Performance Improvement in Wireless Channel Estimation for MIMO-OFDM Systems

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Abstract : The multiple-input and multiple-output, or MIMO, is a method for multiplying the capacity of a radio link using multiple transmission and receiving antennas to exploit multipath propagation. Orthogonal frequency division multiple access modulation technique handled efficiently of multipath channel. This paper proposed efficient approach based on Alamouti STBC for channel estimation. Simulation is carried out using MATLAB software. Signal to noise ratio and Bit error rate is the key parameter to check validation of the proposed methodology. PSK is needed to apply with various simulation conditions. Simulated result shows the significant improvement than existing approach.

IndexTerms - MIMO, OFDM, Modulation, PSK, STBC. Antenna.

I. INTRODUCTION

In radio, multiple-input and multiple-output, or MIMO, is a method for multiplying the capacity of a radio link using multiple transmission and receiving antennas to exploit multipath propagation.[1] MIMO has become an essential element of wireless communication standards including IEEE 802.11n (Wi-Fi), IEEE 802.11ac (Wi-Fi), HSPA+ (3G), WiMAX (4G), and Long Term Evolution (4G LTE). More recently, MIMO has been applied to power-line communication for 3-wire installations as part of ITU G.hn standard and Home Plug AV2 specification.[2][3].

In telecommunications, orthogonal frequency-division multiplexing (OFDM) is a method of encoding digital data on multiple carrier frequencies. OFDM has developed into a popular scheme for wideband digital communication, used in applications such as digital television and audio broadcasting, DSL internet access, wireless networks, power line networks, and 4G mobile communications.

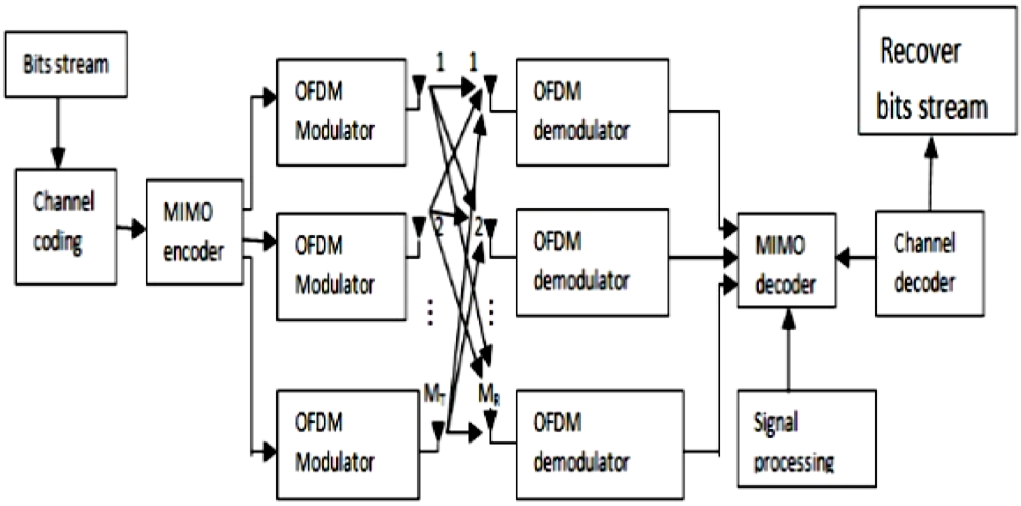

Figure 1: Architectural view of MIMO-OFDM [8]

One requirement of the OFDM transmitting and receiving systems is that they must be linear. Any non-linearity will cause interference between the carriers as a result of inter-modulation distortion. This will introduce unwanted signals that would cause interference and impair the orthogonality of the transmission.

In terms of the equipment to be used the high peak to average ratio of multi-carrier systems such as OFDM requires the RF final amplifier on the output of the transmitter to be able to handle the peaks whilst the average power is much lower and this leads to inefficiency. In some systems the peaks are limited. Although this introduces distortion that results in a higher level of data errors, the system can rely on the error correction to remove them.

