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Unequal Power Allocation for Image Transmission

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***Abstract*— The rapid growth of wireless communication has resulted in a demand for robust transmission of compressed images over wireless channels. The challenge of robust transmission is to protect the compressed image data against loss in such a way so we can maximize the received image quality. Transmission of JPEG2000 images using an unequal power allocation (UPA) scheme and orthogonal frequency division multiplexing (OFDM) over AWGN channels is presented. A distortion model is provided to evaluate the contribution of each Group in the construction of the received image. The optimization algorithm assigns deferent transmission powers to groups. When CSI is available, the powers are adjusted at the transmission time to compensate for the channel fading. The optimization algorithm exploits the hierarchical structure of the JPEG2000 images and uses the distortion model along with the channel state information for allocating optimal values of power for each group to minimize the end-to-end distortion. Check for PSNR value. The PSNR value of Different image with UPA is measured and compared with the PSNR value of EPA that was initially assigned. For the purpose of simulations, the authors set the number of OFDM subcarriers to be 52, the length of the cyclic prefixes equal to 16.**

***Keywords*— JPEG2000, Wireless Image Transmission, OFDM, Unequal Power Allocation, PSNR**

I. Introduction

With the explosive growth in communication networks around the world in recent years, the geographical distance is no longer a barrier for communication and the world is now considered a global village. Information exchange has never been easier for users who cross the borders in the virtual world without any restrictions. Users are connected to the World Wide Web or the Internet through wired or wireless connections and enjoy a wide variety of services and applications such as video conferencing, video streaming, social networking, etc.

Wireless transmission of still images and video streams over fading and noisy channels is a challenging task that has been under enormous developments in recent years. Fading, interference, shadowing, path loss and multipath are sources of disturbance in wireless channels, which introduce error to a transmitted data bit stream. The challenge in transmission of a scalable bit stream is to ensure high reliability of the received signal, while maintaining high data rate during transmission.

One of the recent and advanced source coding techniques for image coding is JPEG2000. This standard is able to generate an error-resilient and scalable bit stream, which allows progressive decoding of the received bit stream at different quality and resolution levels [5]. A scalable coded bit stream has one advantage in which some bits hold more important information compared with others; thus it is natural to have higher protection over the more important bits. The UPA techniques distribute the total available power for transmission of an image unequally over the bit stream in such a way that more power is allocated to the more important bits.

1.1 Related work and contribution

Among available techniques for image transmission that use JPEG2000 source coder, Banister et al. [2] propose UEP by jointly optimizing source rate and channel rate using the Viterbi algorithm. In [3], UEP is achieved by using the error-resilient feature of JPEG2000 images and employing product-coded streams that consist of Turbo codes and Reed–Solomon (RS) codes. In [4], Wei et al. achieve UEP by using RS coding for the header and convolutional coding for the body of the image bit stream.

Most of these methods assume channel coding, which could increase the complexity significantly and lower data rate. Moreover, none of these methods consider frequency-selective fading channels, which are inevitable in multimedia communications. We consider the transmission of JPEG2000 images over orthogonal frequency division multiplexing (OFDM) networks. Our algorithm optimizes the power allocated to the JPEG2000 bit stream at the group level based on minimizing the total received distortion.

The remaining paper organized as follows: Section 2 provides System Model. Section 3 provides a brief overview of JPEG2000 Source coder. Section 4 presents the OFDM. The optimized UPA algorithm is detailed in Section 5. Section 6 shows simulation results and finally Section 7 concludes the paper.

