BER Evaluation of Orthogonal Wavelet Division Multiplexing (OWDM) under various Modulation Techniques

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ABSTRACT
Recently orthogonal wavelet division multiplexing (OWDM) which use wavelet transform is proposed as an alternative approach tofast fourier transform (FFT) based orthogonal frequency division multiplexing(OFDM)system. It is an efficient approach to replace FFT in the OFDM systems due to its better bit error rate improvement, interference minimization, time-frequency localization, improvement in bandwidth efficiency and many more advantages. OWDM is employed in order to remove the use of cyclic prefix which decreases the bandwidth wastage. This paper gives a theoretical overview of OWDM, application and its advantages/disadvantages. The performance of the developed system is investigated in terms of Bit Error Rate.

Keywords
Owdm, Fft, Dwt, Ber.Wpt,Iwpt

1. INTRODUCTION
Wavelets are functions defined over a finite interval and having an average value of zero. The basic principle of the wavelet is to represent any arbitrary function f *(t)* as a superposition of a set of such wavelets or basis functions. These basis functions (baby wavelets) are obtained from a single prototype wavelet known as the mother wavelet, by dilations or contractions (scaling) and translations (shifts) The DWT of a finite length signal *x (n)* having *N* components, for example, is expressed by an *N* x *N* matrix. Wavelets are mathematical functions that were developed by scientists (Engineers) working in various fields for the purpose of sorting data by frequency. Translated data can then be sorted at a resolution which matches its scale. Studying data at different levels allows for the development of a more complete picture [1].Both small features and large features are discernable because they are studied separately. Unlike the Discrete Cosine Transform, the wavelet transform is not fourier based and therefore wavelets do a better job of handling discontinuities in data. The HAAR wavelet operates on data by calculating the sums and differences of adjacent elements. The HAAR wavelet operates first on adjacent horizontal elements and then on adjacent vertical elements [2]. The HAAR transform is computed using:

$$\frac{1}{\sqrt{2}}\begin{bmatrix}1 & 1\\1 & 1\end{bmatrix}$$

One nice feature of the HAAR wavelet transform is that the transform is equal to its inverse. As each transform is computed the energy in the data in relocated to the top left hand corner; i.e. after each transform is performed the size of the square which contains the most important information is reduced by a factor of 4.

2. OWDM ARCHITECTURE
Wavelet Transform decomposes the spectrum of a signal non-uniformly. However, the decomposition is limited to the low pass part of the signal only. There are already a variety of wavelets available including both orthogonal and bi-orthogonal wavelets, many of which can in fact be described entirely on the basis of linear algebras. A typical good pair of wavelet filters often possesses a maximum number of balanced vanishing moments such as, for instance, the so-called bi-orthogonal Coifman wavelets recently proposed [3, 4]. Such wavelet systems are in general very useful in image, sound or video related applications due to the high order of consecutive vanishing moments associated with these systems.Wavelet packet transform applied on a data stream divides the data into its high frequency and low frequency components. Let ‘a’ be the vector having elements ak = a(k), where a(k) is the original discrete time sequence that we wish to decompose via the wavelet packet method then the step involved is the convolution of a(k) with h(k) and g(k) followed by a decimation by two and for inverse WPT, the steps are reversed [5]. These two procedures are shown in Figure 1

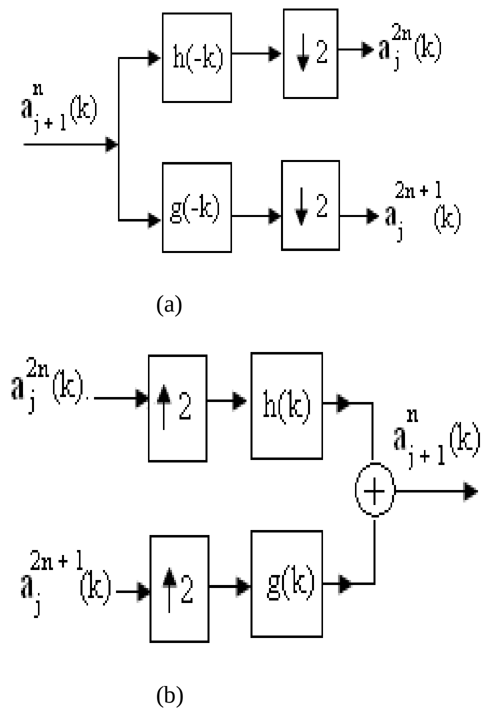

Figure 1: Single stage of (a) Wavelet Packet Transform (b) Inverse Wavelet Packet Transform

Therefore WPT is equivalent to filtering a signal with a low pass and high pass filter bank, while the IWPT is equivalent to combining a low pass and high pass signal into one signal .

