving transmission the reverse process is done at the receiver that grade the good sub channels and discard the bad sub channels.

2.1 Mapping scheme:

In the proposed mapping scheme it is an intelligent mapping of the data vector. The sub channel state information is fed back to transmitter in the form of one bit binary the implies the 'good' ones are treated as logic '1' and the 'bad' ones are treated as logic '0'. This logical approach is simple and less complex in design. All this compressed technique involves in the received signal power with predefined threshold power P_{th}. For bad channel it is understood that the Received signal is under below acceptable levels of the threshold power. With this information data mapping onto the bad sub channels will be stopped at the transmitter. Apart from this receiver checks the

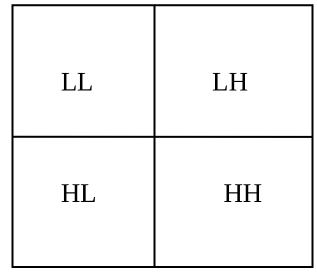

Fig1. First level DWT decomposition of the image.

image consists of $\frac{H}{2} \times \frac{W}{2}$ pixels. The sub images after the conversion DWT are LL, LH, HL and HH as shown in the fig.

And from the sub images we can take the coefficient vectors of length $\frac{H.W}{2}$. These coefficient vectors are uniformly quantized to form the binary code with L bits/coefficient which forms the bit streams. The bits streams are packetized and mapped on the OFDM system.

data vectors received for the power is below the threshold power level are not retransmission of discarded coefficients are avoided. The discarded coefficients are replaced by the average coefficient values of the respective sub image instead of retransmission of the data vector coefficients. This will leads to addition of some distortion.

The distortion caused by the mapping scheme discarding the coefficients has to be minimized and it plays an important role. In general the low pass filtered coefficients of the DWT image, and this are more important and these will have the less variance level. As shown in the fig the data vector arranged in the 32 packets in the frequency domain. The sub channel are grouped whether good are bad in order as specified in the fig. this group information is scanned in order to collect the good ones. The average distortion produced by per the coefficients D. and by choosing the threshold value P_{th} affects the data vectors which are discarded at the transmitter so that quality of reception and the threshold power saving will also increases. P_{th} value is chosen such that it corresponds to the fading margin.

2.2 Channel model:

In this model it revels with the block fading channel which was shown in the Fig 2. where M is the coherence band width in terms of the number of sub carriers in the block fading environment. It is the consequence that M sub channel will simultaneously be 'good' or 'bad'. An M set of sub channel are called sub band. Which denote the OFDM system as

N. Thus, for the proposed system contains the $N \times M$. these sub channels are affected with the Rayleigh distributed envelop, which corresponds to block fading approximation. In this model sub carriers are generated which are assigned with the data vectors in all packets.

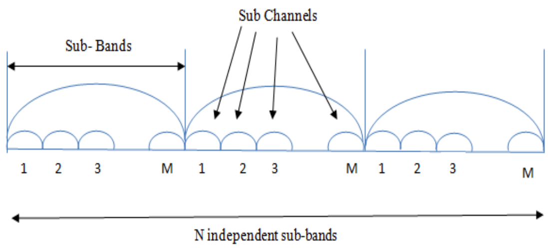

Fig 2. The sub carrier model in the block fading channel of OFDM system

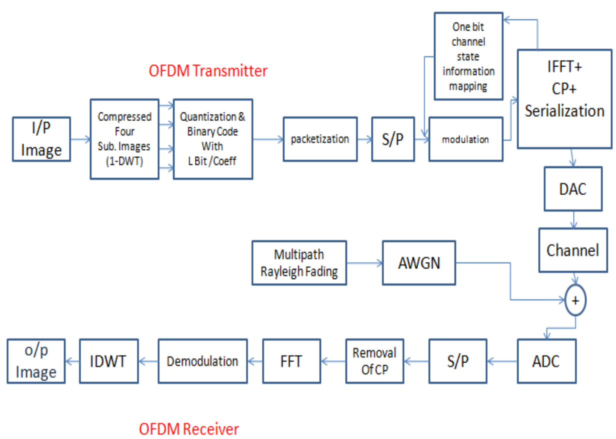

Fig 3. DWT image transmission and reciption on OFDM

3. Mathematical modeling

Measurement of average distortion and energy savings are done in this proposed transmission and a measure of system performance by the probabilistic analysis in the block fading channel has made.

3.1 Distortion Model:

In the proposed model data vectors are arranged in the sub channels with only the specific loss event can occur. Consider the case that data vector with higher important is sent through a bad sub channel which results in a loss likewise the data which is having the less importance is transmitted on the good sub channel and that could be received correctly. So to reduce the distortion this proposed mapping scheme gives an opportunity to decrease the effect of fading as much as possible as given channel condition. So to model that a few loss events are taken place and they can be transmitted.

