ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization *Vol. 4, Special Issue 1, March 2015*

National Conference on Recent Advances in Electrical & Electronics Engineering (NCREEE 2015)

Organized by

Dept. of EEE, Mar Baselios Institute of Technology & Science (MBITS), Kothamangalam, Kerala-686693, India

On 26th & 27th March 2015

Spatial Diversity for Performance Improvement in Multiuser OFDM

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ABSTRACT:In this paper a combined SDMA OFDM system is studied for a multiuser environment.Space division multiple access (SDMA) is a smart antenna technology which using diversity reception technique to mitigate the effects of fading over a communications link. SDMA usually employs antenna arrays at receiver side for achieving space diversity.Orthogonal frequency division multiplexing (OFDM) increases the diversity gain and to upgrade the system capacity on time-variant and frequency-selective channels . Alsoa number of available multiuser detection (MUD) algorithms for use in the base station for an SDMA/OFDM system are discussed along with their limitations when the number of users exceeds the number of receiver antennas, thus creating a rank deficient scenario. When the number of receiver antennas increases the performance improvement results, then BER will fall significantly for smaller values of SNR.

KEYWORDS—BS, CIR, FFT, IFFT, LS, MIMO, MMSE, MS, MUD, OFDM, SDMA

I.INTRODUCTION

Motivated by the huge demands for fast and reliable communications over wireless channels, future broadband communication systems should provide low complexity data processing , higher data rate, and robust performance. In practice, however, the broadband channel is a typically non-line-of-sight channel and includes much impairment such as time-selective and frequency-selective fading. To address these challenges, one promising solution is to combine two powerful technologies, namely, multiple-input multiple-output (MIMO) antennas and orthogonal frequency division multiplexing (OFDM) modulation.

Space division multiple access (SDMA) is an antenna array concept in which various spatial distribution of antenna elements is utilized for improving the system performance. This paper begins with an introduction on how SDMA can be combined with MIMO OFDM Systemsfor a multiuser scenario. Here an uplink (Mobile station to base station) channel is considered and the users are transmitting from various geographic locations. They are assumed to be using same frequency band and transmitting simultaneously. Since the channel is a multipath channel, the receiver has to perform a diversity reception for better performance.

Various multiuser detection (MUD) techniques are discussed here. There are linear and nonlinear classes of MUD. Under linear classification Least square (LS) and Minimum mean square error (MMSE) MUD's are discussed. They are performing the channel equalization in a multipath environment. The LS is the simplest method in a noiseless condition. But the communication channel is noisy always so it will be better to use a MUD which will take care of noise affects. MMSE equalizer will cancel out noise effect also. The spatial diversity provided at the base station improves the BER performance significantly. So this paper is mainly deals with the linear detectors like LS and MMSE.
The structure of this paper is as follows. Section II begins with the introduction to combined SDMA OFDM system model. Overview of various MUD's are given in section III. Section IV deals with the Simulation results and findings. And finally section V has the conclusion.

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II.SYSTEM MODEL

A combined SDMA OFDM system model is shown in fig 1

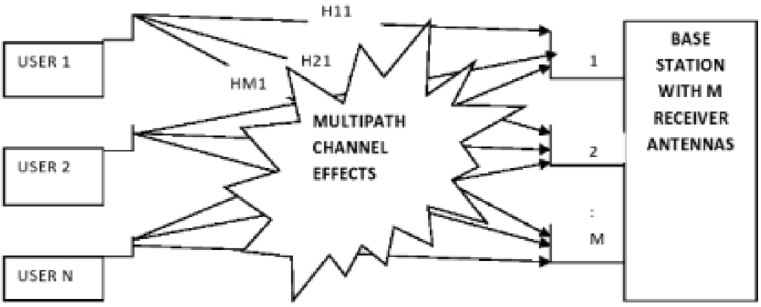

Fig 1. A combined SDMA OFDM system model.

Where each of the N simultaneous mobile users employs a single transmit antenna, while the BS's receiver exploits M antennas. At the l thsubcarrier of the k th OFDM symbol received by the M-element receiver antenna array, we have the received signal vector X [k, l], which is constituted by the superposition of the independently faded signals associated with the N mobile users and contaminated by the AWGN, expressed as

$$\boldsymbol{x} = \boldsymbol{H}\,\boldsymbol{s} + \boldsymbol{n} \; \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; (1)$$

Where the (M×1)-dimensional vector $\boldsymbol{x}$ the (N×1)-dimensional vector $\boldsymbol{s}$ and the (M×1) - dimensional vector$\boldsymbol{n}$ are the received, transmitted and noise signals, respectively. Here we have omitted the indices [k, l] for each vector for the sake of notational convenience. Specifically the vectors ***x, s*** and **n** are given by,

$$\boldsymbol{x} = [\boldsymbol{x_1}, \boldsymbol{x_2}, \boldsymbol{x_3}, \boldsymbol{x_4}, \ldots, \boldsymbol{x_M}]^T; \ldots\ldots\ldots\ldots\ldots\ldots \; \textbf{(2)}$$

$$\boldsymbol{s} = [\boldsymbol{s}^{(1)}, \; \boldsymbol{s}^{(2)}, \; \boldsymbol{s}^{(3)}, \ldots \boldsymbol{s}^{(N)}]^T; \ldots\ldots\ldots\ldots\ldots \; \textbf{(3)}$$

$$\boldsymbol{n} = = [\boldsymbol{n_1}, \boldsymbol{n_2}, \boldsymbol{n_3}, \boldsymbol{n_4}, \ldots \boldsymbol{n}]^T \ldots\ldots\ldots\ldots\ldots\ldots \; \textbf{(4)}$$

H is the channel matrix of size $M \times$N.Here Rayleigh channel model is considered as multipath fading channel.