The WPM transceiver as used in OFDM is illustrated in figure 2.The incoming signal is first converted from serial to parallel form and then modulated. There is up sampling of signal in each iteration of inverse wavelet packet transformation (IWPT). Now the signal is decompose one with HPF and the other with LPF. The outputs of HPF and LPF branches are then subsequently added. In the receiver, Wavelet Packet Transformation (WPT) is performed to bring the signals back to their original domain. In an iteration of WPT the input signal is filtered by HPF and LPF, decomposing original signal into two parts [6, 7]. Each of the decomposed parts is then down sampled by two satisfying the Nyquist rule.

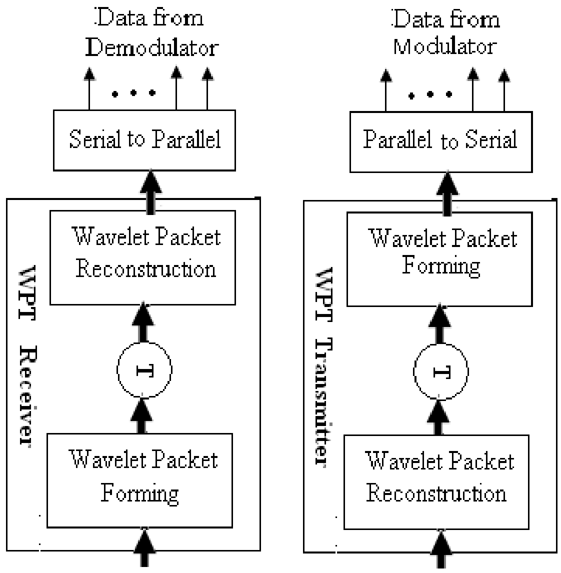

Figure 2: WPM transceiver

The transmitted signal is given as:

$$s_{WPM}(n) = \sum_{p=0}^{N-1} \sum_{k=0}^{\infty} a_p(l) \phi_{i,p}^{syn}(n - lN)$$

Where, ap(l) are complex data symbols of different parallel streams p.

$\phi_{k,p}^{syn}$ denotes synthesis wavelet packet function for the pth sub channel.The process of constructing a wavelet packet function set can be more clearly seen via the wavelet packet construction tree. Figure 3. Shows the wavelet packet tree corresponding to the 'T' blocks in the WPT-OFDM transceiver in figure 2. At each branch of the tree, the wavelet packet forms the wavelet basis function which is split into scaling and wavelet coefficients corresponding to the LPF and HPF coefficients respectively [8, 9]. After wavelet packet reconstruction, the data is converted to parallel form and demodulated.

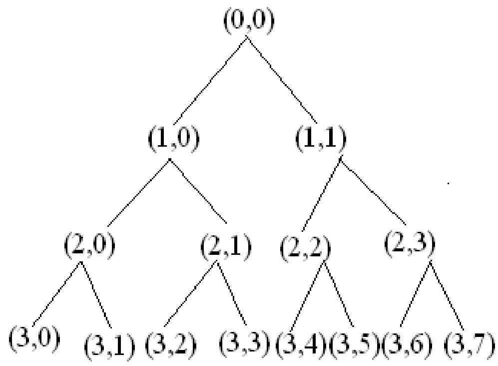

Figure 3 .wavelet packet tree corresponding to 'T' block

The OWDM transceiver is illustrated in Figure 4

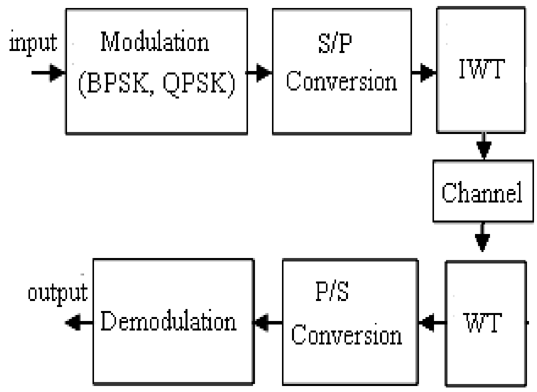

Figure 4: OWDM Transceiver

The incoming signal is first converted from serial to parallel form and then modulated. There is up sampling of signal in each iteration of inverse wavelet packet transformation (IWPT).

