BER Analysis on WLAN using MIMO-OFDM with Minimum Delay Algorithm

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ABSTRACT--- In our communication system, the QoS is an affecting factor by increase in the number of users in a network, but this can be improved or maintained by following the certain rules and regulations according to the regulatory authority and IEEE standards, this factors will not have limitations to the bit errors, noises, natural climatic conditions, etc., but certain factors like number of users and delay can be adjusted according to the situation in the network. In this article, an algorithm with minimum delay is used to transmit the data over the network in wireless medium and simulation is done with MIMO-OFDM to improve the throughput, which implies that QoS can be improved with this method.

Keywords : QoS, MIMO, OFDM, BER, SNR

I. INTRODUCTION

The process of high data rate signal into multiple low data rate signal by a multiplexing method is called OFDM. Sub-carriers are used to transmit this low data rate signals. Interference between these signals is avoided by the use of this sub carrier, because these sub carriers are orthogonal to each other [2,3]. Symbol duration is increased due to the low data rate of sub carriers. The increasing the symbol duration causes the time dispersion in a multipath delay spread. It produces the ISI cyclic prefix is used to eliminate this ISI. Cyclic prefix is added before the start of each OFDM symbol [3,5]. ISI is avoided by using CP, which extends the OFDM symbol cyclically. The CP converts the effect of the channel on the signal to cyclic convolution instead of linear convolution. IFFT is used to diagonalize the transfer function at the transmitter and FFT is used at the receiver. CP holds the delays spread at the channel [6], channel quality, coverage needs; network capacity has to be enhanced in wireless channel. For that, large set of individual flat fading non frequency selective, narrow band channels are used instead of high frequency selective channel. Implementation of OFDM can be done by using the advancements in the DSP. The orthogonality is given by (1).

$$\frac{1}{T_s}\int_0^{T_s} e^{j2\pi fkt}\, e^{-j2\pi ft}\, dt = \begin{cases} 1\ for\ k=1 \\ 0, otherwise \end{cases} \qquad (1)$$

Discrete time representation of (1) is given by (2).

$$\sum_{n=0}^{N-1} e^{j2\pi\frac{k}{T_s}nT}\, e^{-j2\pi\frac{1}{T_s}nT} = \begin{cases} 1\ for\ k=1 \\ 0, otherwise \end{cases} \qquad (2)$$

To make OFDM signal free from ICI, the above orthogonality equation is essential. Single antennas are used by these senders during early days. The signals are also received by single antennas. Multiple antennas are used by the sender and receiver by the MIMO design. MIMO uses the multiple channels between sender and receiver different data streams are sent in multiple channels to increase the data rate [7]. The data rate is increased by using different channels to transmit different encoder data blocks, called as STBC. BER at lower SNR at the receiver is improved by using this coding technique. BPSK modulation is used to analyze the degradation of error performance at the high rate of SNR.

OFDM is used to transform the frequency selective channels into large set of non-selective narrow band frequency channels. This non-selective frequency channels are essential for MIMO structure. To make a channel as frequency selective, non-selective characteristic of each channel is required in MIMO system. High spectral efficiency is achieved by the mixture of MIMO and OFDM model called MIMO OFDM model.

The transmission by multiple antennas makes the reception as a difficult task. This is due to the superposition of multiple transmitter signals at the receiver. So, spectral efficiency improvement is challenging task. ISI makes the deduction of transmitter signal a difficult one. OFDM is used to remove such ISI. In this paper a MIMO- STBC is proposed to make the frequency selective channel into flat fading channel.

Co-relation between the channels is another challenge in the wireless channel; systematic matrix method is used in MIMO-OFDM system. This model makes correlation between the channels by creating orthogonality behavior between channels. Space time block code presented by [1] uses this orthogonal behavior, diversity gain is defined by the number independent channels between sender and receiver in a multiple antenna system. Product of number of transmitter antennas and number receiving antennas determines the maximum diversity gain. This is achieved with the assumption that the paths are orthogonal [4]. Orthogonal behavior of to transmitter and multiple receiving antenna system are also discussed. Power efficiency bandwidth efficiency and error performance of the system are used to measure the performance of the digital system. This proposed MIMO-OFDM uses ML or MMSE equalizer at the receiver. This paper evaluates the performance of the system with fading. BER can be improved by employing multiple antenna system.

First, interference level available is usually fixed using external modules but not possible to alter it by the framework plans. Second, rise of transmitter power, thereby possible in expanding the power levels of the framework, so that power per bit gets extended. Third, low order modulations were employed, compromising on throughput.

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Lastly, reduction in bandwidth is yet an alternative procedure for decreasing BER is to diminish transmission speed.