II. BACKGROUND AND CHALLENGES

Many broadband wireless networks have now included MIMO technology in their protocols including the multicast system. Compared to single input single output (SISO) system, MIMO offers the higher diversity which can potentially lead to a multiplicative increase in capacity. In multiuser OFDM or MIMO-OFDM systems, dynamic resource allocation always exploits multiuser diversity gain to improve the system performance and it is divided into two types of optimization problems: 1) to maximize the system throughput with the total transmission power constraint ; 2) to minimize the overall transmit power with constraints on data rates or Bit Error Rates (BER). To the best of our knowledge, most dynamic resource allocation algorithms, however, only consider unit cast multiuser OFDM systems. In wireless networks, many multimedia applications adapt to the multicast transmission from the base station (BS) to a group of users. These targeted users consist of a multicast group which receives the data packets of the same traffic flow. The simultaneously achievable transmission rates to these users were investigated. Recently scientific researches of multicast transmission in the wireless networks have been paid more attention. For example, proportional fair scheduling algorithms were developed to deal with multiple multicast groups in each time slot in cellular data networks. The dynamic resource allocation for OFDM based multicast system was researched, however it focused on SISO system and cannot be applied to MIMO system directly. On the other hand, the conventional scheme in current standards such as IEEE 802.16 or 3GPP LTE for multicast service considers the worst user very much, which may waste the resource. In this paper, we propose dynamic subcarrier and power allocation algorithms for MIMO OFDMA-based wireless multicast systems. In the proposed algorithms, the subcarriers and powers are dynamically allocated to the multicast groups. Our aim is to maximize the system throughput given the total power constraint. Let us assume that there are multiple multicast groups in a cell and each multicast group may contain a different number of users. The users included in the same multicast group are called co- group users and these can be located in different places in the cell.

CHALLENGES

- The OFDM signal has a noise like amplitude with a very large dynamic range.
- Therefore it requires RF power amplifiers with a high peak to average power ratio.
- It is more sensitive to carrier frequency offset and drift than single carrier systems are due to leakage of the DFT..

