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IMPROVING STFBC MIMO OFDMA WITH CHANNEL ESTIMATION USING DFT AND DCT TECHNIQUE

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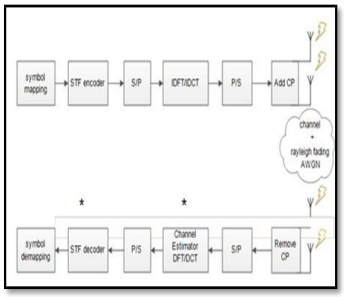
Graphical abstract



Abstract

Higher demand in rapid data transmission makes the wireless technology become more popular in this new modern era. However due to the many users that want to have access in the same time, it can cause congested traffic and affect the data rate. OFDMA modulation scheme with combination of MIMO will support high data signal and become one of the best solutions that can fulfil everybody's dream. These MIMO OFDMA system is based on the diversity coding and appropriate channel estimation in order to achieve maximum diversity order for each user and minimize the interference that have been generated during the transmission. Thus, in this paper in order to boost the overall system performances, Space Time Frequency Block Code (STFBC) and channel estimation technique involving Discrete Fourier Transform (DFT) and Discrete Cosine Transform (DCT) are going to be tested to compare their performance. The result states that when using STF block code, it will gain better performance in MIMO OFDMA system by producing lower bit error rate compare to existence DCT and DFT.

Keywords: MIMO (Multiple Input Multiple Output)OFMDA (Orthogonal Frequency Division Multiple Access), STFBC (Space Time Frequency Block Code), DCT (Discrete Cosine Transform), DFT (Discrete Fourier Transform)

1.0 INTRODUCTION

Over the last few decades, the world has been witnessing the sudden shift in mobile communication technology and reaps a lot of benefits from it. The wired technology becomes aborted as all people are moving towards the wireless technology where everything is controlled within a touch. This new emerging technology becomes more demanding due to its outstanding capabilities in providing the best solution in connecting people and data transmission [1]. The invention of multipurpose antenna in transmitting and receiving multiple data at once has created a lot of advantages in wireless transmission technology and somehow the merges between two technologies also bring a greater impact towards the system.

Therefore in order to explore the goodness of these technologies, this project will focus on the combination of two technologies in wireless communication between MIMO smart antenna and the latest multiple access technique modulation called OFDMA. MIMO can be categorized as the advanced technology in transmitting the data signal and can be diversified in different spaces (antenna), time and frequency or in other words the signal can be sent simultaneously for a different user [2]. While OFDMA is a new modulation technique so called discrete multitoned modulation where an enormous number of subcarrier are modulated by using digital modulation technique such

QAM, BPSK ,QPSK and many more depend on its application[3].
However, the system that promising in supporting high data rate performance is been affected by interference and losses [4]. Thus, it will influence their performances. In addition, with different types of diversity coding such as Space Time Block Code (STBC) and Space Frequency Block Code (SFBC) that attached during the transmission, it will also lead to the fast fading and frequency selective channel respectively [5]. Therefore in order to upgrade and fully utilize the maximum diversity order in MIMO system the Space Time Frequency Block Code (STFBC) will be investigated to see the effects on the system performance [6]. Simulation outcomes are given in comparing between the two systems.

2.0 SYSTEM MODEL

2.1 MIMO OFDMA System

MIMO can be defined as Multiple Input Multiple Output that consists of several transmission antennas and receiver antennas [7]. Whilst MIMO wireless communication can be designated for transmitting the data over wireless links that has been formed by multiple antennas equipped at the transmitter and receiver [8].

Meanwhile OFDMA was induced from FDMA where the users are separated in distinct frequency bands or sub channels [9]. Thus by the execution of this new technology of wireless access the data rate can be decreased for each user or subscriber when the number of them is increasingly large. MIMO also be able to be the next favorite choices in achieving high bandwidth efficiency and can be executed more in OFDMA framework [10].

The new merging technologies are capable to exploit further in the spatial and time dimensions of the channel. In this systems the data signal have been break into multiple unique streams and each of them are modulated and transmitted through a different radio antenna chain at the same time in the same frequency channel [11]. MIMO can be used in two types of modes which are in spatial multiplexing and spatial diversity. In Spatial multiplexing the independent signals is transmitted abruptly over the same frequency channel and it increases the spectral efficiency level [12]. While in spatial diversity the same information signal has been linearly decoded into transmitting stream to enhance the coverage of signal range [1]. The main advantages of this MIMO wireless technology towards the networks are by expanding more coverage range, increasing more throughputs and the robustness of the data link layer [11].Therefore, through the combination of OFDMA that supporting each other in the physical layer and MIMO smart technology, it will be able to improve the effectiveness of physical transmission layer with greater flexibility [13]. Table 1 below shows parameter use for the simulation.