II. SYSTEM DESIGN

In two transmitters and one receiver system two antennas are used for transmitting and one antenna for receiving. The diversity gain is greater than SISO system, which is two times. Symbols x1 and x2 are transmitted using antenna1 and antenna2 during first time interval. Symbols –x2* and x1* are transmitted during second time interval using antenna1 and antenna2 [1]. Complex conjugate is given by

$$X = T_x \begin{bmatrix} x_1 & -x_2^* \\ x_2 & x_1^* \end{bmatrix} \quad (3)$$

Next two symbols are transmitted using same process, consecutive time slot are used to transmit four symbols, two symbols are encoded as a block

Fig1

Additive noise is added with the signal y1 and y2 received by antenna1 and antenna2.

$$y_1 = h_1 x_1 + h_2 x_2 + n_1 \quad (4)$$

$$y_2 = -h_1 x_2^* + h_2 x_1^* + n_2 \quad (5)$$

Additive noise is represented by n1 and n2, channel gain is represented by h1 and h2. The assumptions are memory less channel with flat-fading and receiver has the complete channel state information (CSI). So receiver can calculate h1 and h2 by processing y_1 and y_2 the receiver estimate $\overline{x1}$ and $\overline{x2}$

$$\overline{x1} = h_1^* \, y_1 + h_2 \, y_2^* \quad (6)$$

$$\overline{x2} = h_2^* \, y_1 - h_1 \, y_2^* \quad (7)$$

By substituting y_1 and y_2 in the above equation we get

$$\overline{x1} = (|h_1|^2 + |h_2|^2)x_1 + h_1^* n_1 + h_2 n_2^* \quad (8)$$

$$\overline{x2} = (|h_1|^2 + |h_2|^2)x_2 + h_2^* n_1 - h_1 n_2^* \quad (9)$$

where the estimated signal $\overline{x1}$ and $\overline{x2}$ corresponds to x1 and x2 in the presence of added noise both the value are affected by fading. The matrix form representation is given by

$$\begin{bmatrix} y_1 \\ y_2^* \end{bmatrix} = \begin{bmatrix} h_1 & h_2 \\ h_2^* & -h_1^* \end{bmatrix} \begin{bmatrix} x_1 \\ x_2^* \end{bmatrix} = H \begin{bmatrix} x_1 \\ x_2^* \end{bmatrix} \quad (10)$$

where H is given by

$$H = \begin{bmatrix} h_1 & h_2 \\ h_2^* & -h_1^* \end{bmatrix} \quad (11)$$

The orthogonality of channel matrix H is verified by

$$HHH = I \quad (12)$$

In the above equation HH represents the hermitian matrix and I represent identity matrix. In alamouti scheme, two time intervals are used to transmit, two symbols to make the rate equal to one orthogonality of H matrix is presented is known as space time block code. Only two transmitter antennas are possible in Alamouti scheme. Two transmitters and two Receivers scheme is demonstrated by Fig 2

The diversity gain of two transmitters and two receiver scheme is twice that of the two transmitters and one receiver scheme. Signal x1 is transmitted by antenna1 and x2 is transmitted by antenna2 during first time interval. Symbol –x2* is transmitted by antenna1 and signal x1* is transmitted by antenna2 during second time interval. Signal y11 is received by antenna1 in receiver, where y11 is combination of signals x1 and x2, which is transmitted over a transmitting antenna1 and antenna2 respectively during the first time slot and y12 is the combination of –x2* and x1* transmitted during second slot, and continuously the y21, y22 are calculated with respect to the transmitted signals at next consecutive time slots respectively. The signals are given by

$$y_{11} = h_{11} x_1 + h_{12} x_2 + n_1 \quad (13)$$

$$y_{12} = h_{11}(-x_2^*) + h_{12} x_1^* + n_2 \quad (14)$$

$$y_{21} = h_{21} x_1 + h_{22} x_2 + n_3 \quad (15)$$

$$y_{22} = h_{21}(-x_2^*) + h_{22} x_1^* + n_4 \quad (16)$$

Which can be represented in the another form of matrix

$$\begin{bmatrix} y_{11} \\ y_{12} \\ y_{21} \\ y_{22} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{12} & -h_{11} \\ h_{21} & h_{22} \\ h_{22} & -h_{21} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \\ n_3 \\ n_4 \end{bmatrix} \quad (17)$$

For decoding the original data we have to calculate the $\overline{x_1}$ and $\overline{x_2}$, and the noise terms can be determined with the below equations

$$\eta_1 = h_{11}^* n_1 + h_{12} n_2^* + h_{21}^* n_3 + h_{22} n_4^* \quad (18)$$

$$\eta_2 = h_{12}^* n_1 - h_{11} n_2^* + h_{22}^* n_3 - h_{21} n_4^* \quad (19)$$

As per our concept, two antennas are needed to transmit the data and the two different paths or different time slots are needed. The orthogonality is maintained for three bits for four slots, it is ¾ rates. The method of design the system is given below

- Frame the first row with t elements
- Second row is to maintain orthogonality according to the first row
- Third row is also to maintain orthogonality for above rows
- Up to n rows created according to become an orthogonal, where n is no of time intervals required to transmit t symbols.

$$\begin{bmatrix} h_1 & h_2 & h_3 & & h_t \\ -h_2^* & -h_1^* & 0 & \cdots & 0 \\ h_3^* & 0 & -h_1^* & & 0 \\ & \vdots & & \ddots & \vdots \\ 0 & 0 & 0 & \cdots & -h_1^* \end{bmatrix} \quad (20)$$

- The above matrix is an H matrix.

