Efficient Daubechies and Haar Wavelet Transform OFDM System using Hamming Code

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Abstract - The modern wireless communication era is facilitating everyone in this world and to keep it upgrading is a prime need among researchers. The QoS and the bit error rate are the factors by which we measure the efficiency of the system. Orthogonal Frequency Division Multiplexing (OFDM) and Multiple Input and Multiple Output (MIMO). Providing of enhanced orthogonality which is based on the wavelet transforms of OFDM and improvement of the BER. Increasing of the spectral efficiency we doesn't require the cyclic prefix which is based on the wavelet system. In the upcoming of the 4th generation LTE, using of wavelets in place of fourier transform based OFDM is proposed. Application of the wavelets based OFDM Systems we have analyzed the performance of the BER and this work is done with the SUI channel mode and hamming code which significantly reduces the error rate.

Keywords :OFDM, MIMO, BER, Daubechies and Haar Wavelet Filters.

I. INTRODUCTION

Digital communication system is a system in which information is conveyed from one point to another by using a finite set of discrete symbols. This system has been the subject of numerous research over the past fifty years of its introduction. As such, during the last three decades, the development and use of digital communication systems, has extensively increased and are still becoming more and more attractive due to the ever increase in demand for data communication, ease of regeneration of digital signals, high flexibility and availability of options for data processing in comparison to analogue transmission [1, 2]. Block diagram of a typical digital communication system is shown in Figure 1.1.

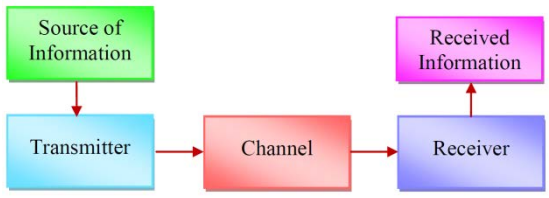

Figure 1.1. A standard digital communication system

The requirement for higher data speed is exponentially increasing, main reason being the availability of smart phones, at low cost and social networking websites. Constant improvement in wireless data rate is in demand[3].

One of the main advantages of digital communication systems is that they are less subject to distortion and interference, in comparison to analogue communication systems, as binary digital circuits operate in one of the two states (i.e. state 0 or 1) and hence disturbance must be large enough to change the circuit operating point from one state to the other. Such two-state operating systems ease signal regeneration and thus prevent noise and other disturbances from accumulating in transmission. In addition, with digital techniques, extremely low error rates producing highly reliable signals are possible through error detection and correction [2]. In addition to the mentioned advantages, digital communications has some other important advantages as follows:

- Digital circuits available in digital communications are reliable and can be produced at low cost
- Digital hardware lends itself to flexible implementation
- Digital communication techniques offer themselves naturally to signal processing functions that protect against interference and jamming, or that provide encryption and privacy
- A great deal of data communication can be carried out, from computer to computer, or from digital instruments or terminal to computer. Such digital terminations are naturally best served by digital communication links.

With the target of creating a collaboration entity among different telecommunications associations, the 3rd Generation Partnership Project (3GPP) was established in 1998. It started working on the radio, core network, and service architecture of a globally applicable 3G technology specification. Even though 3G data rates were already real in theory, initial systems like Universal Mobile Telecommunications System (UMTS) did not immediately meet the IMT- 2000 requirements in their practical deployments. The combination of High Speed Downlink Packet Access (HSDPA) and the subsequent addition of an Enhanced Dedicated Channel, also known as High Speed Uplink Packet Access (HSUPA), led to the development of the technology referred to as High Speed Packet Access (HSPA) or, more informally, 3.5G[9].

Motivated by the increasing demand for mobile broadband services with higher data rates and Quality of Service (QoS), 3GPP started working on two parallel projects, Long Term Evolution (LTE) and System Architecture Evolution (SAE), which are intended to define both the radio access network (RAN) and the network core of the system[8], and are included in 3GPP Release 8. LTE/SAE, also known as the Evolved Packet System (EPS), represents a radical step forward for the wireless industry that aims to provide a highly efficient, low-latency, packet-optimized, and more secure service. The main radio access design parameters of this new system include OFDM (Orthogonal Frequency Division Multiplexing) waveforms in order to avoid the inter-symbol interference that typically limits the performance of high-speed systems, and MIMO (Multiple-Input Multiple-Output) techniques to boost the data rates. At the network layer, an all-IP flat architecture supporting QoS has been defined[8].