Now the signal is decompose one with HPF and the other with LPF. The outputs of HPF and LPF branches are then subsequently added.

3. RESULT & DISCUSSION

We implement and verified the performance of OWDM system under various modulations. We have evaluated the performance for various BER vs. SNR plots for all the essential modulation. Figure 5 shows the performance of developed OWDM system under Additive White Gaussian Noise (AWGN) channel model. The performance of the system under BPSK modulation is quite satisfactory as compared to other modulation techniques in AWGN channel which is smaller than that of other modulation techniques. Similarly Figure 6 shows the performance of developed OWDM under Additive White Gaussian Noise (AWGN) channel model and for differential modulations.

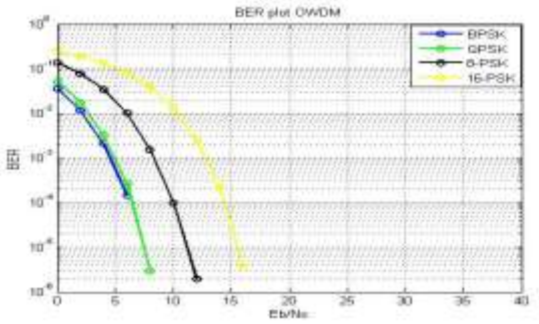

Figure. 5 BER of OWDM under various modulations

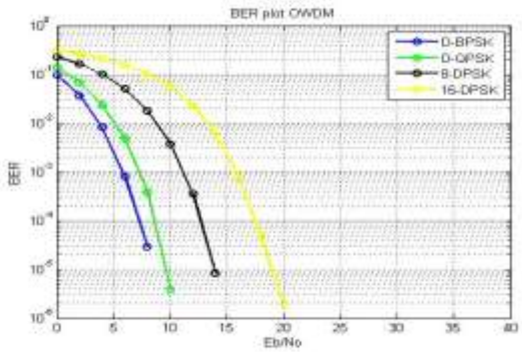

Figure. 6 BER of OWDM under Differential modulations

The performance of the system under BPSK modulation is quite satisfactory as compared to other modulation techniques in AWGN channel which is smaller than that of other modulation techniques. The BER performance of simple modulations is now compared with differential modulations. Figure 7 shows the performance of developed OWDM under simple as well as differential modulations under Additive White Gaussian Noise (AWGN) channel model.

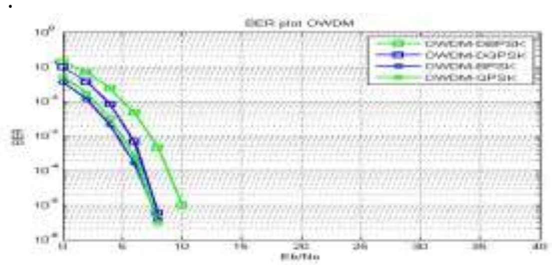

Figure. 7 Comparison of BER under Differential and non differential modulations

4. CONCLUSION

A performance analysis of an OWDM system for various modulations simple as well as differential has been carried out. The BER curves were used to compare the performance of different modulation techniques. Performance results highlight the impact of modulation scheme and show that BPSK modulation technique provides satisfactory performance among the four considered modulations. At the same time the simple modulation gives better results as compared with the differential one.

5. FUTURE SCOPE

In this thesis, we evaluate the performance of OWDM .The research work of this thesis can be carried forward by number of ways. The future work can be extended to include:
Performance evaluation of a OWDM system with different channel coding techniques.Performance evaluation of a OWDM system for different interleaving and synchronization techniques. Finally, there is no practical application up to this date that uses OWDM systems, which makes it a hot topic for researchers to explore.

6. REFERENCES

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