III. MULTIUSER DETECTION

In a wireless communication system the number of users is unpredictable and it feels good when single base station with multiple antennas serve for a multiuser environment. Also the OFDM modulation enhances the data rate significantly.in this section we are discussing two types of MUD. They are least square (LS) and Minimum mean square error (MMSE) detectors.

1. Least square (LS) detector: Here the detected signal is given by [4][5]

$$\boldsymbol{s_{LS}} \;=\; (\boldsymbol{H^H}\,\boldsymbol{H})^{-1}\boldsymbol{H^H}\,\boldsymbol{x} \ldots\ldots\ldots\ldots\ldots\ldots \textbf{(5)}$$

H is the channel matrix and *x* is the received signal and$(.)^H$ denotes the Hermitian transpose operation.

2.Minimum mean-squares error (MMSE) detector: In contrast to the LS combiner, the Minimum Mean-Square Error (MMSE) detectors associated MMSE combiner exploits the available statistical knowledge concerning the signals transmitted by the different users, as well as that related to the AWGN at the receiver antenna elements. The cost-function employed directly reflects the quality of the combiner weights in the transmitted signals' domain. The estimated signal vector generated from the transmitted signal **s** of the N simultaneous users, & obtained by linearly

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combining the signals received by the Mdifferent receiver antenna elements with the aid of the array weight matrix as follows[4]

$$s_{MMSE} = W_{MMSE}^{H}\, x \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (6)$$

Where $W_{MMSE} \in C^{M\times N}$ is given by$W_{MMSE} = (HH^{H} + \sigma_n^2 I)^{-1} H^{H}$…................ (7)

Here $I$is the identity matrix, and $\sigma_n^2$is the AWGN noise variance. As expected, the combiner's performance improves upon increasing the number of array elements M and it degrades, when increasing number of users N.[7]

IV. SIMULATION AND RESULTS

Simulation is done in MATLAB .Basic OFDM system uses a large number of parallel narrow band subcarriers instead of single wideband carrier for data transmission. So that the channel became frequency flat instead of frequency selective [3]. Here data symbols modulate the spectrum and the time domain symbols are obtained using Inverse fast Fourier transform(IFFT) .Simulation parameters are as given below.

PARAMETER	VALUE
IFFT SIZE	512
CYCLIC PREFIX	10
No. of SUBCARRIERS	128
CHANNEL	RAYLEIGH CHANNEL (4 TAPS)
DATA BLOCK SIZE	128
ITERATIONS	100
MODULATOR	QPSK
SNR	0:1:49

Table.1 Simulation parameters for OFDM

Each OFDM symbol consists of 128 subcarriers in the time domain. At the receiver side frequency domain symbols are obtained using Fast Fourier transform (FFT). Then channel equalization is performed for each subcarrier frequencies. The weight matrix for corresponding MUD is calculated for each frequency.Performance comparison is done by analyzing the BER performance of each MUD. Simulation is performed in MATLAB .1st phase of simulation is done by using 2 users and a single base station with 2 receiver antennas. It exactly look like a 2 ×2 MIMO .But instead of using single transmitter with 2 antennas, here 2 different users are transmitting simultaneously in the same frequency band. Fig .4 shows the schematic representation of such a system having 2 users

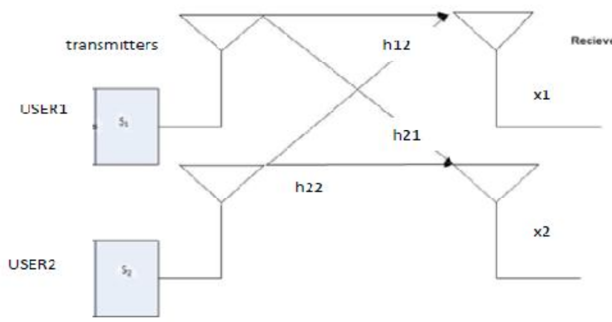

Fig 2 . 2 User SDMA OFDM model

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The multiuser detection is performed using two types of detectors LS and MMSE.
First LS estimation is performed in which the effect of noise is not considered. The BER Vs. SNR plot is as shown below in Fig 5. LS1 and LS2 indicate different paths followed by users. Rayleigh multipath fading channel is assumed here and along with which Additive White Gaussian Noise (AWGN) is added.

