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Diversity Technique Using Discrete Wavelet Transform In OFDM System

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Abstract: Spectrum usage due to an increasing number of mobile users using services like audio, video, and images is one of the challengings for wireless communication. Orthogonal Frequency Division Multiplexing (OFDM) is one of the promising techniques to increase spectral efficiency. However, the conventional OFDM using fast fourier transform (FFT) still has the drawback of reducing spectral efficiency. Discrete wavelet transforms (DWT) has been used as an alternative method replacing FFT to increase the spectral efficiency. This paper presents the fundamental of wavelets and their significance in wireless communication. A review of the literature has been done on how the DWT-OFDM performs better when compared to FFT-OFDM and on diversity technique such as transmit and receive diversity. The advantages of using diversity at both receiver and transmitter, i.e., Multiple inputs and multiple output systems and the overview of the technique is also considered. The flexibility, improve in the performance of BER, mitigate the interference DWT-OFDM with diversity at both transmitter and receiver provides emerging technology for future generation.

Keywords: OFDM, DWT, FFT, BER.

I. INTRODUCTION

Over the last few years, the subscribers of wireless communications have exponential growth. The ongoing progress in radio technology provides more and more new and improved services. With the severe shortage of spectrum in conventional cellular bands, the range of frequencies between 3 and 300 GHz have been attracting growing attention for higher demand of cellular applications (Akdeniz et al., 2014). Current wireless services include transmission of fax, voice and low-speed data flexibly. With the use of interactive multimedia services like video-on-demand like television viewing and internet access for transferring essential data high-frequency band is utilized to support wireless communications (Islam, 2012). Many researchers are investigating and analyzing to meet the high data rate for future generation as the data rate is increasing exponentially with the increase of users. One of the emerging techniques is OFDM which is implemented in wireless communication (Hwang et al., 2009).

In OFDM the cyclic prefix is used to mitigate the intersymbol interference and to increase the delay spread of the channel. The drawback of the cyclic prefix is that it utilizes 20% to 25% of the total bandwidth (Galande & Shah, 2016). Wavelet transform has been used in OFDM which eliminates the use of cyclic prefix; hence the efficiency of bandwidth is enhanced (Gupta et al., 2014). The other advantages of wavelets are flexibility and less sensitivity to signal distortion. Wavelets have been used in various fields of wireless communication systems such as channel modeling, the design of transmitter and receiver for data representation and compression, performance improvement by mitigating interference and signal denoising (Lakshmanan & Nikookar, 2006). The loss of signal also occurs in the channel due to various factors such as multipath, due to obstacles along the path and due to improper tuning between the transmitter and receiver. To overcome these diversity techniques are implemented which helps to reduce the signal loss in terms BER and increase the capacity of the channel. Multiple antennae are used to provide antenna gain or diversity gain which helps to improve the system performance by reducing BER or improving Signal to noise ratio (Mietzner & Schober, 2009). In this paper, section two describes the overview of diversity techniques used in a wireless communication system to mitigate the fading effect of the signal. Next, section three gives the fundamental of the signal representing DWT and their various types of wavelets and comparative study of fast fourier transform-OFDM replace with Discrete wavelet transforms-OFDM to improve the BER and other parameters of the system by various methods. Section four explains the proposed technique Discrete wavelet transforms-OFDM with MIMO diversity in wireless communication for the future generation, and finally, we conclude in section five.

II. DIVERSITY TECHNIQUES

To improve system performance in fading channels diversity technique is used to decrease the fading effect. Some of them are Frequency diversity, Time diversity, Polarization diversity, Angle diversity, Antenna/Spatial diversity. Multiple antennas are used to send signals with information at the transmitter to receive at the receiver to provide multiple independent fading paths in space diversity.

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Most common and popular used diversity technique is antenna diversity technique, so the next section describes the overview of different antenna diversity such as transmit diversity, receive diversity and MIMO diversity.

2.1. Transmit /Receive Diversity

A simple transmit diversity technique was proposed by considering one receive antenna and two transmitter antenna which provides diversity order similar to maximal-ratio receiver combining (MRRC) and any feedback is not required from the receiver to the transmitter (Alamouti, 1998). Lee et al., (2000) have discussed the advantages of space frequency OFDM over space-time OFDM in frequency selective fading channel with transmit diversity technique in wireless communication (K. F. Lee & Williams, 2000). The expression for computing average bit error rate (BER) was derived for different modulation schemes like BPSK, QPSK, 4 PAM and 16 QAM by maximum ratio diversity technique in ricean flat fading channel with different values of Ricean factor k and channel estimation error effect was also considered (Cao & Beaulieu, 2005). Ghavami et al., (2008) analyzed BER performance in wideband code division multiple access (WCDMA) downlink channels with correlated Nakagami fading at transmitter antenna selection was invoked. At receiver to improve ratio of the signal to noise MRC technique and cancels out multiple access interference linear correlating detectors was used. Received signals are combined at the receiver to achieve diversity gain. The commonly used techniques are selection combining, switching receiver, maximal ratio combining (MRC) and equal gain combining.

