AN EFFICIENT TRANSMISSION OF DWT COMPRESSED VIDEO FRAMES OVER AN OFDM SYSTEM

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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 video frames over the OFDM channels with the increasing use of multimedia applications like mobile applications, Digital Video Broadcasting, 3rd Generation cellular networks and video conferencing. 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.**

Keywords—**Frames extraction, DWT compression, transmission & Reception of video frames data coefficients over AWGN OFDM System.**

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 [4-9]. 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 [2,6] 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 [6] 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 video transmission, most common way is progressive (or layered) encoding technique. State-of-the-art image or video compression techniques, layered coding is performed [1]. 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 loss-less transmission [1,4-7] system, in the event of errors reconstruction of image can be difficult 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. 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 [2] 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, we explore the possibility of transmitting DWT Compressed video frames 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 with the transmission of DWT compressed 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 to 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 this, we generate four coefficients from each frame of our video after the first level DWT. Each coefficient in the form of a data vector is mapped on to a sub channels those are orthogonally multiplexed with respect to frequency. We compare the energy saving and reception quality performance, by sending all coefficients over the mapped sub channels versus 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 of the received frame.

II SYSTEM MODEL

In our system model, video frame is compressed using DWT, and the compressed data is arranged in data vectors, each with equal number of coefficients. These vectors are binary coded to get the bit steams, which are then packetized and intelligently mapped onto 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. Otherwise, the sub channel is in fading state and considered as 'bad – sub channel' for that group 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 DWT-OFDM system model in details.

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:

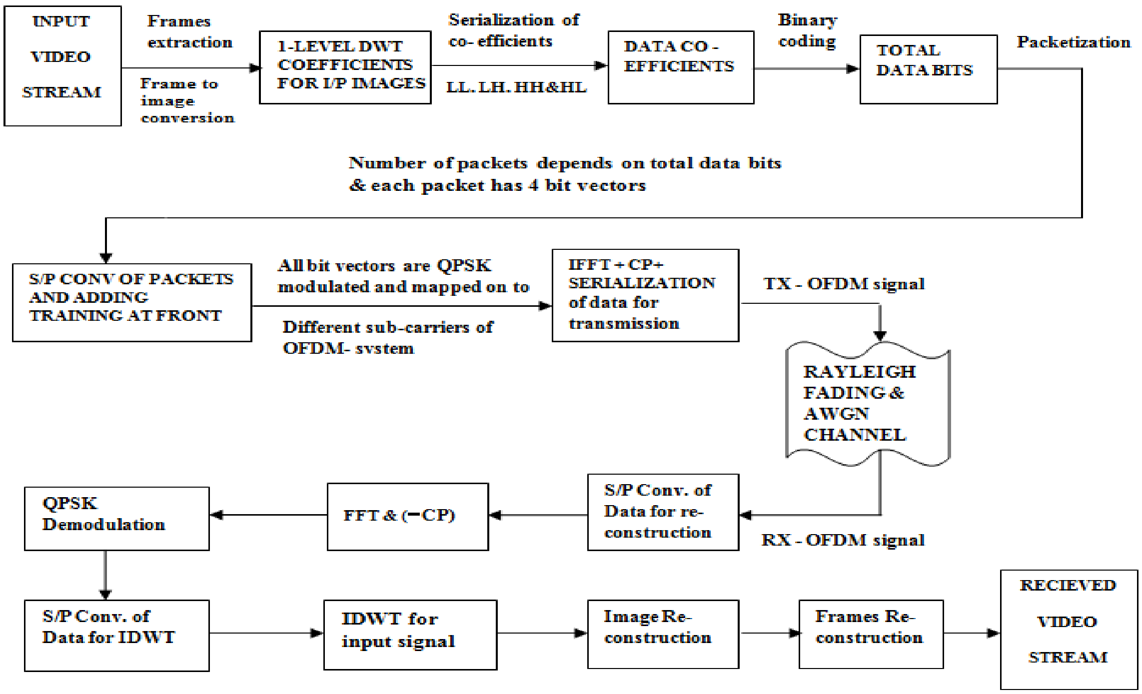

Fig1. Proposed DWT OFDM BASED Block Diagram for video fames transmission

1. In the first step of proposed system initially we read the input video stream into the MATLAB
2. Then we will split the video into number of frames.
3. After splitting the video into frames we will convert the frames into images
4. DWT is applied on an image of particular video frame of original size $S1 \times S2$ pixels, producing four sub-images: HL, LH, HH, and LL, each of the size $\frac{s_1}{2} \times \frac{s_2}{2}$ pixels.
5. From these sub-images four coefficient vectors are generated each of length $\frac{s_1 \times s_2}{2}$.
6. The coefficient vectors are uniformly quantized and binary coded with L bits/coefficient to form four bit streams.
7. The bit streams are packetized and mapped on the OFDM system.
8. The same process will be repeated for each and every frame of input Video stream.

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 X 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. Each bit vector in a packet is *m*-ary modulated and all 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 this is illustrated in [10], Let *M* be 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 $N \times M$. 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 AND ANALYSIS

We now formulate the average distortion and energy savings in our proposed transmission scheme for video frames those are taken from [10]. We also measure the system performance by considering probability density function (pdf) of Rayleigh fading channel, fading margin (F), probability of sub-band which is in deep fade (*p*) & probabilistic analysis of the average distortion in a block fading environment from [10].