Table 1 Simulation parameter

Parameters	Values
IFFT size	128
Sampling Frequency (MHz)	11.2
Number of Subcarrier	128
Channel	Multipath Rayleigh Fading Doppler Shift AWGN

2.2 Antenna Diversity

Diversity become crucial as it performed an important role in a process of transmitting the OFDM signal through the antenna. From the previous study, Space time coding (STC) based on Alamouti Code become the pioneer in spatial diversity scheme as applied according to code rate-1 in getting full spatial diversity for two transmitting antennas with low decoding complexity [14]. Basically there are two types of sub-carrier mapping when applying Alamouti code in OFDMA system. Firstly, two modulation symbols are encodes over two OFDM symbol at the equal sub carrier and over two antenna [4]. The code is known as Space Time Block Coding (STBC) while the other is done by encoding two modulation symbols over two sub-carriers of the same OFDM symbol and over two antennas, called Space Frequency Block Coding (SFBC) [15].
Both of the code STBC and SFBC have a significant drawback that not fully capable to mitigate the effect of flat fading and separating extra frequency of frequency selective fading channel respectively [14]. Therefore the Space Time Frequency (STFBC) is introduced to overcome the flaws by distributing transmitted symbols from the same space in frequency and time. Its ability to separate spatial and frequency diversity by mapping the information symbol makes STFBC become a perfect method to get low overhead, increase latency and achieving maximum efficiency during the transmission [16].

3.0 CHANNEL ESTIMATION

The suitable type of channel estimation technique is significant in order to improve the received signal accuracy and quality [17]. It is important character in transmitting the radio signal through a multipath channel by recognizing the unknown parameter for amplitude and phase variation of the received signal [14]. The most suitable channel estimation technique will provide better performances to the system [18]. Even though there are many type of channel estimation techniques but it still has the same goals. In this paper, our main focus is to compare the system performances between DFT and DCT channel estimation techniques. The systems are described as follows;

3.1 DFT as a Channel Estimator

DFT channel estimation is a time domain estimation technique. It is used to suppress noise in time domain because energy is concentrated in time domain [19]. The equations N-point of the finite length sequence x (n) of DFT is:

$$X(k) = \sum_{n=0}^{N-1} x(n) e^{-\frac{j2\pi kn}{N}}, \quad k = 0, 1, \ldots\ldots N\text{-}1 \qquad (1)$$

While the inverse transform in frequency domain called inverse DFT or IDFT provide a way to recover the finite length sequence as:

$$X(n) = \frac{1}{N} \sum_{k=0}^{N-1} X(k) e^{\frac{j2\pi kn}{N}}, \quad k = 0, 1, \ldots\ldots N\text{-}1 \qquad (2)$$

3.2 DCT as a Channel Estimator

DCT normally attempts to de-correlate the image data and then transform each coefficient that can be encoded independently without losing its compression efficiency [20]. Due to important properties, DCT has been widely deployed as a channel estimator to improve the performance in data transmission [6]. The time domain for DCT given

$$F(k) = \frac{2c(k)}{N} \sum_{j=0}^{N-1} f(j) \cos \frac{(2j+1)\pi k}{2N} \qquad (3)$$

When k=0,1, ……..N-1 and $c(k) = \frac{1}{\sqrt{2}}$

Whereas the inverse DCT or called IDCT sequences as:

$$f(j) = \sum_{k=0}^{N-1} c(k) F(k) \cos \frac{(2j+1)\pi k}{2N}$$

When i=0,1, ……..N-1 and $c(k) = \frac{1}{\sqrt{2}}$

4.0 SYSTEM DESCRIPTION

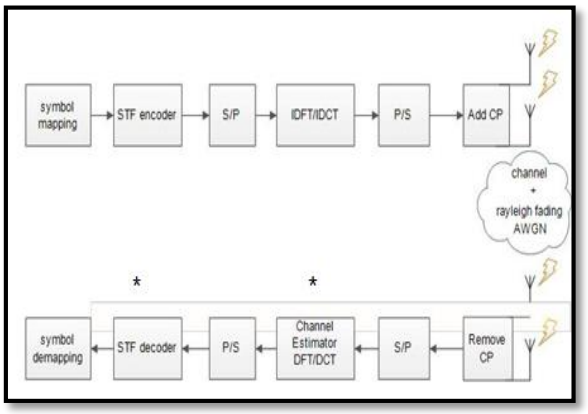


Figure 1 MIMO-OFDMA Transceiver Block Diagram with Channel Estimator

At the transmitter, the input bit data stream in serial order is converted to parallel using S/P converter after going through the STFBC encoder [21]. Then all the subcarriers is processed and modulated into OFDMA modulation segment by using IDFT/IDCT in frequency domain [13]. The frequency domain of the data set then will be transformed into the time domain. The waveform with multiple orthogonal frequency components will be formed and generated [22]. The guard interval, called CP (Cyclic Prefix) will be added to reduce the inter symbol interference between the symbols that been transferred in the system [14]. The converter parallel to serial will create the orthogonal signal of OFDMA signal by outputting sample of time domain [23]. The channel models that have been considered in this transmission are fading channel and Additive White Gaussian Noise (AWGN) with a suitable Doppler Shift [24]. The converter of serial to parallel is going to use again at this stage to split the OFDMA data at the receiver part [2]. Then CP is discarding from the received signal [16]. All the data will be going through the channel estimator in order to get the accurate amplitude and phase variation of the received signal that have been transmitted [17].In this paper there are two different types of channel estimation technique that already being analyse which are DFT and DCT method in order to compare their performances. Finally the converter of parallel to serial will transform the processed data back to its original data signal [25].