III. PROPOSED METHODOLOGY

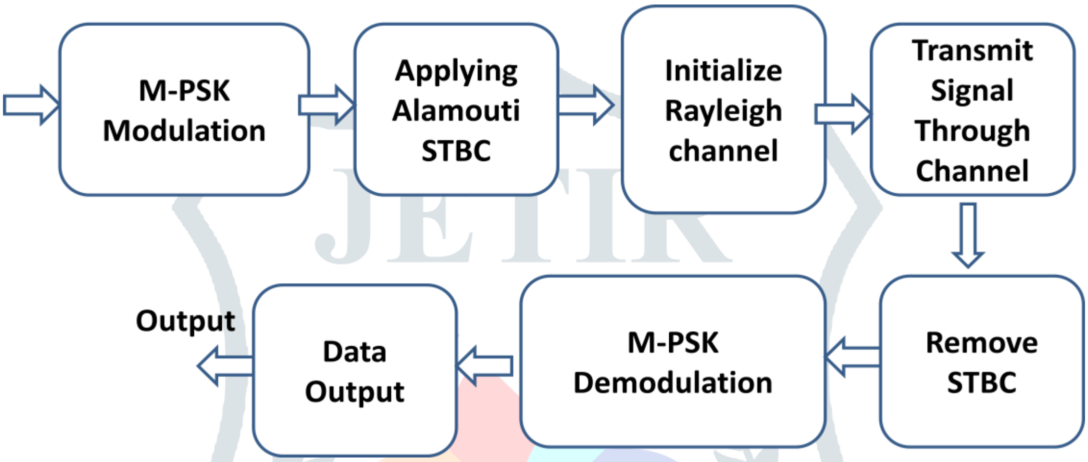

Figure 2: Block Diagram of Proposed Methodology

Figure 2 depicts the transmitter modules. After channel encoding of information bits b_k with a convolution encoder of coding rate R, the encoded bits are mapped according to a Gray quadrature amplitude modulation (QAM) scheme. The Gray mapped assigns B bits for each of the complex constellation points. Using M_T transmitting antennas, a space time (ST) block code (STBC) encoder assigns a (M_T,T) matrix $X=[x_{i,t}]$ to each group of Q complex symbols $S=[s_1,\ldots,s_Q]$ from the input of ST module. The ST coding rate is then defined by $L=Q/T$. The output matrix is transmitted over M_T antennas during T symbol durations i.e. each column is transmitted once during one symbol duration. The different elements $x_{i,t}$ ($i=1,\ldots,M_T$; $t=1,\ldots,T$) are functions of the input symbols s_q ($q=1,\ldots,Q$) depending on STBC encoder type.

The symbols at the output of STBC are fed to OFDM modulators of N subcarriers. The output at each OFDM modulator is a sequence of samples having a rate $F_e=1/T_e$. After digital to analogue conversion (DAC), the signal is transposed to the transmitter carrier frequency F_{TX} by the RF unit, and transmitted through the channel. At the receiver (**Error! Reference source not found.**), it is transposed to base band with the receiver carrier frequency F_{RX} and sampled at sampling frequency $F_s=1/T_s$ using analogue to digital converter (ADC). In this work, we assume equal carrier frequencies F_{TX} (respectively equal sampling frequencies F_e) for all transmitting antennas and equal carrier frequencies F_{RX} (equal sampling frequencies F_s) for all receiving antennas. The CFO is therefore given by $\Delta F=F_{RX}-F_{TX}$ and the SFO is defined by $1/\Delta T=1/(T_s-T_e)$. After OFDM demodulation, the signal received by the j^{th} antenna at each time sample t on the n^{th} subcarrier could be written as:

$$Y_j[n,t]=\frac{1}{\sqrt{M_T}}\sum_{m=0}^{M_T-1}\sum_{p=0}^{N-1}X_i[p,t]h_{j,i}[p]\phi(n,p)+W_j[n,t] \qquad (1)$$

where $h_{j,i}[p]$ is the frequency channel coefficient on the p^{th} subcarrier assumed constant during T OFDM symbols, $W_j[n]$ is the additive white Gaussian noise (AWGN) with zero mean and $N_0/2$ variance. $\phi(n,p)$ is a function of the CFO and SFO, given by:

$$\phi(n,p)=e^{j\pi\frac{N-1}{N}\left(N\Delta FT_s+\frac{\Delta T}{T_s}e(n)+e(n-p)\right)}\times \frac{1}{N}\frac{\sin\left(\pi\left(N\Delta FT_s+\frac{\Delta T}{T_s}e(n)+e(n-p)\right)\right)}{\sin\left(\pi\left(N\Delta FT_s+\frac{\Delta T}{T_s}e(n)+e(n-p)\right)\Big/N\right)} \qquad (2)$$

$$\text{ωιτη}\;\; e(n)=\begin{cases} n & if\;\; n\le N/2 \\ n-N & elsewhere\end{cases}$$

The signal received by the M_R antennas on subcarrier n are gathered in a matrix $Y[n]$ of dimension (M_R,T). It can be deduced from □1□ by:

$$\begin{aligned} Y[n] &= \phi(n,n)H[n]X[n] + \sum_{\substack{p=1 \\ p\neq n}}^{N} \phi(n,p)H[p]X[p] + W[n] \\ &= H_{eq}[n]X[n] + \sum_{\substack{p=1 \\ p\neq n}}^{N} \phi(n,p)H[p]X[p] + W[n] \end{aligned} \tag{3}$$

In □□□, the first term represents useful signal, the second term indicates ICI and the last one is AWGN. $\phi(n,n)$ could be seen as phase rotation and amplitude distortion of the useful signal due to CFO and SFO. The ICI could be seen as an additive noise to the useful signal. It will be neglected in the equalization process. $H[n]$ is a (M_R,M_T) matrix whose components are the channel coefficients $h_{j,i}[n]$. $X[n]$ is a (M_T,T) matrix whose components are the transmitted symbols on the M_T antennas during T OFDM symbols on the n^{th} subcarrier and $W[n]$ is the AWGN.

$$\begin{aligned} \hat{V}_u^{(l)} &= Y - G_{eq,u}\tilde{S}_u^{(l-1)} \\ \hat{s}_u^{(l)} &= \frac{1}{g_u^{tr} g_u} g_u^{tr} \hat{V}_u^{(l)} \end{aligned} \tag{4}$$

The exchange of information between detector and decoder runs until the process converges.