In this paper we have compared the performance of wavelets based OFDM system and utilized HAAR and Daubechies 2 transforms with performance of conventional OFDM system (DFT Based i.e. FFT) for different LTE modulation techniques QPSK and m-QAM. For wavelet based system we have used daubechies2 and haar wavelets. Additive White Gaussian Noise (AWGN) channel is used for transmission. The paper is organized as first of all the conventional(FFT) OFDM system and wavelet (HAAR and Daubechies 2) based OFDM system. The proposed wavelet based OFDM design is presented and then the performance evaluation and the results obtained from the simulation are discussed and Conclusion is summarized[7].

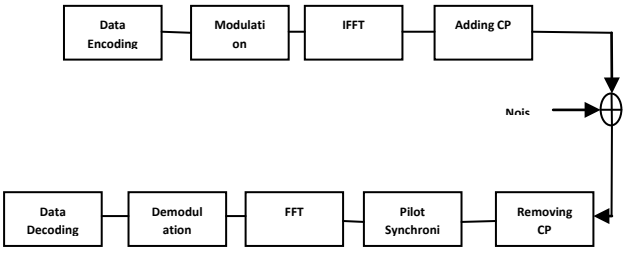

Fig 1.2. DFT based OFDM transmitter and receiver

The revolution of wireless communications certainly was one of the most extraordinary Changes underlying our contemporary world although we may not realize it, everyday our lives are profoundly affected by the use of radio waves. Radio and television transmissions, radio-controlled devices, mobile telephones, satellite communications, and radar and systems of radio navigation are all examples of wireless communications happening around us[6]. However, less than a hundred years ago, none of these existed, while the telegraph and telephone were most common for communication, which required direct wire connection between two places

There mark able advancement in communication of today is the result of an Italian scientist, Gugliemo Marconi, as he began experiments using radio waves for communication in 1895. These invisible transmittable waves traveled in air, and since the receiving and transmitting equipment was not connected by wires, the method of communication used was then recognized as wireless communication. Marconi's first success was in 1897,as he Demonstrated radio's ability to provide continuous contact with ships sailing the English channel[3].

II. CONVENTIONAL OFDM SYSTEM SUI CHANNEL MODEL

For typical OFDM system sinusoids of DFT type associate orthogonal basis perform set. In DFT the system correlates orthogonal basis functions are the subcarriers utilized in OFDM. At the receiver the signals are combined to get the information transmitted. much, Fast Fourier Transform (FFT) and Inverse Fast Fourier Transform (IFFT) are used for the implementation of the OFDM system as a result of less range of computations needed in FFT and IFFT[4, 5]. Multiple replicas of the signal are received at the receiver finish attributable to the time dispersive nature of the channel, thus frequency selective fading results and to scale back this interference guard interval is used, that is termed cyclic prefix . Cyclic prefix is copy of the some fraction of image finish. As long because the channel delay unfold remains among the limit of the cyclic prefix there would not be any loss in orthogonality. For LTE, in the downlink information of various users is multiplexed in frequency domain and access technique is termed Orthogonal Frequency Division Multiple Access (OFDMA).

SUI Channel Model:

The 802.16 IEEE group, jointly with the Stanford University, carried out an extensive work with the aim to develop a channel model for WiMAX applications in suburban environments. One of the most important results obtained was the SUI (*Stanford University Interim*) propagation loss model, which is an extension of an early work carried out by AT&T Wireless.

To calculate the median path loss using the SUI model, the environment is categorised in three different groups with their own characteristics:

Category A: hilly terrain with moderate-to-heavy tree densities, which results in the maximum path loss.

Category B: hilly environment but rare vegetation, or high vegetation but flat terrain. Intermediate path loss condition is typical of this category.

Category C: mostly flat terrain with light tree densities. It corresponds to minimum path loss conditions.

