A Novel Technique in Channel Estimation using Wavelet Transform in OFDM Systems

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Abstract— now a day there is increasing a demand for high touching performance, higher bit rate in wireless communication system. In wireless communication, orthogonal frequency division multiplexing (OFDM) is multi-carrier modulation scheme. So, OFDM has higher transmission rate ability with higher bandwidth efficiency and robust to multipath fading. Moreover, in wavelet based OFDM is more bandwidth efficient as compared to DFT based OFDM system. In this system analyzed the various wavelet families (Haar, Symlet, Daubechies, Biorthogonal, Coiflet). And it compared with DFT based OFDM system. Also, analyzed the LS channel estimation using different wavelet and it compared with DFT based OFDM system. The result constitute that DWT based OFDM system is better than DFT-OFDM through the bit error rate (BER).

Key words: OFDM, DWT, FFT, Channel Estimation

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is one of the latest modulation techniques used in order to combat the frequency-selectivity of the transmission channels, achieving high data rate without ISI. The basic principle of OFDM system is gaining a wide spread popularity within the wireless transmission community. OFDM (Orthogonal Frequency Division Multiplexing) is digital multicarrier modulation scheme, which uses a large number of orthogonal sub-carriers that is particularly suitable for frequency-selective channels and high data rates. OFDM signal split into several narrow band channel at different frequency. In OFDM is used to compress a large amount of data into small amount of bandwidth so, that data can transmit simultaneously with number of frequency. Today, most people using the communication apparatus. So, requirement of high date rate increased rapidly. With the data rate rise the distortion of the received signal and result in multipath fading channel. One of the main causes to use OFDM is to increase robustness against frequency-selective fading.

In OFDM system, channel estimation is needed to the channel state information also achieve a distortion less output data and to reducing the bit error rate [1]. Channel estimation is estimation of the frequency response of the path between the transmitter and receiver. It can be used to optimize performance and maximize the transmission rate. There are various methods to channel estimation such as: pilot based methods, frequency and/or time domain analysis [1]. Generally, channel estimation based on OFDM systems can be classified into two groups as blind which is Block based channel estimation and non-blind which is Combination type channel estimation technique. The block type pilot channel estimation is least square (LS) estimator, minimum mean square (MMSE) estimator and modified MMSE estimator. In combination type pilot channel estimation type is 1-dimensional interpolation and maximum likelihood (ML) estimator.

In this paper included a following details: Section II briefly describes the DWT-OFDM system. In Section III discussed the channel estimation. Section IV System description. Section V existing the experimental results. Section VI concludes the paper.

II. DWT-OFDM SYSTEM

Fourier transform based OFDM system signals only overlap in the frequency domain but the wavelet transform signals overlap both in the time and frequency domain so there is no need of the cyclic prefix in the model. Cyclic prefix is 20% or more of the symbol. Thus wavelet based OFDM gives 20% or more bandwidth efficiency [2]. Also, additional bandwidth efficiency in wavelet based OFDM systems is also provided since pilot tones are not necessary.

In wavelet transform there are mainly two groups: continuous and discrete. Performance of wavelet OFDM system using different orthogonal wavelet basis families like Haar, Daubechies, coiflet, Symlets, Biorthogonal and Reverse Biorthogonal over wireless communication channel.

There are several benefits using wavelets in wireless communication system:

1) Wavelet transform can create subcarriers of different bandwidth and symbol length.
2) Wavelet based algorithms have long been used for data compression.

Wavelet transform is a instrument for analysis signal in the joint time and frequency domains. And it is obtain good orthogonality [2]. The merit of wavelet transform in OFDM system is capable of reducing the power of inter symbol interference and inter carrier interference [3].

DWT of x(n) is given by:

\[ X(m,k) = \sum_{n} x(n)2^{-m} \phi (2^{-m}n - k) \]

ISI and carrier frequency offset. Due to these problems use the Wavelet transform.

III. CHANNEL ESTIMATION

In OFDM system, channel estimation is needed to the channel state information also achieve a distortion less output data and to reducing the bit error rate and achieving a distortion less output data in the system [1]. Channel estimation is estimation of the frequency response of the path between the transmitter and receiver. It can be used to optimize performance and maximize the transmission rate. There are various methods to channel estimation such as: with or without a need to parametric
models, blind or pilot based methods, frequency and/or time domain analysis, adaptive or non-adaptive techniques [1].

Generally, channel estimation based on OFDM systems can be classified into two groups as blind which is Block based channel estimation and non-blind which is Combination type channel estimation technique.

