

ANALYSIS OF AN OFDM BASED APPROACH FOR COLOUR IMAGE TRANSMISSION USING DWT

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ABSTRACT

In many applications retransmission of lost packets are not permitted. In an OFDM system, due to channel fading, only a subset of carriers is usable for successful data transmission. If the channel state information is available at the transmitter, it is possible to take a proactive decision of mapping the descriptions optimally onto the good subcarriers and discard at the transmitter itself the remaining descriptions, which would have been otherwise dropped at the receiver due to unacceptably high channel errors. Image transmission over the fading channels without degrading the perceptual quality is a challenging task while mitigating the power consumption in many fields such as broadband networks, mobile communications, Image sharing and video broadcasting. Also, it is not possible to resend the lost packets every time in many applications such as video broadcasting. Here, an effective approach for color image transmission has been proposed with power saving approach over OFDM system. Experimental results shows that the reception quality of received image is good enough with various peak signal to noise ratios also saved 60% of energy. In this paper we present a energy saving approach to transmission of discrete wavelet transformation based compressed image frames over the OFDM channels. Based on one-bit channel state information at the transmitter, the descriptions in order of descending priority are assigned to the currently good channels. In order to reduce the system power consumption, the mapped descriptions onto the bad subchannels are dropped at the transmitter.

1. INTRODUCTION

In general, there is always a need for higher data rates over any communication network. But due to the inter symbol interference (ISI) and frequency selective fading channel such as Rayleigh fading channel, higher data rates will be limited [1], [2] and [3]. One of the best approaches to mitigate the ISI is multi-carrier modulation [4]. Orthogonal frequency

division multiplexing is a well known multi-carrier modulation scheme that is having excellent performance which allows overlapping in frequency domain [5-6]. 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. However, if some channel state information (CSI) (e.g., binary indication, like „good“ or „bad“) is available at the transmitter to know the packets, are on the good or bad channels. The discrete wavelet transform (DWT) is used to compress the data packets that 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.

Orthogonal Frequency Division Multiplexing (OFDM) introduced in the year 1960, based on the multicarrier modulation techniques used in high frequency range for military application. In the year 1971, the basic idea created

based on Discrete Fourier Transform (DFT) for the implementation of OFDM and removing the requirement for banks in the analog subcarrier oscillators [1]. Each FDM channel is separated from the others by a frequency guard band to reduce interference between adjacent channels. With the advance of communications technology comes the demand for higher data rate services such as multimedia, voice, and data over both wired and wireless links. Even though the Wireless Communication Systems like OFDM can reveal efficient bandwidth it makes deteriorate effect on

performance by multi-path fading channels. Forever, to enhance the performance there is a need in development to recognize the system in addition a well organized channel estimation and equalization methods [2]. The relevant subcarrier causing Inter Symbol Interference (ISI) in addition with unlike sub-carriers causing Inter Carrier Interference (ICI) will have self-interference occur along with successive symbols in the dispersive channel. This is avoided in timeinvariant frequency-selective channel [5]. In this project ,the proposed work based on the color image transmission with the help of OFDM(Orthogonal Frequency Division Multiplexing) and DWT (Discrete Wavelet Transform). Here we are using OFDM because we know that OFDM is a multicarrier transmission scheme and high data bit rate . 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 subchannels are affected by flat fading, so for a period of time, condition of the subchannels may be good, or they might be deeply faded. The packets which are transmitted through these faded subchannels 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, such as JPEG2000 [1] (which uses Discrete Wavelet Transform DWT), 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 loss-less 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.

2. WAVELET ANALYSIS

The basic idea of this proposal is to use wavelets as a mean of extracting features from a voice signal. The wavelet technique is considered a relatively new technique in the field of signal processing compared to other methods or techniques currently employed in this field. Fourier Transform (FT) and Short Term Fourier Transform (STFT) and are the current methods used in the field of signal processing. However due to severe limitations imposed by both the Fourier Transform and Short Term Fourier Transform in analyzing signals deems them ineffective in analyzing complex and dynamic signals such as the voice signal. In order to substitute the shortcomings imposed by both the common signal processing methods, the wavelet signal processing technique is used. The wavelet technique is used to extract the features in the voice signal by processing data at different scales. The wavelet technique manipulates the scales to give a higher correlation in detecting the various frequency components in the signal. These features are then further processed in order to construct the voice recognition system. Extracting the features of the voice signal does not limit the capabilities of this technique to a particular application alone, but it opens the door to a wide range of possibilities as different applications can benefit from the voice extracted features. Applications such as speech recognition system, speech to text translators, and voice based security system are some of the future systems that can be developed.

A. Fourier Transform:

The signal can be analyzed more effectively in frequency domain than the time domain, because the characteristics of a signal will be more in frequency domain. One possible way to convert or transform the signal from time to frequency domain is Fourier transform (FT). FT is an approach which breaks down the signal into different frequencies of sinusoids and it is defined as a mathematical approach for transforming the signal from time domain to frequency domain. Fig.1. Analysis of FT

with an example FT has a drawback that it will work out for only stationary signals, which will not vary with the time period. Because, the FT applied for the entire signal but not segments of a signal, if we consider non-stationary signal the signal will vary with the time period, which could not be transformed by FT. and one more drawback that we have with the FT is we cannot say that at what time the particular event will has occurred.