Typically, for the three previous categories, the general scenario is as follows:

- Cells are < 10 km in radius
- Receiver antenna height in the range of 2 to 10 m.
- Base station antenna height between 15 and 40 m.
- High cell coverage requirement (80-90%)

According to IEEE 802.16 documentation, the SUI model is a suitable propagation model for WIMAX and BFWA (Broadband Fixed Wireless Applications) implementations. In order to investigate the performances of OFDM based BWA an accurate channel model needs to be considered. Usually all the wireless channels are characterized by path loss (including shadowing), multipath delay spread, fading characteristics, Doppler spread, and co-channel and adjacent channel interference.Ricean distribution can be used for characterization of narrow band received signal fading.

III. WAVELET BASED OFDM SYSTEM

In previous works use of Discrete Fourier Transform was proposed for the implementation of OFDM. Wavelet transform show the potential to switch the DFT in OFDM. Wavelet Transform could be a tool for analysis of the signal in time and frequency domain together[4]. it's a multi resolution analysis mechanism wherever signal is distorted into completely different frequency elements for the analysis with explicit resolution matching to scale. Using any explicit sort of wavelet filter the system will be designed in line with the necessity and additionally the multi resolution signal will be generated by the utilization of wavelets. By the utilization of varying wavelet filter, one will style waveforms with selectable time/frequency partitioning for multi user application[6]. Wavelets possess higher orthogonality and have localization each in time and frequency domain . Because of good orthogonality wavelets area unit capable of reducing the power of the ISI and ICI, which ends from loss of orthogonality. To cut back international intelligence agency and ICI in typical OFDM system use of cyclic prefix is there, that uses 2 hundredth of available information measure, therefore leads to information measure unskillfulness however this cyclic prefix isn't needed in wavelet primarily based OFDM system. quality also can be reduced by discrete wavelet transform as compared with the Fourier transform as a result of in wavelet quality is O[N] as compared with quality of Fourier transform of O[N log2 N] . wavelet primarily based OFDM is simple and also the DFT primarily based OFDM is complicated[7]. Wavelet based OFDM is versatile further and since higher orthogonality is provided by it, there's no a need of cyclic prefixing in wavelet primarily based OFDM, that is needed in DFT based OFDM to take care of orthogonality therefore wavelet based system is a lot of information measure economical as compared with the DFT based OFDM.

In Discrete Wavelet Transform (DWT), signal presented can experience many completely different filters and can be decomposed into low pass and high pass bands through the filters. throughout decomposition the high pass filter can take away the frequencies below 1/2 the best frequency and low pass filter can take away frequencies that area unit on 1/2 the highest frequency[8]. Two forms of coefficients area unit obtained through process, 1st ones area unit called elaborated coefficients obtained through high pass filter and second ones area unit referred to as coarse approximations obtained through low pass filter connected with scaling method. After passing the info through filters the destruction method are performed. the entire procedure can continue till the required level is obtained[9].

