Azlina Idris[1,*], Nor Azlizan Hussien[2], Mohd Syarhan Idris[3], Suzi Seroja Sarnin[4], Siti Maisurah Sulong[5]

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Improving Transmission Rate with Efficient Bandwidth by using Diversity Technique for MIMO-OFDMA Resource Allocation

MIMO-OFDMA (Multiple Input Multiple Output-Orthogonal Frequency Division Multiple Access) resource allocation is studied in this paper. The considered problem is to provide each user with more data rates in wireless communication system by using the suitable value of bandwidth. The objective of this research is to focus on how to improve the data rate by using efficient bandwidth in MIMO-OFDMA system. The different diversity techniques are also applied to observe which technique is the best for the achievement of maximum diversity order. The simulations show that the space time frequency (STF) diversity technique achieves the highest diversity order by achieves more than 50 percent improvement compared to the system without diversity method, and the value of suitable bandwidth is identified to improve the transmission rate of the system.

Keywords: Multiple Input Multiple Output-Orthogonal Frequency Division Multiple Access (MIMO-OFDMA), Resource Allocation, Diversity Technique, Transmission Rate, Bandwidth.

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1. Introduction

OFDMA is a form of orthogonal frequency division multiplexing (OFDM) that recently used as access technique in wireless network, which is a technique that has high potential for high speed wireless multiuser communication network. This technique has becomes part of IEEE 802.16 wireless metropolitan area network (WMANs) [1] and IEEE 802.22 wireless regional area networks (WRAN) standards [2]. In OFDMA system, each user will be allocates by the base station (BS) as a fraction of the subcarriers where it have a strong channel. The WMANs connect several Wireless LANs together and this standard is used for compliant implementations of Wireless MAN for example the Worldwide Interoperability for Microwave Access (WiMax). The coverage can reach up to a radius of over 30 miles around the WiMax tower. In OFDMA system, the input signal can be transmitted simultaneously on the different subcarriers by multiple users. The probability of users experiencing fading in a particular subcarrier is low; it is because the subcarriers are assigned to the users who are suitable channel on them. Since this technique is extended of OFDM system, so it has the ability to compensate channel distortions in the frequency domain without the computationally demanding time-domain equalizers. The MIMO concet is used in this research because multiple antennas are assigned at both transmitter and receiver, the system can serve for better communication performance. And this is the reason why MIMO considered as a form of smart antenna technology. Recently, MIMO and OFDMA are combined in order to handle the problem of efficiency created by multipath channel and as an approach for high data-rate transmission systems [4]. As the

* Corresponding author: Nor Azlizan Hussien, Siti Maisurah Sulong; Faculty of Electrical Engineering Universiti Teknologi MARA Shah Alam, 40000, Selangor, Malaysia

number of users is increase, the optimal resource allocation must be considered in wireless communication system. This is because, the resource allocation is able to control the transmit power, modulation scheme, channel allocation and error coding which involved the algorithms. Besides that, it is necessary to consider date rates issues in resource allocation despite having low bandwidth, but depending on Quality of Service (QoS) requirements and channel conditions [10]. Even with convincing features, the design of an OFDMA system also facing some challenges. One of the problems is transmission data rate in wireless communication system. High data rate is important because it provides each user with more data rate but at the same time the bandwidth is remain constant. This research is proposed to solve that matters.

2. Methodology

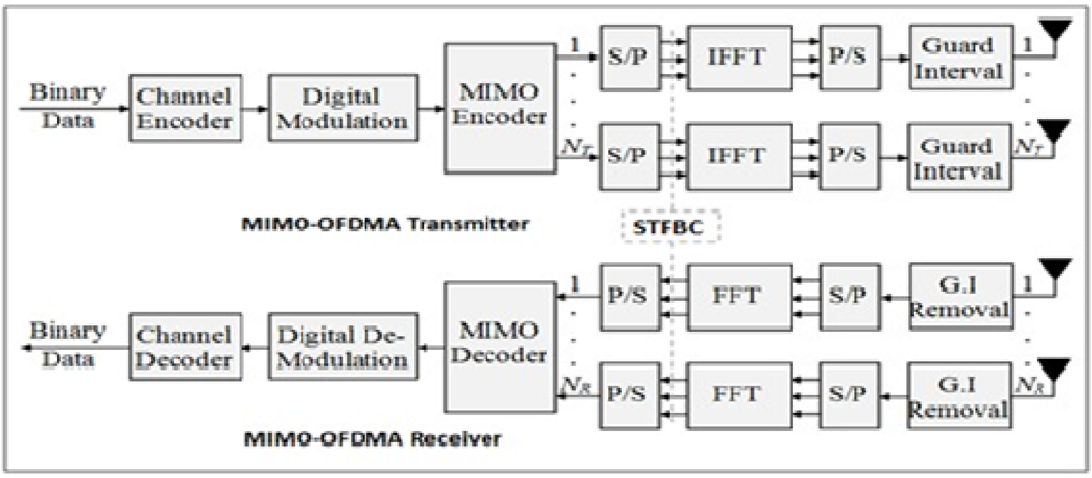

Figure 1: Block diagram of MIMO-OFDMA System [6]

Figure 1 show the MIMO-OFDMA system block diagram. The data bit that about to be transmitted are encoded by channel encoder. The encoded codeword is mapped to data symbol (Quadrature Amplitude Modulation –QAM) by the digital modulation. Then, the data will encoded at MIMO encoder before transmit. The *NT* and *NR* are defined as number of antenna. After the transmit signal is converted to parallel state, the signal then sending to space time frequency block code (STFBC) for the diversity process [6].