III. SYSTEM MODEL

The system is designed with 1x1, 2x2, 2x3, 2x4 types of transmitter and receiver antennas, where the simulation is executed with basic building blocks for the transmitter and receiver with minimum delay algorithm as used in previous article,

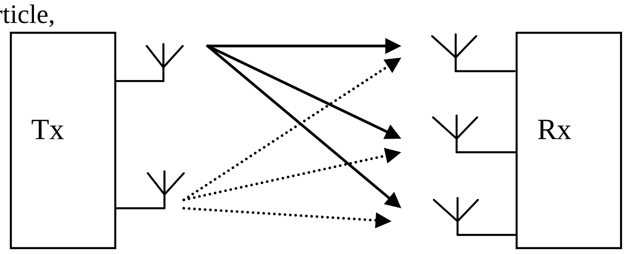

Figure. 1. 2x3 MIMO Model

Here the antennas will transmit the data over space at a high rate signal and it can be split into the many number of lower rate signals that can be transmitted through the every transmitter antennas. When the signal is received by the receiver antenna with many multipath signals is received by these antennas. Where the number of antennas used in receiver side is helpful in receiving the data, but the spatial multiplexing is very powerful in increasing the channel capacity and our channel selection algorithm will also help to increase the channel capacity. The above figure represents those two (Tx1 and Tx2) antennas at the transmitter side and three (Rx1, Rx2, Rx3) antennas at the receiver side. From Tx1 to Rx1 one signal is travelling as x11 and Tx1 to Rx2 same signal is travelling in another path is represented as x12 and respectively x13, x21, x22, x23 are the multiple signals that can be taken for consideration of the calculation of receiving signals.

IV. RESULT AND DISCUSSION

The simulation was done for the system with minimum delay algorithm for channel selection, where the results were plot between the bit error rate (BER) to the average Eb/N0 (SNR). The environment selected for the simulation is WLAN.

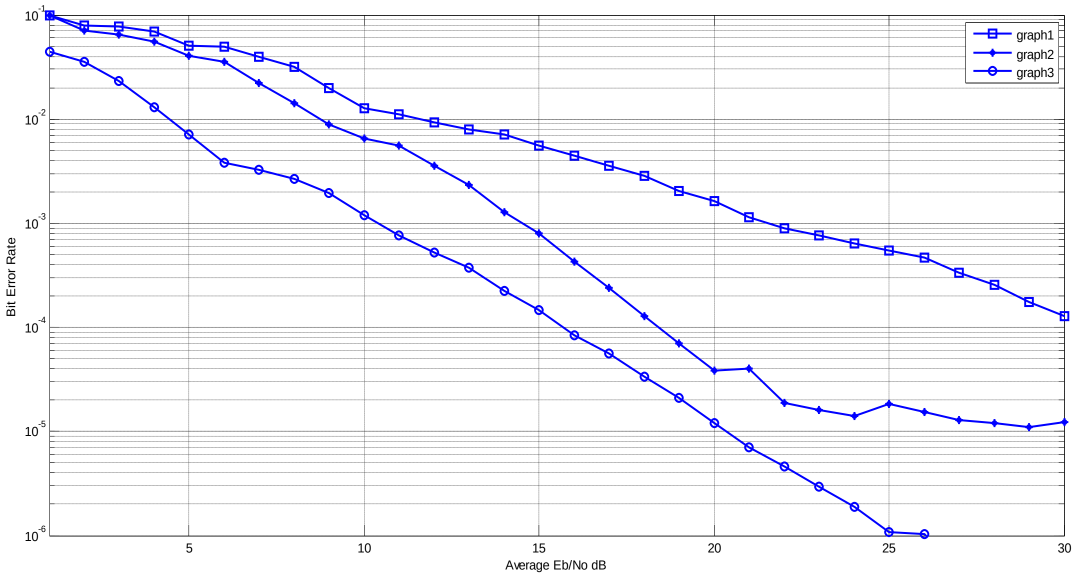

Figure 1

The above figure shows that simulation results with defined system model and different transmitting and receiving antennas. This simulation is done with Rayleigh fading and plot between BER vs SNR. The graph1 is result of 2x2, graph2 is result of 2x3 and graph3 is result of 2x4. So from this analysis, more number of receiving antenna will provides minimizing the error rate.