II. System Model

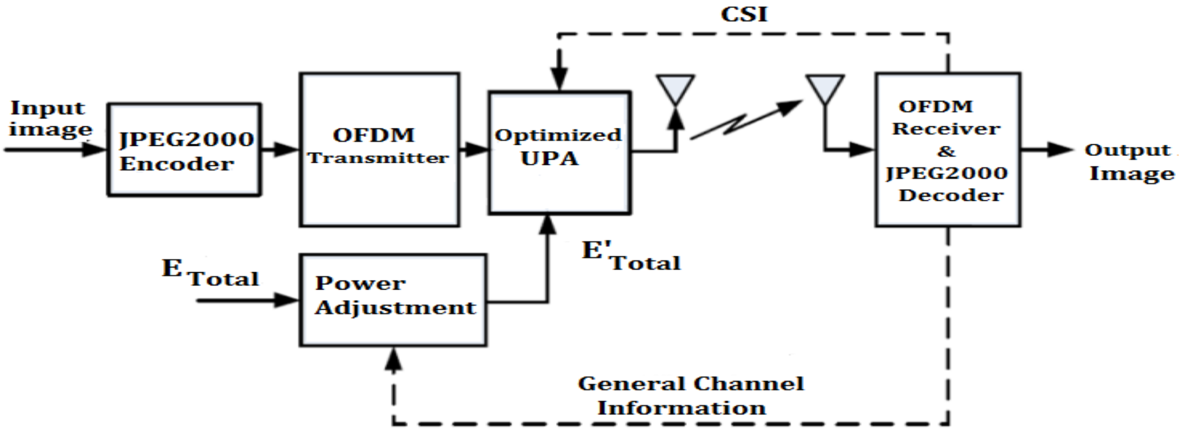

Fig-1 System Block Diagram

We focus on the transmission of JPEG2000 bit streams over wireless AWGN channels using UPA with OFDM as channel coder. Here for higher bandwidth efficiency and lower system complexity, we do not use any error correction coding. Instead, we take advantage of the inherent scalable properties of the JPEG2000 bit stream along with Channel State Information (CSI) to enhance the quality of the transmitted image. Power adjustment unit have two inputs. One is total power and second is feedback from the reconstructed image. At all stages we kept total power E_{Total} as constant.

The general block diagram of the proposed system is shown in Figure 1. The first part of the system includes the JPEG2000 encoder. The JPEG2000 encoder first divides the image into disjoint rectangular tiles. Wavelet transform is then applied to each tile to generate sub bands, which are divided into rectangular-shaped precincts, and further divided into square-shaped code blocks. Each bit plane of a code block is encoded by an arithmetic encoder in three coding passes. This provides a progressive bit stream for each of the code-blocks. After the Entropy encoding we have scalable bit stream at the output of JPEG2000 encoder. It is important to note that deferent groups bit streams have deferent impact on the quality of the decoded image.

III. Overview of JPEG2000 Source Coder

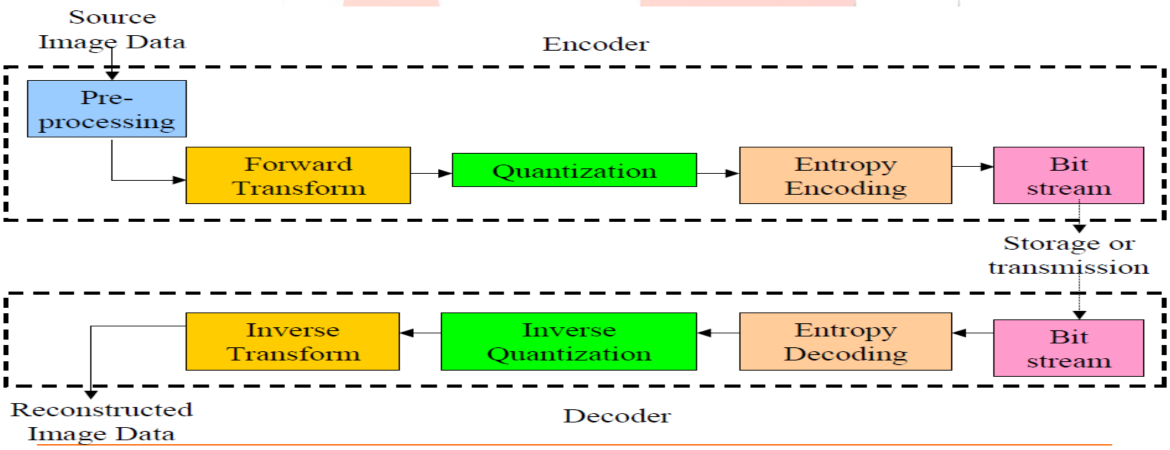

Fig-2 the general block diagram of JPEG2000 codec structure

The first stage of the JPEG2000 is Pre-Processing which will convert original color image into gray scale image so this stage is optional .After this transformation technique used in JPEG2000 is the discrete wavelet transform (DWT). Then DWT is applied to each tile which essentially analyses an image by decomposing it into sub-bands at different levels of resolution. The first level of decomposition consists of four sub-bands LL1, LH1, HL1 and HH1 [5]. The LL1 sub-band is the lowest resolution of the tile and is a down-sampled low resolution representation of the original tile component. The LL1 sub-band can be further decomposed by applying DWT.