IV. SIMULATION AND RESULTS

Firstly, defined all parameters then make function of STBC OFDM with 2 level montecarlo. Now run this file with different M-PSK order. Result graph is showing considerable improvement in bit error rate and signal to noise ratio.

Table 1: Simulation Parameters

Parameter	Value
Number of blocks	1e2
Number of transmit antennas	4
Number of receive antennas	32
Number of subcarriers	128
Guard interval percentage	¼
M-PSK Modulation	8-1024
Subcarrier space between two pilots	1
Signal to noise ratio	15 dB
Symbols	1000-2000

In table 1, simulation parameters are showing which is taken during the execution of MATLAB script. In this number of transmitter and number of receiver antenna keep change. Also set PSK modulation scheme from 8 to 512 PSK.

4x32 MIMO OFDM with 128 PSK Modulation Scheme

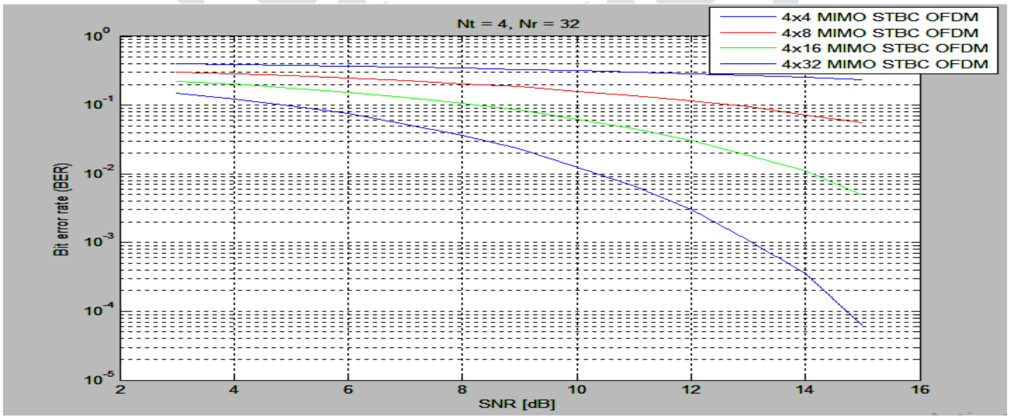

Figure 3: BER vs SNR graph for Tx=4 and Rx=4 to 32

Figure 3 is showing output graph between bit error ratio and signal to noise ratio. Here modulation scheme is 128-PSK, after analyzing both graphs, we can say while SNR & BER both needed to significant then it is proposed dimension of MIMO i.e. 4x32 Transmitters-Receiver.