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 [10]. Let *Pi* = probability associated with the loss event *i*, for *i* = 0, 1, 2, 3, 4, which produces distortion *Di* [10]. Thus, for an arbitrary received packet we can write:

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

Then the average distortion can be given as

$$\overline{D} = \sum_{i=0}^{4} D_i P_i \qquad (2)$$

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 high fading environment. Denoting the percentage of data not transmitted in a packet as a measure of the percentage of energy saving, using (1) we can write energy saving expression as:

$$\%\text{Energy saved} = 100 \times \sum_{i=0}^{4} iP_i / 4 \qquad (3)$$

IV SIMULATION RESULTS

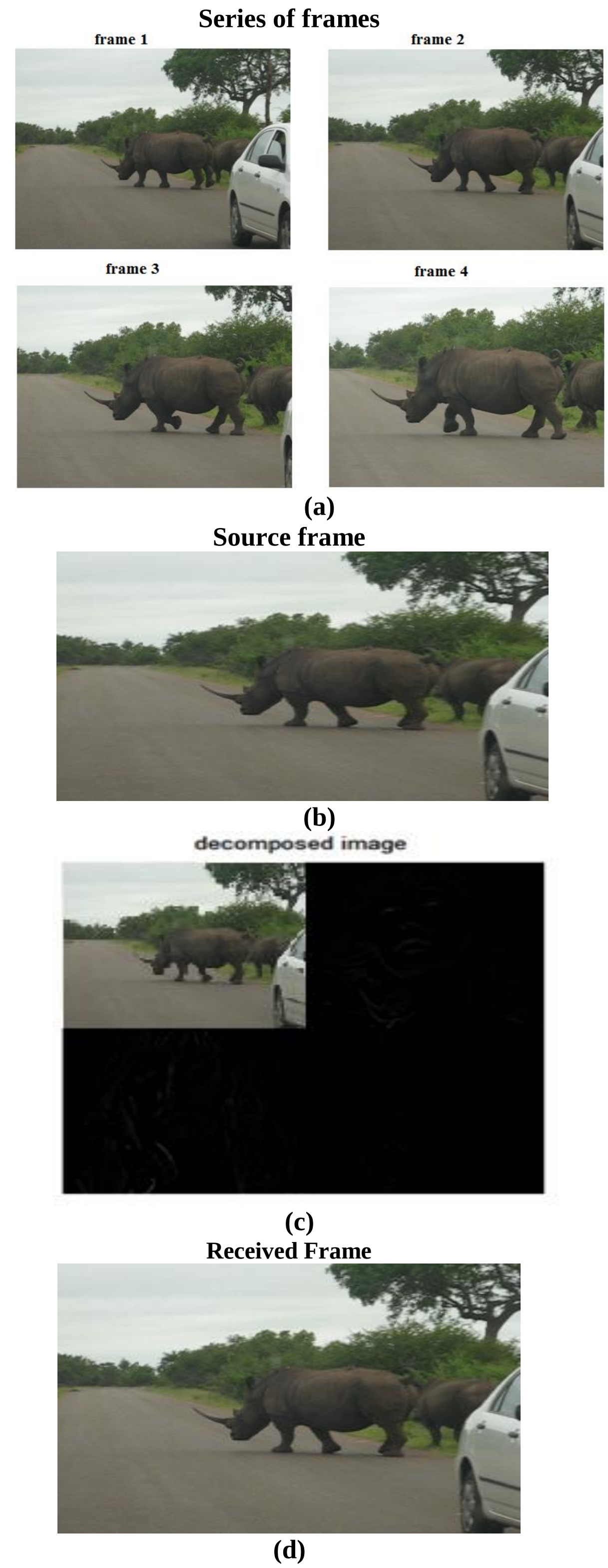

Fig2. (a) Series of extracted frames from video (b) Input frame (c) DWT decomposed frame (d) output received frame after transmitting through OFDM channel

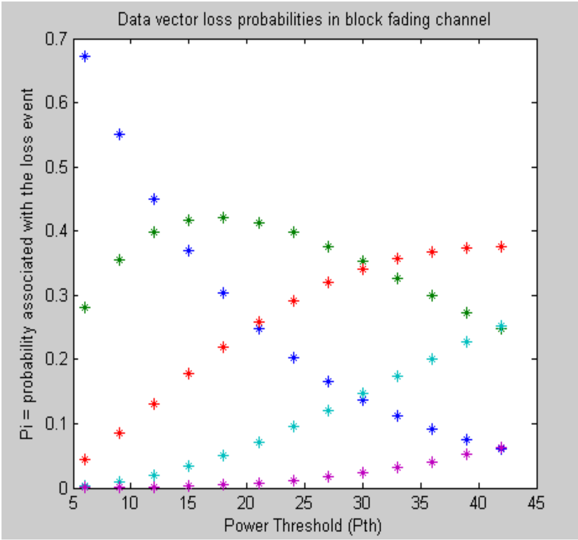

Fig3 data vector loss probabilities in block fading channel

Here Simulation results are shown in above figures i.e., fig2 (a) shows that the Input video frame. Here we have shown the 4th frame from the input Video stream. After that DWT decomposed image will be shown in fig2 (c), then in fig2 (d) we have shown the Received frame, finally the Data vectors loss probabilities in block fading channel w.r.t Power threshold in fig3 and also we calculate the % Energy saved per every frame by using equation (3).

V CONCLUSION

To conclude, we present a case of DWT compressed video frames transmission over OFDM channels at the transmitter but retransmission is not allowed. We propose an energy saving approach, where the compressed coefficients for each frame are arranged in descending order of priority and mapped over the channels starting with the good ones. The coefficients with lower importance levels are likely mapped over the bad channels are discarded at the transmitter to save power without significant loss of reception quality. While at the time of reception we are considering the averaging of surrounding pixels to reconstruct the lost coefficients. Our analytic observations on reception quality and energy saving performance are validated by extensive MATLAB simulations.

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