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COMPARISON OF OFDM OVER AWGN CHANNEL

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Abstract
In this paper the comparison of DWT-OFDM and FFT-OFDM is presented. DWT-OFDM system model uses zero padding and vector transpose to transmit OFDM signal. Chaotic interleaving scheme for transmitting data efficiently over AWGN channel is described. This scheme is the simplest and most popular. The concept of chaotic Baker map is used in this approach. The proposed chaotic interleaving approach adds a degree of encryption to the transmitted data. The BER performance of the multiple copy chaotic interleavers Discrete Wavelet Transform OFDM (DWT-OFDM) and FFT-OFDM is compared. The simulation results show that multiple copy chaotic interleaver based DWT-OFDM system is better than the FFT-OFDM system.
Keywords: Orthogonal Frequency Division Multiplexing (OFDM), chaotic interleaving, DWT, FFT, BER.

Introduction

Orthogonal frequency division multiplexing (OFDM) is a Multi-Carrier Modulation (MCM) technology. OFDM modulation divides the entire frequency selective fading channel into many narrow band flat fading sub channels in which high-bit-rate data are transmitted in parallel and do not undergo IS1 due to the long symbol duration. Therefore, OFDM modulation has been chosen for many standards, including Digital Audio Broadcasting (DAB) and terrestrial TV in Europe, and wireless local area network (WLAN). Moreover, it is also an important technique for high data-rate transmission over mobile wireless channels. On the other hand, wavelet based modulation system satisfies the condition of orthogonality using orthogonal wavelet filter banks [2]. All the benefits of OFDM can be achieved by replacing the Fourier based OFDM with suitable wavelets. Wavelet based systems shows better immunity to impulse and narrowband noises than Fourier OFDM [3, 4].

Also, wavelet based OFDM doesn't require any CP, hence does not produce the ripples, reduces complexity, and no power wastage for redundancy. Also the equalizer performance is better in wavelet OFDM system as compared to conventional OFDM [6]. The transmitted signals of wavelet system consist of much lower side lobes and thus help in reducing the inter-carrier interference (ICI). An optimal beam-forming technique is also used to maximize signal quality of individual user.

2.Ofdm Transceiver

A.fft-Ofdm

The inverse transform block can either be IDWT/IFFT and forward transform block can be DWT/FFT. The data generator used here is a sine wave of bit stream d. It is processed using QPSK modulator to map the input data into symbols Xm. The more the levels of QPSK, the more complex the receiver which results in more bit errors as the system becomes more complex. The modulated symbols are transmitted through IFFT block to perform IFFT operation to generate N parallel data streams. Its output in discrete time domain is given by [5],

$$X_{k(n)} = 1/\sqrt{N} \sum_{i=0}^{N-1} Xm(i) \exp\left(j2\frac{\pi ni}{N}\right)$$

Cyclic prefix is added to the data before transmission, to mitigate the effect of ISI. CP is usually taken as 25% of the last part of the original OFDM symbol and then it is passed through AWGN channel with proper input power and SNR value set. At the receiver, the reverse operations are done to recover back the input data.

$$U_m(i) = \sum_{n=0}^{N-1} Uk(n) \exp\left(-j2\frac{\pi ni}{N}\right)$$

The output of the FFT in frequency domain is given by [7],

B.DWT-OFDM

For reliable and high speed communication over wireless links, an efficient modulation scheme, like a Discrete Wavelet Transform (DWT) modulation technique, is required. It provides better symbol rate and increases spectral efficiency. In the DWT-OFDM, the IDWT and DWT take place of the IFFT and the FFT [8].