This process can be repeated to obtain different resolution levels. Then, each resolution of each tile component is further partitioned into precincts. Within every sub-band, each precinct contributes one packet to the code stream of the image. Entropy encoding is used to further subdivide the precincts into code blocks (CBs). Each CB is then decomposed into a number of bit planes. Finally the coder scans through the bit planes within three CPs. Each of the CPs collects the relevant information about the bit-plane data. The encoder uses this information to generate a compressed bit stream [1].

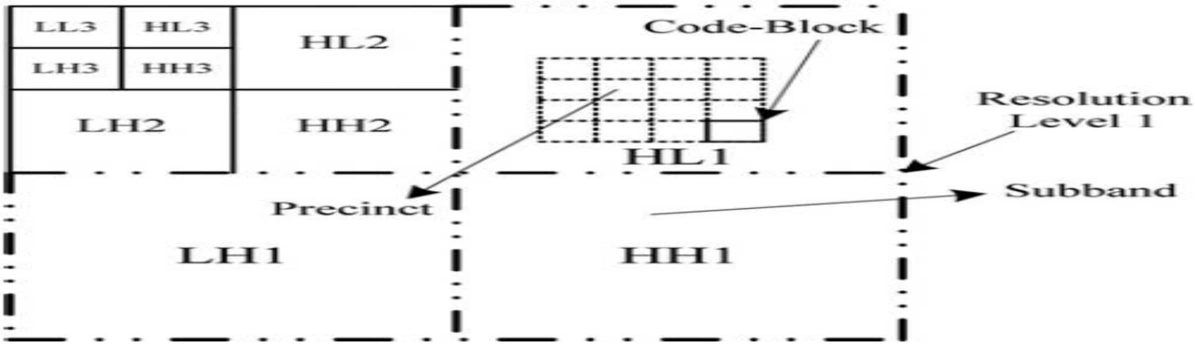

Fig-3 Components of a JPEG2000 transformed image

Fig. 3 illustrates a three layer decomposition of a source image using DWT and it's partitioning into four resolution levels, sub-bands, precincts and CBs. After this we can apply quantization on DWT output data. If we select the quantized value 1 then we can achieve lossless image compression. After this Embedded Block Coding with Optimum Truncation (EBCOT) used as entropy encoder. At decoder side reverse processing is done and we can achieve reconstructed image as output. Reconstructed image quality is depends on wavelet family, Decomposition level, channel parameter etc.

IV. ORTHOGONAL FREQUENCY DIVISION MULTIPLICATION

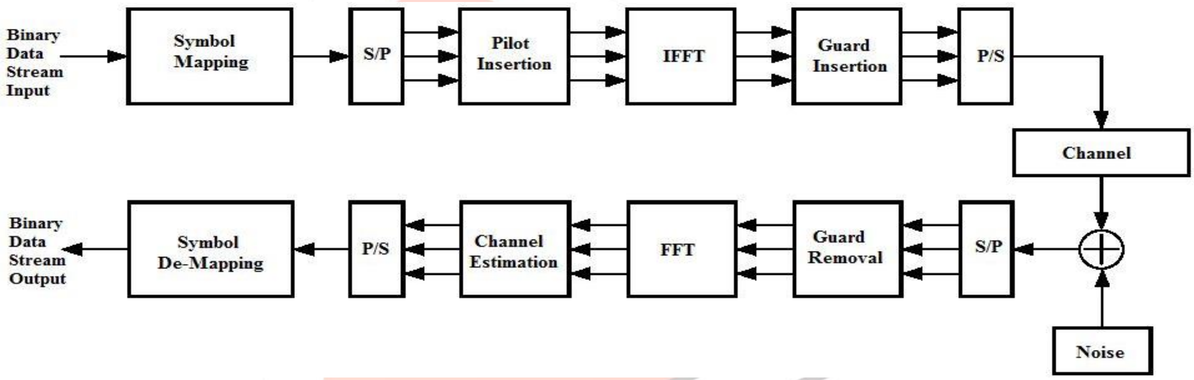

Fig-4 Block diagram of a Typical OFDM Transceiver

Block diagram of a Typical OFDM Transceiver is shown in Fig.4 [11].It is a multi-carrier modulation technique known as Orthogonal Frequency Division Multiplexing (OFDM), which enables robust high data-rate communications over time-varying wireless communication channels. Multi-carrier transmission uses two or more modulated signals, each carrying a single data stream over a communications channel. The multiplexed signals are independently demodulated in the receiver and then de-multiplexed resulting in the received bit stream.