Moreira et al., (2002) evaluated various diversity techniques such as antenna selection, equal gain with both coherent and incoherent and maximum ratio combining in a Hiperlan/2 receiver. Alkurd et al., (2014) analyzed the average error rate performance of cooperative maximum ratio combing receiver over fading channels using different coherent modulation techniques and approximate average BER was calculated. Crawford et al., (2017) investigated the performance of multicarrier index keying OFDM with hybrid low complexity detection and diversity reception using MRC and Selection combining. Villanueva et al., (2017) studied the effect of the Signal input and multiple output (SIMO) spatial diversity on the OFDM mobile radio signal propagating by using two receiving antennas at the diversity and calculated capacity improvement. Khelil et al., (2017) proposed single carrier frequency division multiple access techniques using one transmitter and two or three receivers that is SIMO with MRC in the receiver. The result was used to identify channel capacity and BER.

2.2. MIMO diversity

Martin et al., (2009) studied the performance of MIMO systems in Rayleigh fading channels with co-channel interference and thermal noise using maximum ratio transmission with two different receive antenna array configuration and derived expression for average bit error rate or symbol error rate. Lee, (2018) analyzed the performance of dual selection (i.e., combining user selection and transmit antenna selection) with MRC in a MIMO system and derived the exact and approximate cumulative density function and probability density function for the dual selection with MRC over non-identical imperfect channel estimation. Akhtar et al., (2018) analysis of a MIMO-OFDM model in Rayleigh Fading and AWGN channel with different MIMO configuration scheme using QAM modulation to reduce the BER with mitigating the interference with adding cyclic prefix with FFT.

Singh & Prakasa Rao, (2017) studied the performance of MIMO system over various modulation orders and various diversity orders in wireless communication. Different modulation techniques improve the quality of MIMO wireless channel, transmit diversity with coding using complex algorithm is used in MISO channel, receiver diversity like MRC, selection diversity is used in SIMO channel. Channel estimation and equalization is necessary to prevent the loss of signal in MIMO channel with spatial multiplexing or beamforming. MIMO systems have the features to provide multipath propagation in a scattering environment by using many antennas at transmitter and receiver to improve the performance in terms of capacity.

III. DWT-OFDM

3.1. Fundamental of Discrete Wavelet Transform

The DWT analyses the information signal at various frequency bands by decomposing the signal into different coefficients. This decomposition is achieved by consecutive small pass and extraordinary pass through a filter of isolated domain indication. The signal x[n] is passed through g[n] which is high pass filter and h[n] which is low pass filter as shown in figure 1.

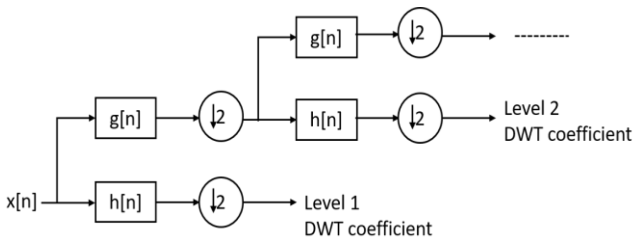

Figure 1: Level wavelet decomposition

Then after filtering the signal is downsampled by 2.

According to Nquist rule, the decomposition of the signal expressed in terms of mathematical equations;

$$y_h[k] = \sum_n x[n]\, g[2k-n] \qquad (1)$$

$$y_l[k] = \sum_n x[n]\, h[2k-n] \qquad (2)$$

The decomposition doubles the frequency resolution. Similarly, the signal is reconstructed by a successive pair of reconstruction filters such as g1[n] and h1[n] which satisfies the perfect reconstruction condition. Figure 2 explains the wavelet reconstruction.

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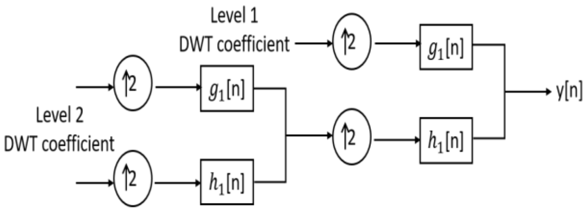

Figure 2 Level wavelet reconstruction

There are many types of wavelets depending upon properties of wavelets like orthogonality, regularity, symmetry, compact support such as Haar, Daubechies, Symlets and Coiflets. Haar wavelet is the simplest wavelet and Daubechies wavelets are very popular wavelets. Wavelets transform have many scopes in wireless communication such as the flexibility to carriers, sensitivity to channels; power consumption is reduced as data is transferred using data compression algorithms.