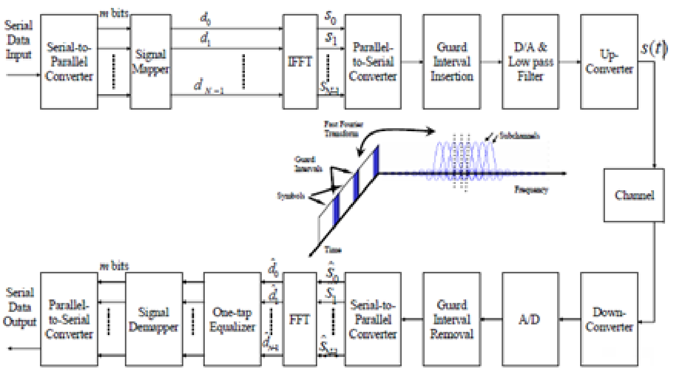

Fig. 1: OFDM transceiver

1. CHAOTIC BAKER MAP

Errors in burst form are difficult to detect and correct in a wireless communication channel. So several interleaving schemes are used in mobile communication systems. The block interleaving is the simplest and most popular scheme, but this scheme is not efficient with 2-D error bursts of data symbols [1].

As a result, there is a need for advanced interleaver for such systems. The discretized version of 2-D chaotic Baker map is a good choice for this purpose. In the system model, the signal samples can be arranged into a matrix concatenation form and then randomized with the help of the Baker map [5]. The chaotic baker map generates a permuted version of square matrix. This Baker map transfers each element in a square matrix into a new position according to the map. Let B (n1…. nk) represents the discretized map, where the vector n1…….nk denotes the secret key Skey.The key is chosen in such a way that each integer ni divides N and n1 + n2 + ……nk =M.

Chaotic interleaving of an N×N square matrix can be summarized as follows:

1. An M x M square matrix is divided into k vertical rectangles of height M and width ni.
2. These vertical rectangles are stretched in the horizontal direction and contracted vertically to obtain a ni x M horizontal rectangle.

3. These rectangles are stacked as shown in Fig. 2a, where the left one is put at the bottom and the right one at the top.

4. Each vertical rectangle ni x M is divided into ni boxes of dimensions (M/ni) x ni containing exactly N points.

5. Each of these boxes is mapped column by column into a row of data items as shown in Fig.2.

Fig.2 shows an example of chaotic interleaving of an (8×8) square matrix. The secret key, Skey = (n1, n2, n3) = (2, 4, 2).

The block diagram of the (FFT/DWT)-OFDM with chaotic interleaving is shown in Fig. 3. an interleaving stage is added in the previous block.

At the receiver, the reverse process is applied. Since the data is processed to the chaotic de-interleaving, the receiver is assumed to have an ideal knowledge of the secret key of the chaotic map.

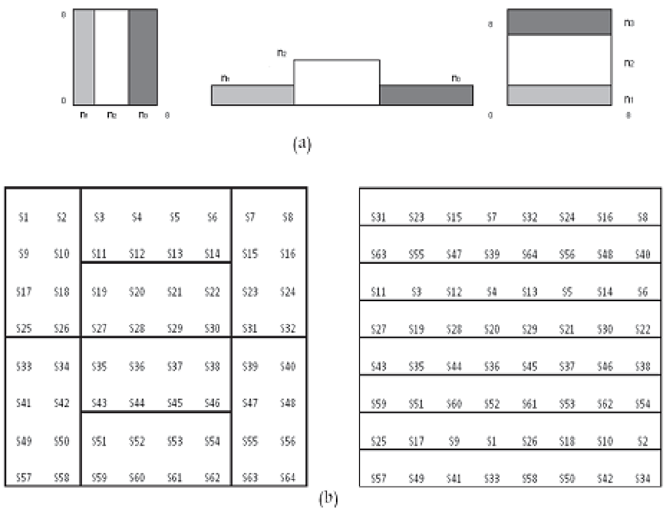

Fig 2: Chaotic interleaving. (a) Discretized Baker map. (b) Randomization of an 8 × 8 block [1].

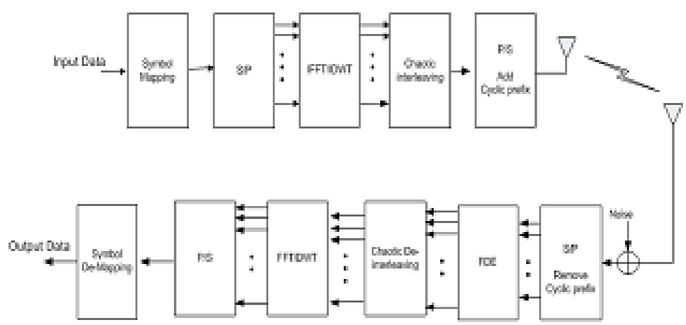

Fig. 3: Block diagram of the OFDM chaotic system model [1].