Diversity technique is able to improve wireless link at lower cost. The random nature of radio propagation can be exploits by this technique on finding independent signal path for communication. This technique is needed in OFDMA system because if a single radio path goes in a deep fade another independent shall have a strong signal.

After that, the information is modulated from all subcarriers in baseband at Inverse Fast Fourier Transform (IFFT) and transform back into serial information. The guard interval parts are functioned to avoid Inter Symbol Interference (ISI) from the effect of multipath fading then finally the data is transmitted. At the receiver part, the information will go through the same situation as in transmitter but the information will be demodulated to recover the transmitted data.

3. Problem formulation

3.1. Transmission Rate

In this section, the transmission rate is briefly discussed. Based on the problem studied, this focused on transmission rate of the data and can be formulated in [5] as follows:

$$\max_{p_{k,n}} \frac{B}{N}\sum_{k=1}^{K}\sum_{n\in\Omega_k}\left[\sum_{i=1}^{M}\log_2(1+p_{k,n}g_{k,n}^{(i)})\right] \tag{1}$$

The data rate user k in [5] is then

$$R_k = \frac{B}{N}\sum_{n\in\Omega_k}\left[\sum_{i=1}^{M}\log_2\left(1+p_{k,n}g_{k,n}^{(i)}\right)\right] \tag{2}$$

Based on equation (1) and (2), *k* and *n* can be considered as users and subcarriers. Each user has it owns receiving antenna (*Mt*) and the base station has transmitting antennas (*Mr*) where M = min (Mr, Mt)[5]. Each transmit and receive antenna consists the value of 2 antenna based on the MIMO system. The available bandwidth can be declared as *B*, and the allocated power of user *k* on subcarrier *n* is *Pk,n* The channel-to-noise-gain for user *k* and subcarrier *n* can be defined from equation (2) in [5] as

$$g_{k,n}^{(i)} = [\sigma_{k,n}^{(i)}]^2 / N_0 \tag{3}$$

$P_{k,n}g_{k,n}$ gives the corresponding SNR, where N_0 is the noise power. With the transmission rate formulated, the data rate can be computed with the proposed rate by varying different bandwidth to see the different result.

3.2. Diversity Order

STFB coding schemes are used to enhance the reliability and system performance by exploiting from the diversity of space, time and frequency inherent in MIMO-OFDM system. The coding distributes symbols along transmit antennas, time slots and OFDM sub channels. A STFB codeword may consist several OFDM symbols which can increase the diversity order. The encoding matrix of this type of diversity order that represented in [6] is shown as

$$X = \begin{bmatrix} X_1 & -X_2^* \\ X_2 & X_1^* \end{bmatrix} \tag{4}$$

The X1 and X2 are the transmit symbol sending by the multiple antennas at the transmitter. These multiple symbols are then combined at the receiver to be transferred as the output signal.

4. Simulation Results and Performance Evaluation

In this section, the performance of transmission rate is evaluated through the simulation and the bit error rate is analyzed based on the data rate obtained that implemented with the diversity technique. The simulation is done by following the parameters given for computer simulations as shown in table ;

Table 1: system parameter

Parameter	Value
Bandwidth 1	5 (MHz)
Bandwidth 2	10 (MHz)
Bandwidth 3	15(MHz)
Power	46 (dBm)
Noise power	-174 (dBm)
FFT size	2048
Modulation	BPSK,16QAM

4.1. Transmission Rate versus Number of Users

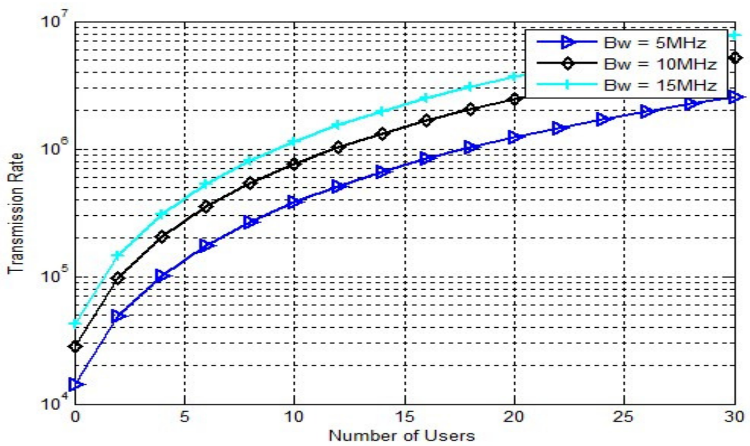

Figure 4: Transmission rate on differerent bandwidth

Figure 4 illustrates the performance of transmission rate versus number of users, where k = 30 users. By using three different sets of bandwidth, the figure shows the level of the data rate as the bandwidth is increased. Theoretically, if the value of bandwidth is increased, the transmission rate performance from equation (2) is also increased, because the data rate is directly proportional with the bandwidth.