3.2. Comparative Study of Discrete Wavelet Transform

Abdullah & Hussain, (2009) studied the comparison of DWT-OFDM replacing FFT-OFDM and their performance in terms of BER which shows that DWT-OFDM was better when compared to FFT-OFDM. The DWT-OFDM features with zero padding and vector transpose in transmitting the signal. Abdullah et al., (2011) discussed the BER performance in DWT-OFDM with impulsive noise effects by varying the Poisson recurrence parameter from small to large and results prove that the impact of impulsive noise is limited on the system when the value is tremendous. Kumar & Jangra, (2017) studied the BER performance of DWT-OFDM using BPSK modulation with MATLAB Simulink in AWGN channel and compared with DCT-OFDM and FFT-OFDM and the wavelets based performance was improved. Chaudhary & Jadhav, (2015) analyzed the performance of OFDM with STBC-MIMO system using FFT and DWT (Haar wavelet) in AWGN and Rayleigh channel by QAM modulation technique. The DWT–OFDM with less hardware and reduce BER with the perfect reconstruction of the signal with and without the cyclic prefix (Saad & Shokair, 2010). The performance of Meyer wavelet based OFDM for different channels and different equalizers and results show that the BER in terms of 6.5dB without affecting the bandwidth efficiency (Chafii et al ., 2016).

The feedback from the receiver to the transmitter is necessary for synchronization to have such synchronization the performance of FFT-OFDM and DWT-OFDM to mitigate ISI with different wavelets and improve the spectral efficiency by 25% was studied with a feedback loop (Asif et al., 2013). However, the computational complexity increases. Kadhim et al., (2013) introduces a new Non-Linear precoding method for the Worldwide Interoperability for fixed Microwave Access (WiMAX) baseband with IEEE 802.16d standard using OFDM along with DWT and 16-Quadrature amplitude modulation and half of the coding rates which helps to reduce BER of interference signals and increases the spectral efficiency. Kaur et al., (2016) investigate to reduce BER of DWT-OFDM by replacing with FFT-OFDM systems in multipath fading and noisy environment for mobile WiMAX. The DWT-OFDM shows lower BER which increases the performance in mobile multipath environments using different modulation schemes.

IV. PROPOSED TECHNIQUE AND RESULTS

Figure 3 illustrates the proposed technique for wireless communication to enhance the performance of the system by reducing BER. This technique is similar to OFDM, but FFT is replaced with DWT to avoid insertion of a cyclic prefix which improves the spectral efficiency. The data has been modulated and demodulated with quadrature amplitude modulation and demodulation as it has more advantages, compared to other modulation schemes. The DWT transmitter consists of a serial to parallel converter and extraordinary pass and small pass filter to decompose the signal into coefficients. Then at the receiver, the signal is reconstructed with reconstruction filters which satisfies the reconstruction property of wavelets. The channel is AWGN channel with multiple and input and multiple outputs. The MIMO antenna diversity technique is implemented to provide the antenna gain and diversity to reduce the BER and improve the SNR in the multipath channel.

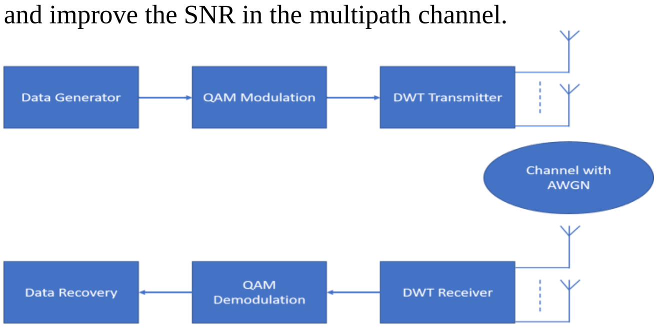

Figure 3 MIMO diversity with DWT-OFDM

V. CONCLUSION

The wireless communication has raised many hopes as the technology is changing from one generation to other generation. Each generation has some advanced features for transferring the information, multimedia and entertainment. Wavelets have been considered for future generation as increase the spectral efficiency. The flexibility and orthogonality are also the advantages of wavelets. However, the researchers are focused on how to enhance the DWT-OFDM with more convolution coding, modulation, and other features. Moreover, the Multiple inputs and multiple outputs (MIMO) have also been used to meet the requirements of the next generation. In future this can be considered on MIMO-OFDM with wavelets to inhance the rate of the data, progress the enactment of the communication scheme in terms of BER, spectrum efficiency and capacity of the network is also improved. There are many advantages of using wavelets transform in OFDM is analyzed. The DWT-OFDM performs better due to avoiding of the cyclic prefix. They also have a feature of multicarrier modulation. Multiple inputs and multiple output antenna are used to prevent the loss of signal and improve the performance of the system. DWT-OFDM with multiple input and multiple outputs can be used for future generation.

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