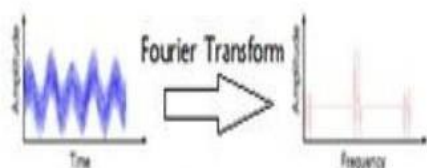


Fig.1. Analysis of FT.

B. Short-Time Fourier Analysis:

To correct the deficiency in FT, Dennis Gabor in 1946 introduced a new technique called windowing, which can be applied to the signal to analyze a small section of a signal. This adaptation has been called as the Short-Time Fourier Transform (STFT), in which the signal will be mapped into time and frequency information.

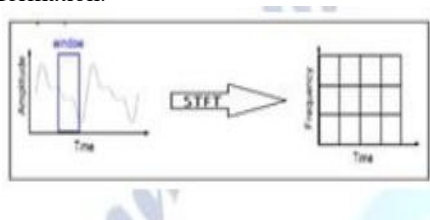


Fig.2. STFT analysis of a signal

In STFT, the window is fixed. So, we this window will not change with the time period of the signal i.e., for both narrow resolution and wide resolution. And we cannot predict the frequency content at each time interval section. To overcome the drawbacks of STFT, a wavelet technique has been introduced with variable window size. Wavelet analysis allows the use of long time intervals where we want more precise low-frequency information, and shorter regions where we want high-frequency information.

C. Discrete Wavelet Transform (DWT):

Discrete Wavelet Transform (DWT) is a revised version of Continuous Wavelet Transform(CWT). The DWT compensates for the huge amount of data generated by the CWT. The basic operation principles of DWT are similar to the CWT however the scales used by the wavelet and their positions are based upon powers of two. This is called the dyadic scales and positions as the term dyadic stands for the factor of two [12]. As in many real world applications, most of the important features of a signal lie in the low frequency section. For voice

signals, the low frequency content is the section or the part of the signal that gives the signal its identity whereas the high frequency content can be considered as the part of the signal that gives nuance to the signal. This is similar to imparting flavor to the signal. For a voice signal, if the high frequency content is removed, the voice will sound different but the message can still be heard or conveyed. This is not true if the low frequency content of the signal is removed as what is being spoken cannot be heard except only for some random noise.

3. SYSTEM MODEL

In our system 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 streams, 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 P_{th} . Otherwise, the subchannel is in fading state and considered „bad“ for that batch of coefficients. Note that the data transmitted through deeply faded subchannels 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.

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:

- 1) DWT is applied on an image frame of original size $S1 \times S2$ pixels, producing four sub-images:
- 2) The coefficient vectors are uniformly quantized and binary coded with L bits/coefficient to form four bit streams.
- 3) The bit streams are packetized and mapped on the OFDM system.

B. Packetizing and mapping onto the OFDM system:

As described in Fig. 3, 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 subchannels at the receiver [7]. 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).[†] Each bit vector in a packet is *many* modulated, and 32 packets are simultaneously

transmitted through different subchannels set. Here we use the feedback to decide the subchannel condition („good“ or „bad“), and accordingly rearrange 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.