4x32 MIMO OFDM with 256 PSK Modulation Scheme

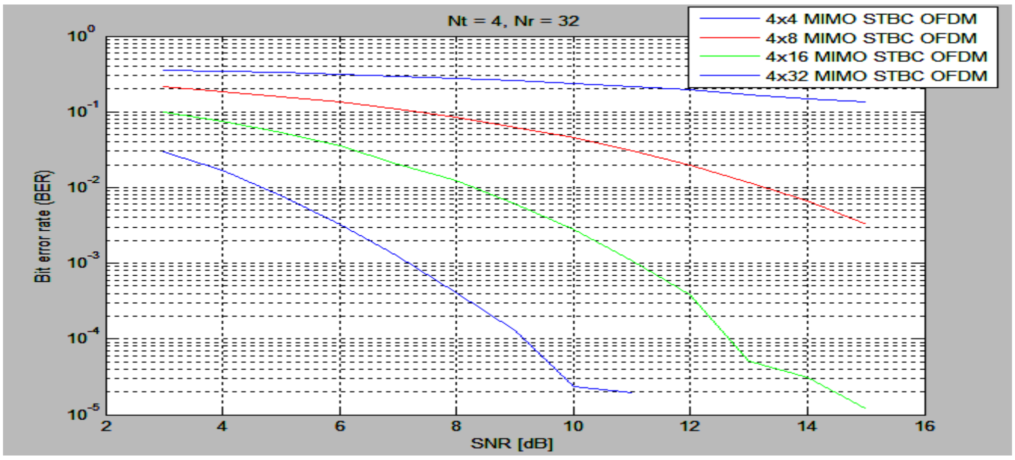

Figure 4: BER vs SNR graph for Tx=4 and Rx=4 to 32

Figure 4 is showing output graph between bit error ratio and signal to noise ratio. Here modulation scheme is 256-PSk, after analyzing both graphs, we can say while SNR & BER both needed to significant then it is proposed dimension of MIMO i.e. 4x32 Transmitters-Receiver.

4x32 MIMO OFDM with 512 PSK Modulation Scheme

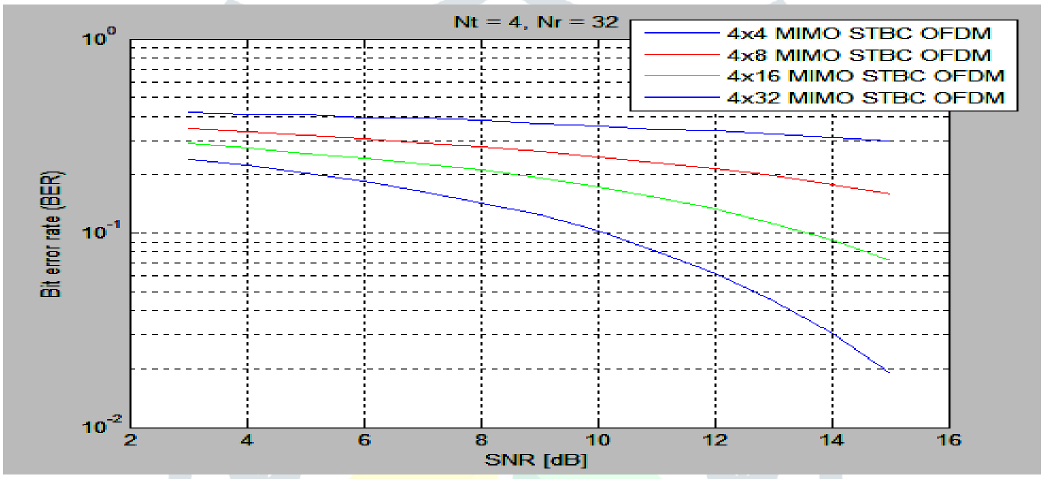

Figure 5: BER vs SNR graph for Tx=4 and Rx=4 to 32

Figure 5 is showing output graph between bit error ratio and signal to noise ratio. Here modulation scheme is 512-PSk, after analyzing both graphs, we can say while SNR & BER both needed to significant then it is proposed dimension of MIMO i.e. 4x32 Transmitters-Receiver.