Assumption data vectors are to be mapped with different specifications. In the fallowing case it was such that all the four vector are received with any lost, or only three events are received except s_4, or only two event are received except s_3 and s_4 are lost, or only one event is received except s_2, s_3 and s_4 are lost. And there is a possibility of all events is lost. Thus, according to the events are this mapping scheme was designed. Now consider the distortion for the lost data vector coefficients or discarded coefficients

When no coefficients are lost in the in the process, distortion is taken as:

$$T_{1111} = T_4 = \frac{4\delta^2}{12} \qquad (1)$$

Where δ is the step size of quantizer and $\frac{4\delta^2}{12}$ is total quantization noise. If s_4 is lost then the corresponding distortion is taken as

$$T_{1110} = T_3 = \mu_4 + \frac{3\delta^2}{12} \qquad (2)$$

Similarly, if $s_3$and s_4 are lost then the corresponding distortion is taken as

$$T_{1100} = T_2 = \mu_3 + \mu_4 + \frac{2\delta^2}{12} \qquad (3)$$

If s_2, $s_3$and s_4 are lost then the corresponding distortion is given by

$$T_{1000} = T_1 = \mu_2 + \mu_3 + \mu_4 + \frac{\delta^2}{12} \qquad (4)$$

And if all the vector coefficients s_1, s_2, s_3 and s_4 are lost then the distortion is taken as

$$T_{1000} = T_0 = \mu_1 + \mu_2 + \mu_3 + \mu_4 + \frac{\delta^2}{12} \qquad (5)$$

From the above equation we can rewrite the equation as

$$T_i = \begin{cases} \frac{i\delta}{12}, & i = 4 \\ \sum_{i+1}^{4} \mu i + \frac{i\delta^2}{12}, & other \end{cases} \qquad (6)$$

Where T_i is the diction and i is the number of lost data vector out of four (i = 1, 2, 3, 4)

Fading channel model: The performance of the mapped scheme depends on the probability of the lost events. And here the fading parameters decides the lost events as mention above in System model the packets are mapped channel fading can be independent to all the four data vectors. So for the Rayleigh fading channel the received power P is the exponentially distributed with probability density function (*pdf*):

$$f_p(a) = \frac{1}{\bar{P}} e^{-a/\bar{P}} \qquad (7)$$

Where $\bar{P}$the average is received power. If Ψ is the fading margin, which can be related to the received power and the thresh hold power sensitivity P_{th} as

$$\Psi = \frac{\bar{P}}{Pth} \tag{8}$$

Let p is the be the probability associated with sub-bands and using the above equation we can rewrite as

$$P = \int_0^{Pth} fp(a)da = 1- e^{-1/F} \tag{9}$$

This model the coefficients are due to the sub images which are mapped onto sub channel per the group these are interleaved coefficients of the mapping scheme. Thus, *p* is the probability associated with the sub channels. And let Pi is the probability associated with the lost event *i*, for *i* = 1, 2, 3, 4, which produces distortion Ti. So we can write for received packet as:

$$P_i = \binom{4}{i} p^{4-i}(1-p)^i \tag{10}$$

And we can write the average distortion as

$$\bar{T} = \sum_i^4 TiPi \tag{11}$$

This P_i and T_i are obtained from the above equation

3.2 Energy saving:

The data which is affected by fading is unimportant data which will be discarded at the transmitter to save the power. This will also denote the percentage of the data packets that are not transmitted. And these data packets represents energy saved E.

$$E = \sum_{i=0}^4 \frac{iPi}{4} \tag{12}$$

And percentage of the energy saved

$$\%E = 100 \times \sum_{i=0}^4 \frac{iPi}{4} \tag{13}$$

4. Simulation Results.

The simulation results with respect to mathematical model have done. For this simulation an image of the size 256 × 256 is transmitted over the OFDM fading channel. The OFDM system consists of 128 sub carriers which is $N \times M$. So it is clear that 32 packets can be transmitted simultaneously through the OFDM system. The packets are in time and frequency domain as described before, but the packets that are transmitted back are corrupted due to slow time varying behavior of fading. So that it is better to maintain the coherence time to more than the packet transmission time through the sub channel. And the channel condition is fed back for each packet. Block fading channel are simulated with sub bands $N = 4$ and the coherence bandwidth equivalent to 32 sub carriers ($M = 32$). QPSK is used in the modulation scheme. Thus, 128 × 2 bits per symbols is transmitted in the channel. The variance in the image provides the distortion values associated with different lost vectors. The conditional distortion is plotted against P_{th} *i*.e., thresh hold power value. It is observed that for low value of P_{th} high fading margin and have effective distortion probabilities are observed to be decreased. And give an opportunity to save the power. The distortion measured in the and the percentage of the energy save are plotted against the P_{th}. The analyzed results are supported by the simulated values. To show the effective values fading we neglect the AWGN in the simulation. As the threshold power increases distortion also increases. And it is observed that this increase is not high, the data values which have lower importance will have higher probability in transmission of bad sub channel. This will also show that restriction of the less important data from transmission on to bad sub channels gives the energy saving. From the results it can be seen that 60% energy can be saved. Image transmission through OFDM system provides the simulation data. The PSNR and the energy saving variance are shown in the fig. In this AWGN was also included. Before this proposed scheme for fair compression with the base scheme in this the data vector are rejected at the receiver hence power is wasted. In this proposed model the data vector which is going to be affected will be discarded at the transmitter. So, rather receiver will rejects the coefficients with the instantaneous power SNR below the acceptable levels. It is observed that the system shows the better results at the optimal threshold power of 9dB. For the lower value of P_{th} less than 9dB AWGN dominates. These produce the higher distortion, and the sub channel will be deeply faded this provides less energy saving. But, for the higher values of thresh hold power P_{th} > 9dB the affect of AWGN will diminishes and this will also give the energy saving. Depending on the power received transmission can be restricted. The decision is made from the threshold power value P_{th}. So, the system can be controlled by threshold power P_{th}. From the fig the received image with PSNR 21dB has the poor response quality. So, by choosing right P_{th} quality and energy saving can be improved.