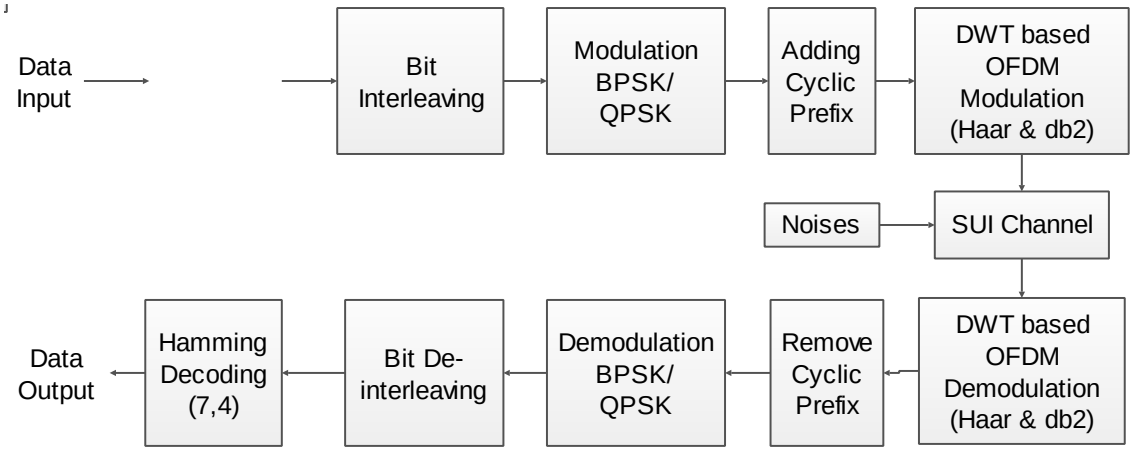

Fig 4.2. Block Diagram of the Proposed Model

IV. PROPOSED METHODOLOGY

In this proposed model we are using IDWT and DWT at the place of IDFT and DFT. SUI channel is used for transmission with cyclic prefix. Here first of all Hamming (7,4) encoding is done followed by interleaving then data is converted to decimal form and modulation is done next.

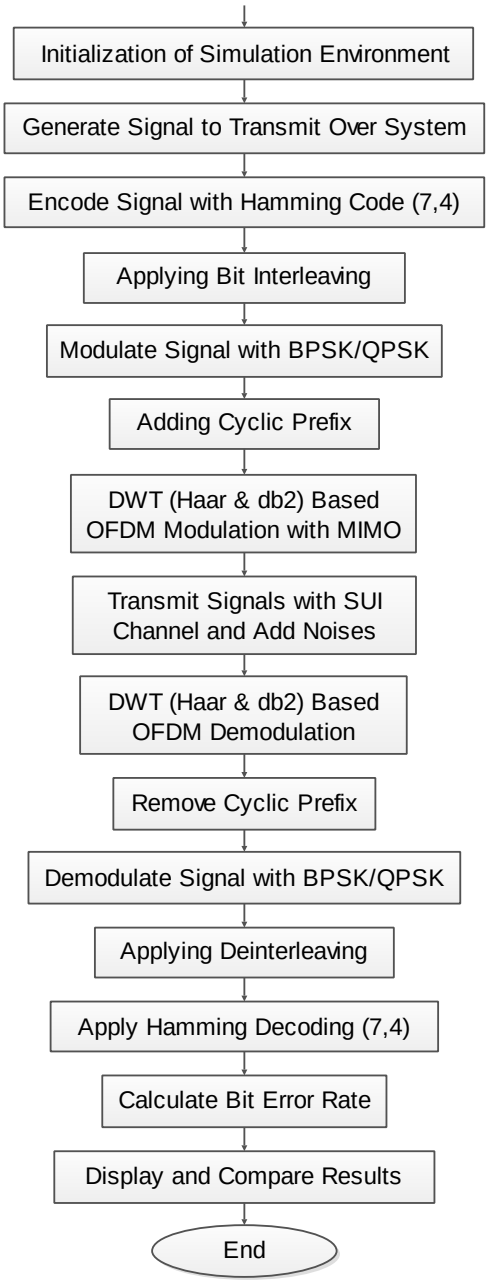

Fig 4.1. Flow chart of the Proposed Model

After modulation it comes the IDWT of the data, which provides the orthogonality to the subcarriers. IDWT will convert time domain signal to the frequency domain. After passing through the channel on the signal DWT will be performed with Hamming Encoding and Decoding Process. Demodulated data is converted to binary form and the de-interleaved and decoded to obtain the original data transmitted.

The wavelet transforms are HAAR and Daubechies 2, which significantly reduces the error rate. The block diagram of the proposed methodology shown in below figure.

The execution of the proposed algorithm is explained in figure 4.1. The steps are showing the characterization of the proposed communication model and its working.

V. SIMULATION RESULTS

The proposed OFDM MIMO system is proposed with the unconventional (Non-DFT based transform) wavelet transform based OFDM system and to reduce the error rate system is equipped with Hamming codes and the wireless channel model is SUI channel model which was designed for the modern wireless communication system.