OFDM is a type of frequency division multiplexing transmission scheme that allows users to transmit information across a communications channel at high data rates and offers a more robust alternative to traditional signal carrier-frequency transmission systems in noisy communication channels that suffer from fading. OFDM offers much more efficient use of the available Radio Frequency (RF) spectrum than single carrier-frequency communication systems due to the simultaneous use of multiple frequencies for data transmission. The rapid increase in popularity for this scheme is due to the fact that it allows the available channel bandwidth to be used very efficiently. OFDM also enables very high data-rate transmission to be achieved.

V. OPTIMIZED UPA ALGORITHM

Now, we have combine output bit stream of JPEG2000 encoder and OFDM encoder .After getting this whole bit stream we divided it into an L number of Groups.

Provide the initial equal power (EPA) to all groups and check the distortion (PSNR). Total power" $E_{Total} = 10 * \log(Encoder\ Bits * 10)$ dB" . Apply Unequal Power to each group and apply more power to important data groups which have more information's as compared to rest of groups. After Transmitting image to receiver we check for quality of image or PSNR of image. Now calculate the PSNR value and compare this value with Threshold value. If PSNR is less than Threshold value than rearrange power value again and check for PSNR value. After number of iteration increases we will achieve our desired result.

After getting desired PSNR value we can fix this optimum power value for different images. So we can directly apply optimum power value to the any images and transmit it. Now we can find optimum power value in such a way that $e_{new} = \alpha * e_{initial}$. So we decide value of alpha for different L number of groups and assigns optimum power value to each group.

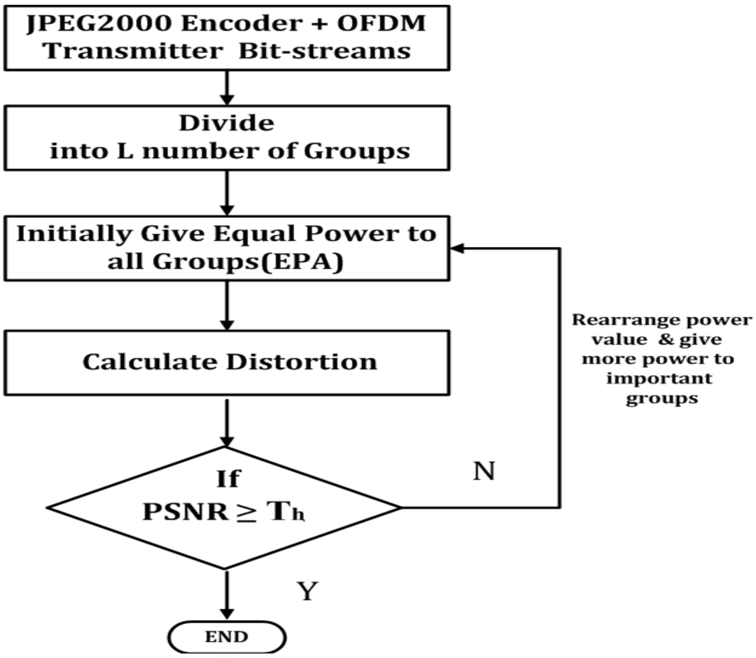

Fig-5 UPA Algorithm

This information we can achieve by Channel State Information (CSI). And according to CSI we can increase number of groups L or further adjust the power given to each groups. If PSNR is greater than or equals to threshold value PSNR no need to adjustment of power or further divide groups L. Now we can stop at this stage. Here as per number of group's increases PSNR value of image also increases but after reaching at certain amount of value of number of groups PSNR is decreasing. So we transmits image at number of groups where we can get maximum PSNR value.

VI. Simulation Results

To obtain simulation results, mat lab software is used. In which we checked result for different 512×512 image at rate of 0.25 bpp and 5 Decomposition level. 16 QAM is used to modulate the bit stream produced by the JPEG200 encoder. OFDM technique is applied to eliminate the effect of ISI and inter carrier interference (ICI), together with UPA. The number of subcarriers (N) used in the OFDM transmitter is 52. The value of N does not have any impact on the performance of the system. However, the higher the number of subcarriers the more the computational complexity of the system. AWGN channel is used for transmission. Visual Comparison of Lena.bmp image with UPA shown and which enhanced the image clarity as compare to EPA scheme.