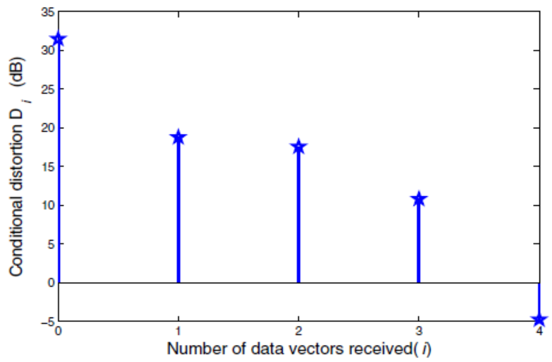

Fig 4. Distortion models with respect to the lost event

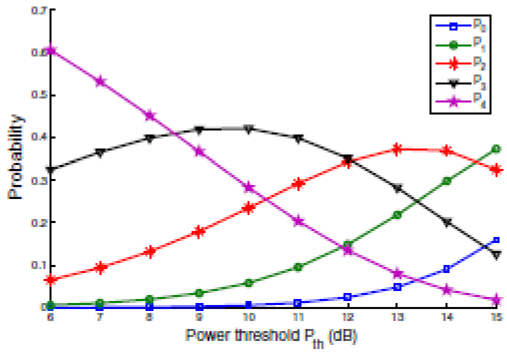

Fig 5. Probabilities associated with the lost packets in different fading channel condition

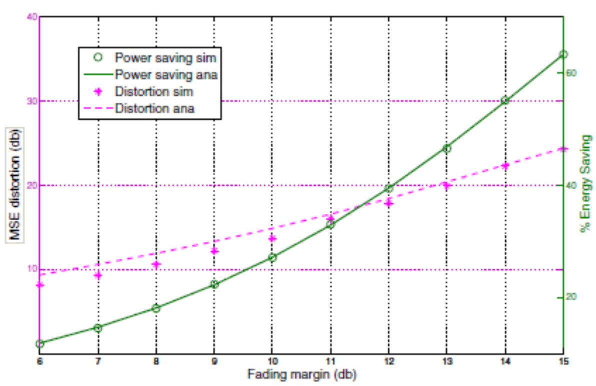

Fig 6. Mean square error in the fading margin

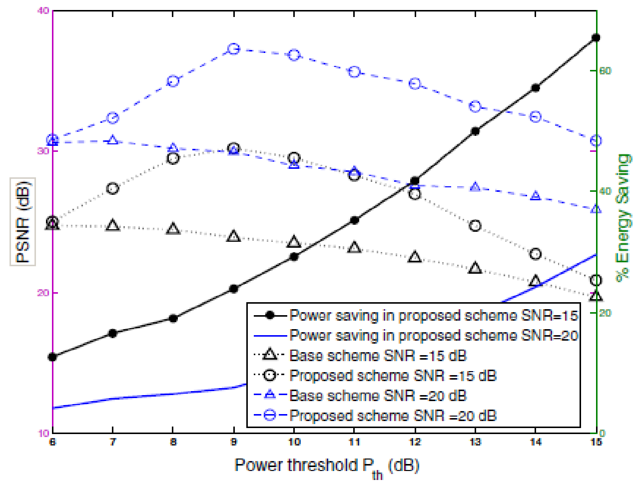

Fig 7. Energy saving PSNR with respect to threshold power P_{th}

(a) (b)

(c) (d)

Fig 8. Transmission of 'Lena' image with different SNR values. (a) Original image. (b) Received image with PSNR 38dB. (c) Received image with PSNR 28dB. (d) Received image with PSNR 21dB

5. Conclusions

In this paper, transmission of the DWT image in OFDM fading channel with one bit channel state information is done. This proposed scheme is designed for the energy saving in the transmission. In this model the descending order priority in the mapping scheme is done. Only the good ones are considered. The coefficients with the lower important power level will be discarded at the transmitter with this power can be saved. All the analytical parameter and observations of the performance is done using MATLAB simulation software. As the work ahead, it can be extended to CSI adaptive channel rate and a power control which is a trade-off between transmissions.

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