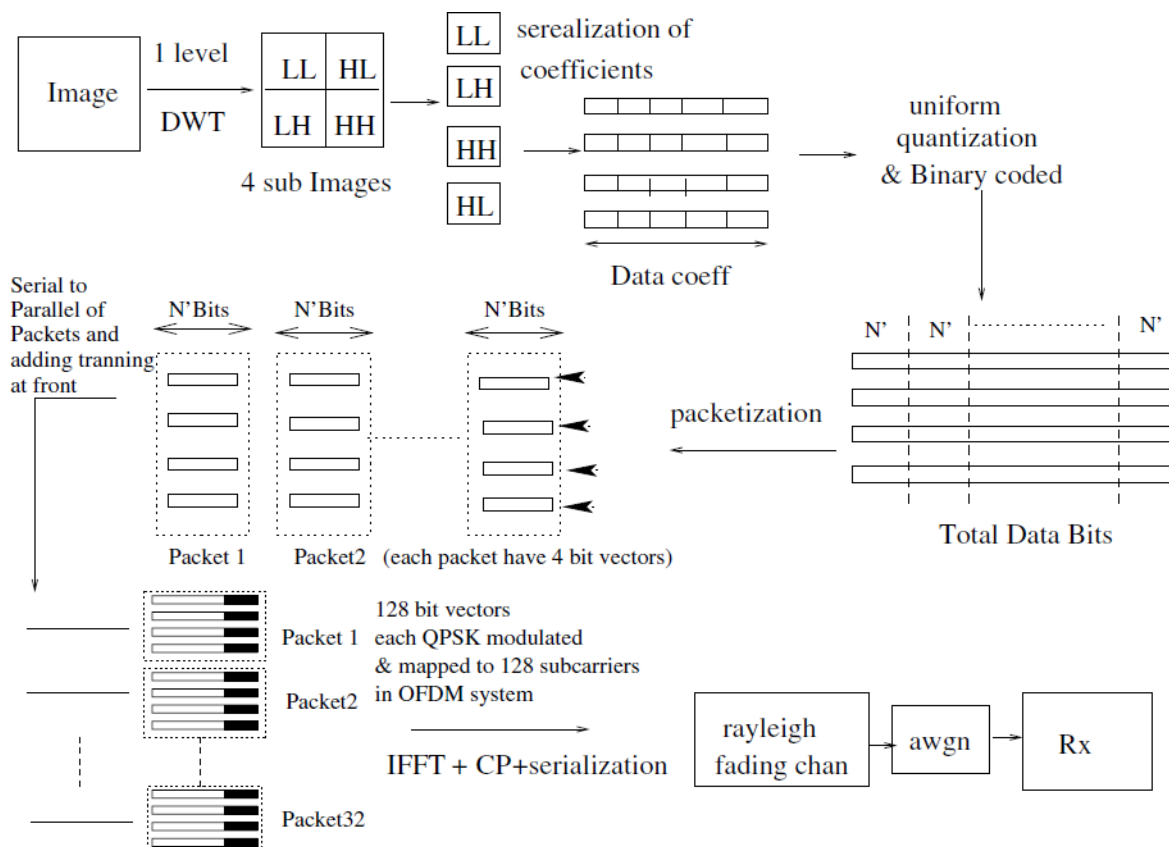


Fig. 3. DWT-OFDM system.

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.

To reduce the distortion due to discarding some data, we propose a mapping scheme which takes care of the importance level of the mapped data such that the less important data (i.e., in general for DWT image, low pass filtered components are more important: the ones with lower variance levels) are mapped to the bad subchannels. As described in Fig. 4, we arrange the bit vectors from all 32 packets such that they are spaced as apart as possible in frequency domain. The subchannels are grouped in to good and bad categories, as depicted in Fig. 4. For this group formation we scan all the subchannels and collect the bad subchannels in order, while maintaining the order of the good ones.

The average distortion per coefficient in a packet produced by this scheme is denoted by D for the analysis purpose. The chosen threshold value P_{th}

affects the selection of data vectors that are to be discarded at the transmitter. Thus, the quality of reception and the amount of power saved are also changed. It may be mentioned here that the chosen P_{th} corresponds to a particular fading margin.

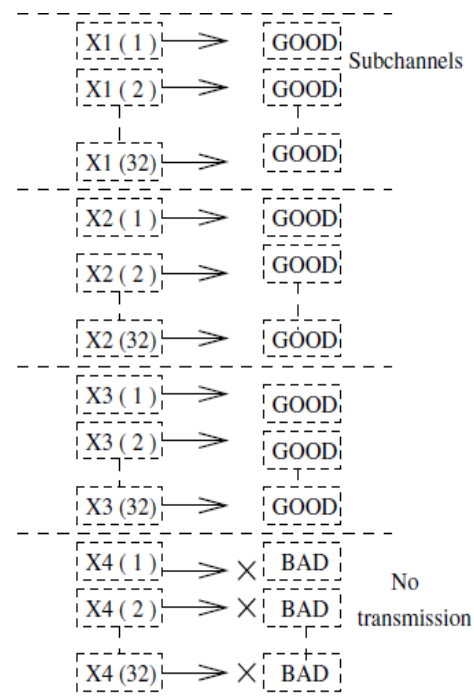


Fig. 4. Packet mapping based on channel state DWT-OFDM system.

C. Channel model:

In this study we use block fading channel model as in [8]. The channel model is illustrated in Fig. 5, where M is the coherence bandwidth in terms of number of subchannels. In a block fading environment, M consecutive subchannels will simultaneously be either bad or good. Each such set consisting M subchannels is called a "sub-band". We denote total number of such sub-bands in the OFDM system as N . Thus, the total number of subchannels 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.

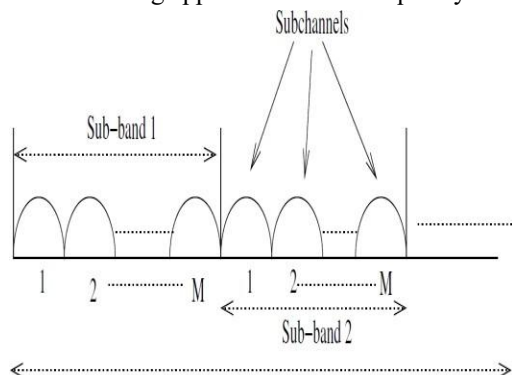


Fig. 5. The concept of block fading channels in OFDM system.

CONCLUSIONS

To conclude, we present a case of DWT compressed image 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. As a future work, we plan to extend the current study with CSI adaptive channel rate as well as power control to find a more generalized trade-off between transmission rate and energy saving in image as well as video transmission applications.

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