4.2. Bit Error Rate versus Signal to Noise Ratio (comparison between with and without diversity for BW=5MHz)

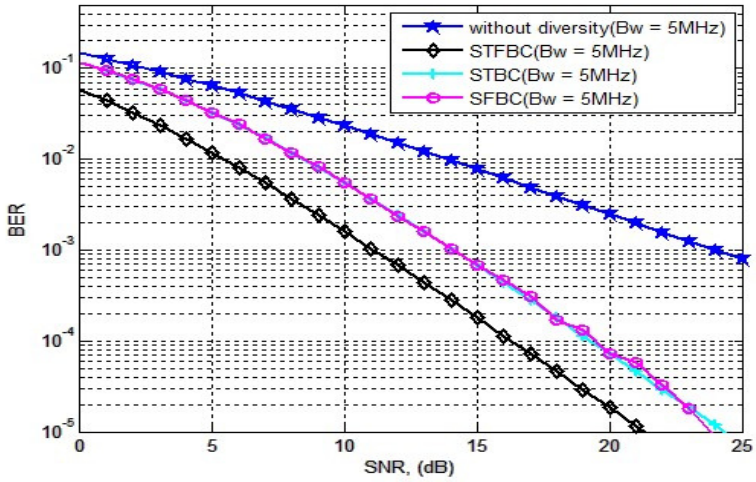

Figure. 5: BER performance on different types of diversity

Figure 5 shows the graph of BER versus SNR for the bandwith of 5MHz. From the result, it can be said that without thee diversity technique the performance of BER is high compare when the diversity technique is applied. The diversity technique improves the transmission reliability based on equation (4) using matrix to vary time and frequency domain. Besides that, the graph also shows the different performance of diversity techniques which are space frequency block code (SFBC), space time block code (STBC) and space time frequency block code (STFBC).

By comparing these three techniques, the STFBC is more satisfied than the other two techniques. This is because the STF diversity controls the space, time and frequency domain which makes the technique is reliable. The STBC and SFBC have similar BER performance because both block codes controls one domain which make their performance of BER is almost the same.

4.3 Bit Error Rate versus Signal to Noise Ratio (with diversity technique comparing three bandwidth)

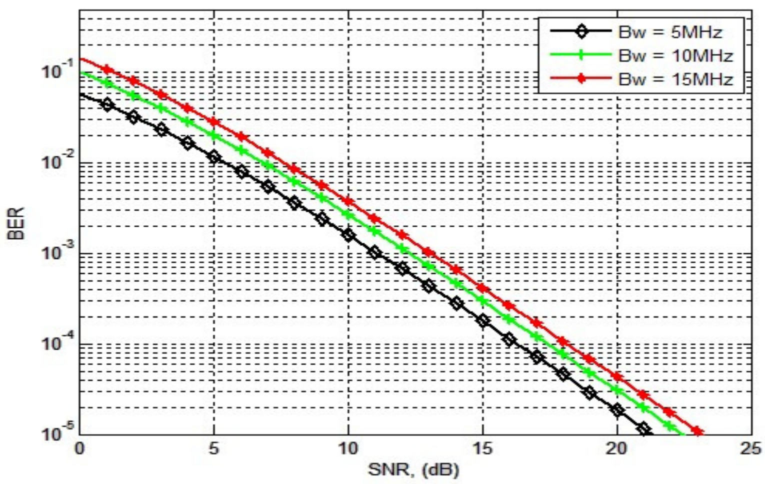

Figure 6: BER performance on STFBC MIMO-OFDMA System

Figure 6 shows the graph plot between BER and SNR with STF diversity and compared between three different bandwidths. Based on the graph, it is shows that when the bandwidth is increased the performance of BER is decreased. This is because when the bandwidth is increase, the efficiency might be drop or the error data is increasing. Same condition as power because interference level between users must take into an account and the effect of increasing power might adjust battery consumption. So, based on figure 6 the increasing bandwidth is not a very good idea because it might increase BER value.

5. Conclusion

As conclusion, the diversity technique applied to the resource allocation scheme can improved the existing resource allocation scheme of MIMO-OFDMA system. Besides that, by using certain value of efficient bandwidth value in this scheme, the transmission rate and BER performance can be improved.

Acknowledgment

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