5.0 RESULT AND DISCUSSION

All the results have been obtained through the simulation process that tested using MATLAB Software. Table 1 show the parameter that has been used for MIMO OFDMA based on IEEE 802.16 Mobile WiMAX. Three multipaths had been considered in this simulation. The simulation results are about the

performances of MIMO OFDMA Diversity and Channel Estimator which are using DFT and DCT in terms of BER. The section has been divided into two; where the first part is to compare the BER performance of MIMO OFDMA with SF, ST and STF coding. While another section compare the MIMO OFDMA using STF coding with different type of channel estimator such as DFT and DCT.

5.1 Performance of SF, ST and STF for MIMO OFDMA

Figure 2 shows the simulation results that consist of three types of coding which are ST, SF and our proposed STF coding. The bit error rate (BER) for STF system is the best compare to ST and SF system. SF is applicable in channels with low frequency-selectivity or can be achieved by using an enormous number of subcarrier in order to make the subcarrier spacing very narrow. For ST, the problem arises when symbol duration channel keep changing during the transmission. Therefore the performance of STBC will degraded during the signal transmission. Based on the result depicted from MATLAB simulation, it can be summarized that the graph (signal to noise ratio) denoted as Eb/No in the graph is inversely proportional to BER (bit error rate). The value for SNR increases as the value of BER decreases. Therefore it indicate that ISI (inter symbol interference) is slowly lessen. It shown that STFBC coding is able to improve the system performance in MIMO OFDMA system as well provides the maximum diversity order.

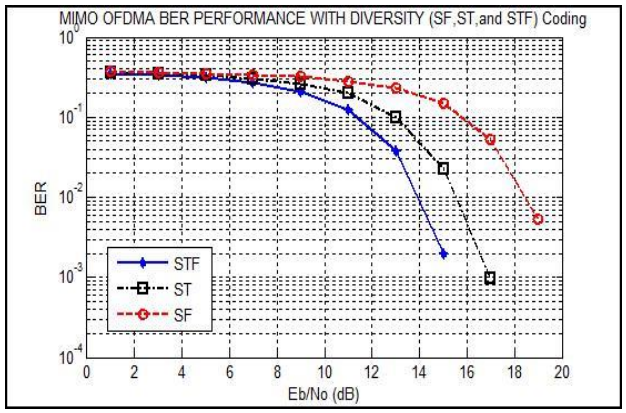


Figure 2 MIMO OFDMA BER Performance with Diversity (SF, ST and STF) Coding

5.2 Performance of DFT and DCT for MIMO OFDMA

Based on the Figure 3, the result shows that comparison of BER performance between the systems using different type of channel estimator. The graph shows that DCT channel estimator shows a very significant BER compare to DFT in minimizing losses during the transmission [20]. DFT use complex exponential functions while DCT use real computation. In terms of hardware, DCT is simpler than DFT. Besides that, DCT is better than DFT because it is lack of continuities. Signal is tend to lose its form in DFT because the signal is represented periodically. Therefore it can be concluded that DCT with MIMO OFDMA with STFBC coding as an alternative channel estimator to the system with very minimize BER.

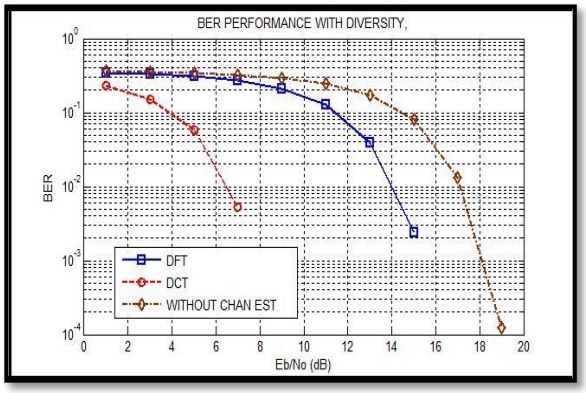


Figure 3 Comparison MIMO OFDMA STFBC with DFT and DCT Channel Estimation and without CE.

6.0 CONCLUSION

The paper compared different types of diversity which consists of SFBC,STBC and STFBC in improving BER performances for the system [26]. The STFBC that had been introduced in this paper is able to upgrade and boost more on the capabilities of MIMO antenna. The percentage of improvement for diversity is 20%. The system also portrays how the STFBC system utilizes the maximum diversity order compared to STBC and SFBC coding. The alliances between both system MIMO OFDMA with SFTBC coding and DCT channel estimation also prove that it can be able to be reduce BER and other losses. The percentage of improvement is 25%. As a conclusion MIMO STFBC OFDMA system with DCT channel estimation manage to improve the overall system performance in wireless data transmission. It also can be one of the choices to overcome the wireless problem in fulfilling the demand of multiuser for rapid data transmitting simultaneously. [27].

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