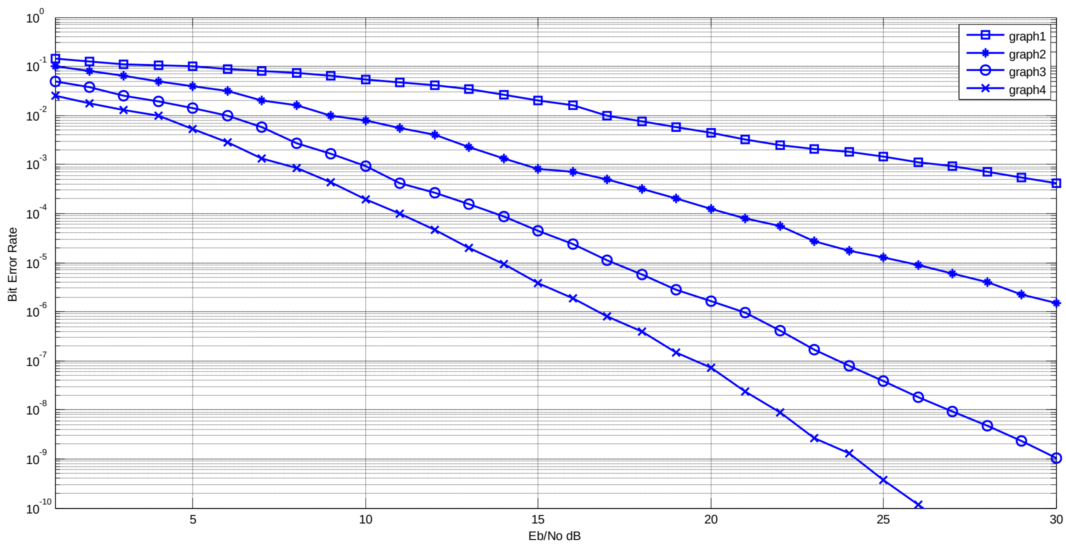

Figure 2

The figure 2 represents the simulation result of above said system model with different transmitting and receiving antennas. Simulation is done with Rician fading and plot between BER vs SNR. The graph1 represents output of 2x2, graph2 represents output of 3x3, graph3 represents output of 2x3 and graph4 represents output of 2x4 antennas.

V. CONCLUSION

In this paper a better BER rate was given by system and this can improve the network with better QoS with congested area. The number of antennas used in the receiving side to be maintained high compared to transmitting antenna will results in minimized bit error rate while using this minimum delay algorithm. This paper comprehensively evaluates a better MIMO model for newly modified algorithm. For future there is scope to improve QoS, same simulation with this system model to be done for throughput analysis and may be result in excellent solution of high speed network.

REFERENCES

1. Yahui Hu ,"*Cross Layer Dynamic Resource Management with Guaranteed QoS in MIMO OFDM Systems*", 2008 IEEE Pallaviram Sure, Narendra Babu C and Chandra Mohan Bhuma, "*Large random martrix-based channel estimation for massive MIMO-OFDM uplink*" ,IET Communications, 2018
2. Ngo, H.Q., Larsson, E.G., Marzetta, T.L.: '*Energy and spectral efficiency of very large multiuser MIMO systems*', IEEE Trans. Commun., 2013, 61, (4), pp. 1436–1449
3. Hemlata Sinha, M.R.Meshram and G.R.Sinha, *"BER Performance Analysis of MIMO-OFDM Over Wireless Channel"*, International Journal of Pure and Applied Mathematics, Vol 118, No.5, 2018
4. M.Kahvand, M.T. Soleimani, and M.Dabirranzohouri, *"Channel Selection in Cognitive Radio Networks: A New Dynamic Approach"*, 2013 IEEE, 11th Malasiya International Conference on Communications 26th-28th November 2013, Kuala Lumpur, Malasiya, pp. 407-411.
5. W.Wong, K.G.Shin, and W.Wang, *"Distributed Resource Allocation Based on Queue Balancing in Multihope Cognitive Radio Allocation Based on Queue Balancing in Multihop Cognitive Radio Networks"*, IEEE/ACM Transactions on Networking, vol. 20, No. 3, pp. 837-850, 2012.
6. Giuseppe Caire, *"On the Ergodic Rate Lower Bounds with Applications to Massive MIMO"*, IEEE Transactions on Wireless Communications, 2018.
7. Zhi Quan and Jie Liu, *"Efficient Complex Matrix Inversion for MIMO OFDM Systems"*, Journal of Communications and Networks, Vol. 19, No. 6, December 2017.