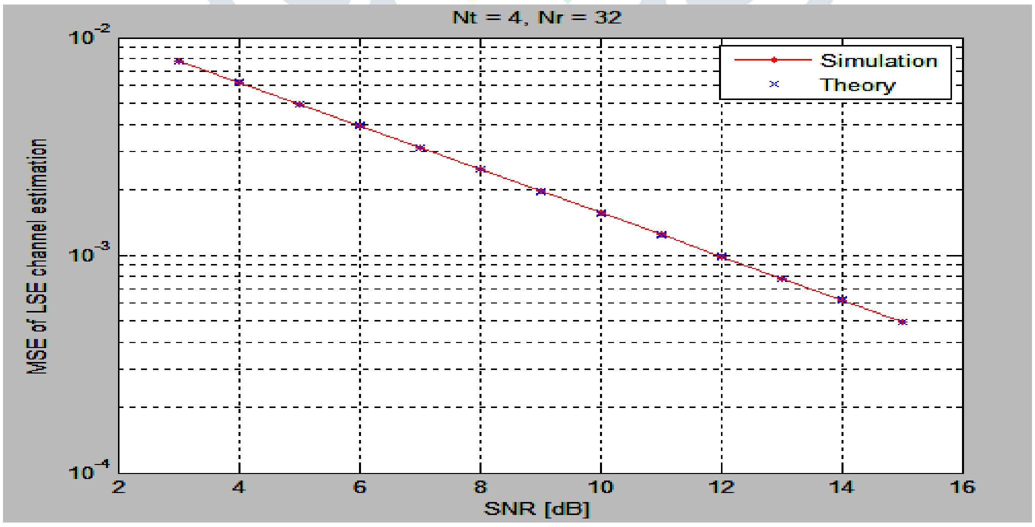

Figure 6: MSE vs SNR graph for Tx=4 and Rx=4 to 32

Table 2: Simulation Result

Tx-Rx Antenna	BER	MSE	Max .SNR
4Tx-4Rx	$10^{-1.6}$	$10^{-3.5}$	15
4Tx-8Rx	10^{-2}	$10^{-3.5}$	15
4Tx-16Rx	10^{-5}	$10^{-3.5}$	15
4Tx-32Rx	$10^{-4.5}$	$10^{-3.5}$	15

Table 3: Comparison chart of proposed work with Base Paper

Parameters	**Base Paper work**	**Proposed Work**
Method	Alamouti-STBC	Alamouti-STBC
Modulation	M-QAM(M=8,16)	M-PSK(M=8 To 512)
BER	$10^{-1.2}$	$10^{-5.0}$
MSE	-	$10^{-3.5}$
SNR	10	15
Tx Antenna	2	4
Rx Antenna	4	32

Therefore proposed work result is better than previous work so STBC-OFDM approach is considerable and significant result is achieved.

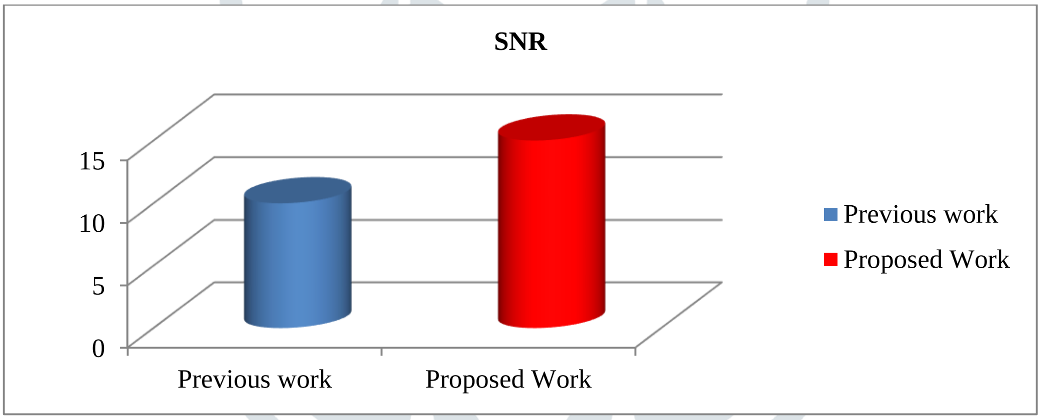

Figure 7: Comparison of SNR

V. CONCLUSION

It is clear that there is an improvement in capacity of MIMO-OFDM channel when the proposed method is implemented to achieve capacity maximization is used to allocate different modulation and antenna combination. Illustrate the Bit error rate versus SNR for different MIMO-OFDM systems. The result table and graph shows that the capacity of the MIMO-OFDM channel increases as the number of antennas used at both the transmitter and the receiver increases upto 4x32 MIMO systems provide better channel capacity. This indicates that a higher order MIMO system increases the system performance.

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