3. PROPOSED SYSTEM MODEL

In this paper we are using chaotic interleaving which provides better data encryption. Only one copy of burst data is obtained using chaotic interleaving while in proposed DWT-OFDM system model we receive two copies of burst data.For this a block of matrix concatenation is used. With the help of these two copies it becomes easy to estimate about the exact copy of data. Due to this the system becomes somewhat complex but better as compared to DWT-OFDM with chaotic interleaving and FFT-OFDM system for short distances.The system performance is greatly enhanced using this method.

4. EFFECT OF CHANNEL

AWGN Channel Model

The transmitted signal is then applied to an AWGN channel model. The model allows for the Signal to Noise Ratio (SNR) variation. The additive white Gaussian noise (AWGN) will use for both modulation, basically, model is a channel whose sole effect is the addition of white Gaussian noise process to the transmitted signal. This channel is mathematically described by the relation:

$r(t) = S(t) + n(t);$

Where S (t) is the transmitted signal and n (t) is a sample waveform of a zero-mean white Gaussian noise process with power spectral density of No/2; and r (t) is the received waveform. [4]

V.SIMULATION RESULTS

In this section, simulations are performed to test and evaluate the proposed DWT system and to compare it with chaotic DWT and FFT. Two types of OFDM systems were simulated; FFT-OFDM and DWT-OFDM with and without chaotic interleaver using MATLAB and the table shows the Bit Error Rate for the systems. The effect of chaotic interleaving over DWT-OFDM is studied in AWGN channel. The system model and the table showing bit error rate are shown in Fig. 4 & 5. From the results, it is clear that proposed DWT-OFDM system is better than the chaotic DWT-OFDM and FFT-OFDM in terms of BER, specially, over short distance fading channels.

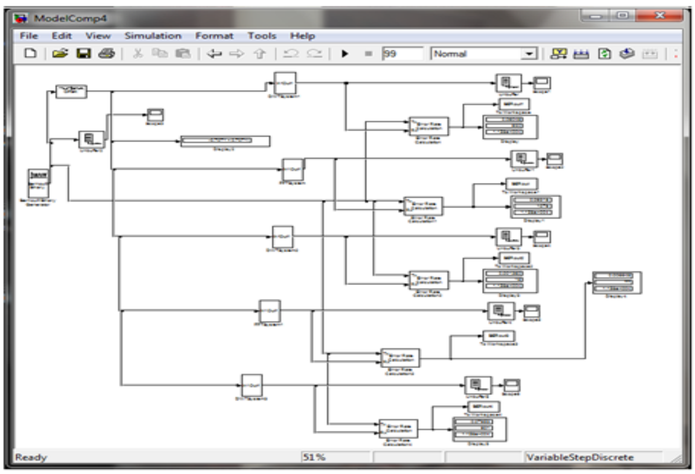

Fig. 4: Codec design of DWT-OFDM system [8]

DWT & FFT DESIGN	NO. OF ERRORS DETECTED	TOTAL NO. OF SYMBOLS COMPARED	ERROR RATE
FFT-OFDM	77	1.158e+0.004	0.006649
PROPOSED DWT	16	1.158e+0.004	0.001382
DWT-OFDM	921	1.158e+0.004	0.07953

Fig. 5: Comparison of error rate of different systems

VI. Conclusion

An efficient multiple copy chaotic interleaving scheme with orthogonal frequency division multiplexing (OFDM) has been presented for wireless data transmission. Matrix concatenation is used in proposed DWT-OFDM system. This approach helps in reducing multipath fading. This scheme has been applied on FFT-OFDM and DWT-OFDM.

From the simulink model and the table, it has been shown that multiple chaotic interleaving enhances the performance of DWT-OFDM system as compared to FFT-OFDM system.

VII. **References**

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