In the block type pilot channel estimation, an OFDM symbols are transmitted periodically which depend on time. All this sub-carrier is used as pilots. In Block type arrangement ‘Tc’ and ‘Bc’ parameters is time and bandwidth of the channel. In this channel estimation has different method based on least square (LS), minimum mean square error (MMSE) and modified MMSE, estimation with decision feedback, wavelet based method.

In the Least square estimation is a natural estimation technique. So, this estimator will be the most efficient use of the data. LS estimator can minimizes the parameter is \((\bar{Y} - \bar{X}H)^H(\bar{Y} - \bar{X}H)^\dagger\), where \((\cdot)^H\) is the conjugate transpose of operation. So, the LS estimator of \(\bar{H}\) is given by;

\[
\hat{H}_{LS} = \bar{X}^{-1}\bar{Y} = \left([\bar{X}x]_k\right)^T
\]

In combination type pilot channel estimation, the pilot symbols are transmitted continuously over specific channel in OFDM symbol.

In other pilot channel estimation method has different types which are 1-dimensional interpolation and ML estimator.

In this channel estimation techniques include the 2-dimensional estimation and iterative channel estimation.

IV. SYSTEM DESCRIPTION

The DWT-OFDM system based on channel estimation is figure is shown in below. In DFT based OFDM system uses the discrete Fourier transform, but in wavelet based OFDM used the IDWT replace of IDFT. In these systems binary input signals are grouped to get the M-array symbol. These symbols are modulated using a mapper. The next block is S/P sub block which is serial to parallel sub block which convert the serial data to a block data. Then pilots are adding in these systems. The signal is moved to the inverse discrete wavelet transform (IDWT). After that adding the cyclic prefix. The cyclic prefix is also known as the guard interval. Finally, the signal is converted into the parallel form. Then, it transmitted to the receiver side through the channel [1].

At the receiver data is converted back to frequency domain \(X(k)\) from time domain \(x(n)\) by Discrete wavelet transform (DWT). After pilot signal are removed. Then channel is estimated \(H(k)\) through the LS estimator.

V. EXPERIMENTAL RESULTS

In this section, the results of the system are discussed. First of all the compared the DWT-OFDM and DFT-OFDM system. In this system used the AWGN channel and 16-QAM modulation technique. Table-1 is outlines of the parameters which is used.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>DFT-OFDM</th>
<th>DWT-OFDM</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Subcarriers</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td>Modulation</td>
<td>16-QAM</td>
<td>16-QAM</td>
</tr>
<tr>
<td>Pilots</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Cyclic prefix</td>
<td>25%(16)</td>
<td>-</td>
</tr>
<tr>
<td>Channel</td>
<td>AWGN</td>
<td>AWGN</td>
</tr>
<tr>
<td>Wavelet</td>
<td>-</td>
<td>Haar, Bi-orthogonal, Symlet</td>
</tr>
</tbody>
</table>

Table 1: Simulation Parameters for DWT-OFDM and DFT-OFDM System

Different DWT-OFDM families are compared with the DFT-OFDM system which results are shown in Table-2.

<table>
<thead>
<tr>
<th>Eb/N0(dB)</th>
<th>DFT-OFDM</th>
<th>DWT-OFDM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Haar</td>
<td>Bi-orthogonal</td>
</tr>
<tr>
<td>6</td>
<td>0.3162</td>
<td>0.1584</td>
</tr>
<tr>
<td>8</td>
<td>0.2512</td>
<td>0.0794</td>
</tr>
<tr>
<td>10</td>
<td>0.1259</td>
<td>0.0123</td>
</tr>
<tr>
<td>11</td>
<td>0.0399</td>
<td>0.0013</td>
</tr>
</tbody>
</table>

Table 2: Results of Dwt-Ofdm and Dft-Ofdm System

The study and comparisons are based on simulations performed using MATLAB. At SNR =11 dB the Haar wavelet gives 0.013 bit error rate which is less than other wavelet families in DWT-OFDM system. Where a bit error rate of 0.0399 is obtain for DFT-OFDM.
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VI. CONCLUSION

This paper concludes with successful performances of DWT-OFDM based system using channel estimation. The system is experimented for different parameters. The comparison of DFT-OFDM and DWT-OFDM are analysed. Simulation analysis shows that the DWT-OFDM system performs better than the DFT-OFDM system with regards to the bit error rate (BER). In channel estimation the wavelet transform get the better result compared to the DFT-OFDM system. This paper also concludes that the wavelets family like Haar is the better transform in DWT-OFDM system.

REFERENCES