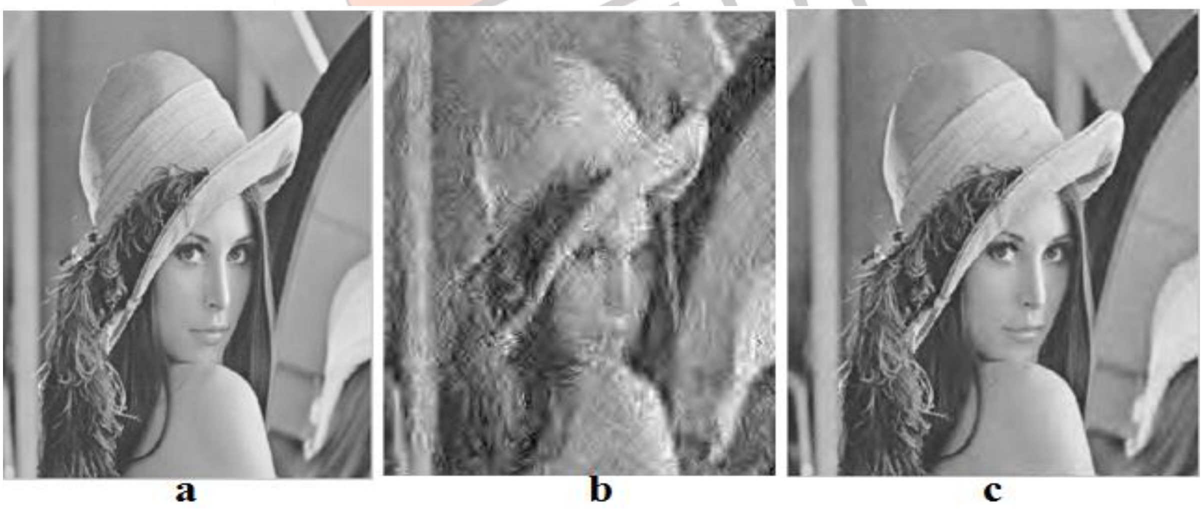

Fig-6 Visual Comparison of lena.bmp image at 0.25 bpp at SNR= 20 dB

a. Original Image
b. Reconstructed image with EPA-PSNR=16.8127
c. Reconstructed image with UPA-PSNR=32.1559

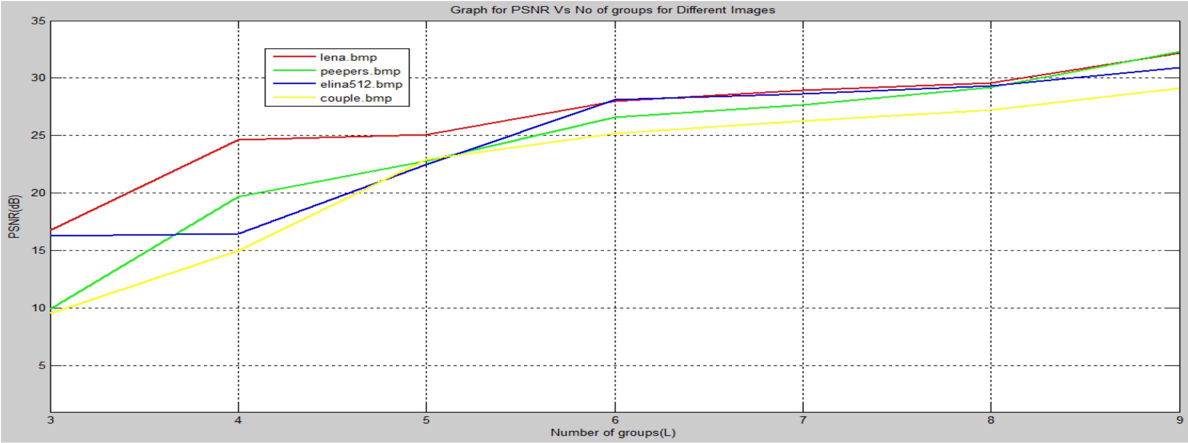

Fig-7 Evolution of PSNR value of the Received Different image at Different group numbers

VII. Conclusion

JPEG2000 images are transmitted with two techniques and they are Unequal Error Protection (UEP) and Unequal Power Allocation (UPA) among them UPA gives better Result (image quality) and easy to implement. The simulation results of research papers for the „Lena" image confirmed that employing the UPA algorithm over EPA technique improves the PSNR value. This method helps in removing the negative effects of ISI and ICI. Total Power consumed for EPA and UPA are same but UPA gives better PSNR value.

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