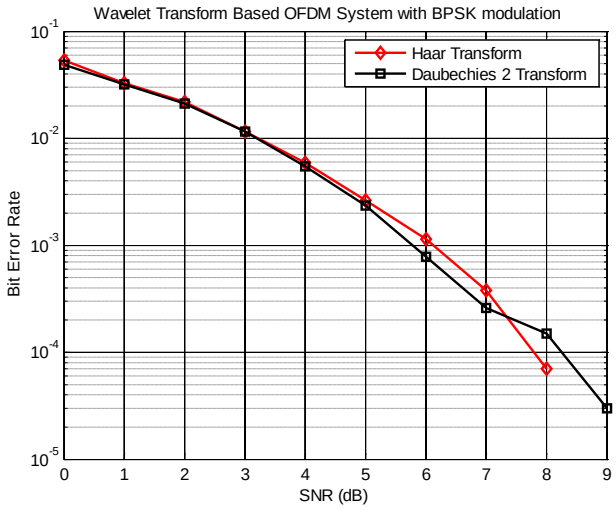

Fig. 5.1 Performance outcomes with BPSK Modulation

The system is analyzed with bipolar phase shift keying(BPSK) and quadrature phase shift keying(QPSK). The simulation outcomes are shown in below figures.

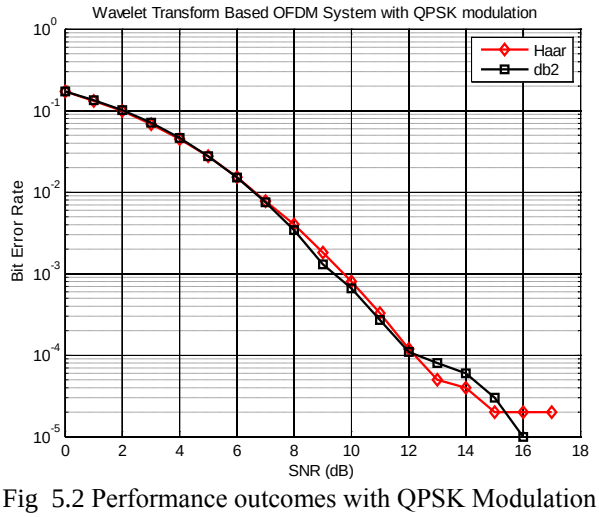

Fig 5.2 Performance outcomes with QPSK Modulation

For the purpose of simulation, signal to noise ratio (SNR) of different values are introduced through AWGN channel. Averaging for a particular value of SNR for all the symbols is done and BER is obtained and same process is repeated for all the values of SNR and final BERs are obtained.

Firstly the performance of wavelet based OFDM are obtained for different modulation techniques. Different wavelet types daubechies2 and haar is used in wavelet based OFDM for QPSK and BPSK. The sysm and performance comparison is shown in the below tables 5.1 and 5.2.

Table 5.1: Results Comparison

SNR	Proposed Work	Existing Work
0	1.8×10^{-1}	2.8×10^{-1}
2	1×10^{-1}	1×10^{-1}
4	4.5×10^{-2}	1.2×10^{-2}
6	1.7×10^{-2}	1.1×10^{-3}
8	3.5×10^{-3}	-
10	7×10^{-4}	-
12	1.1×10^{-4}	-
14	6×10^{-5}	-
16	1×10^{-5}	-

Table 5.2 Comparison of Proposed Systen with Existing System

Particulars	Proposed System	Existing System
System	OFDM Based Wireless LTE System	OFDM Based Wireless LTE System
OFDM Technology	Wavelet Transforms (Haar and Daubechies2)	Wavelet Transforms (Haar and Daubechies2)
Modulation	BPSK, QPSK	QPSK, 16-QAM and 64-QAM
Wireless Channel Model	SUI Channel	AWGN Channel
Noise Model	AWGN	AWGN
Encoding	Hamming Codes(7,4)	-
Symbols	100	100

VI. CONCLUSION

In this paper we have analyzed the performance of unconventional OFDM system which is based on wavelets and compared it with the performance of QPSK and BPSK Modulation techniques based OFDM system. From the performance outcomes we determined that the BER curves obtained from OFDM area unit higher than that of DWT based OFDM. In Haar and Daubechies based wavelet OFDM the BER is performed better than the existing work done without Hamming codes. We've used daubechies2 and haar wavelets, each offer their best performances at totally different intervals of SNR.

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