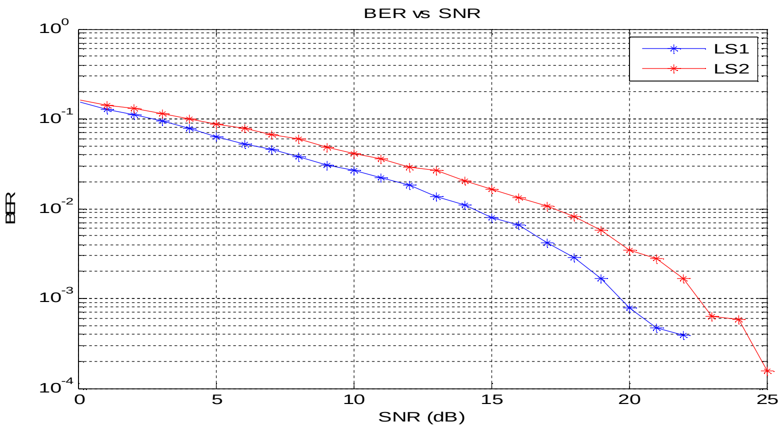

Fig 3 BER vs. SNR for LS MUD in 2×2 SDMA OFDM

Second MMSE detection is one of the simplest linear detection techniques which will take care of noise at the receiver side. Fig 6 shows the BER Vs. SNR plot for MMSE. The plots are drawn for 100 Monte Carlo simulations, (Theyare a broad class of computational algorithms that rely on repeated random sampling to obtain numerical results).Here BER falls below $\mathbf{10^{-4}}$for values of SNR greater than 12 dB

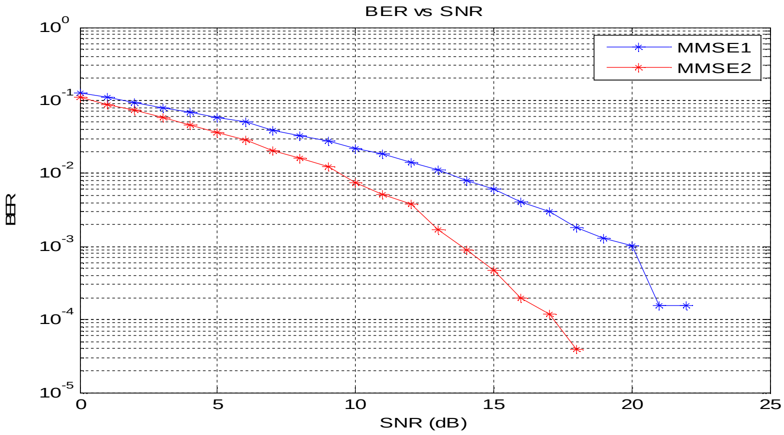

Fig 4 BER Vs. SNR for MMSE in 2×2 SDMA OFDM

While comparing the BER values for LS and MMSE detectors for same values of SNR. It can be observe that MMSE outperforms the LS detector in a noisy environment. With these results a system with more number of receiver antennas is simulated. So that space diversity will improve the system performance. If the number of antennas at the receiver is increased by one it became 3×2 SDMA OFDM system.

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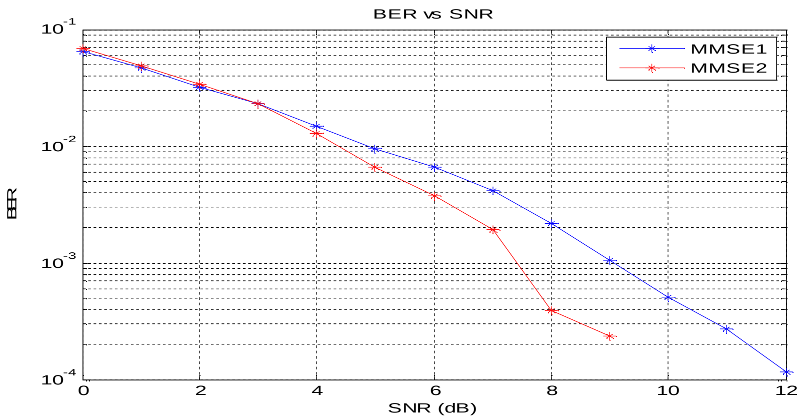

Fig 5 BER Vs. SNR for MMSE in 3×2 SDMA OFDM

If the number of receiver antennas are more than number of users the BER will fall significantly for lower values of SNR. The table 1 shows the performance improvement of a 3× 2 system over 2 × 2 systems. Here the 3 receiver antennas extract the full diversity and array gain.

SNR(dB)	Number of receiver antennas	
	3	2
	BER	
1	0.03421	0.08023
5	0.006602	0.01852
8	0.0003906	0.003281
10	0.00002312	0.0003125
12	0.0000077	0.0000783

Table 2.Comparison of BER performance

V.CONCLUSION

This paper explained SDMA OFDM system model for multiuser communication. Various detection techniques such as LS and MMSE are discussed out of which MMSE outperforms the LS in a noisy environment. If the users are limited MMSE performs well. Spatial diversity achieved by providing more number of antennas at the base station. When the number of receiver antennas is more than the number of users in an uplink SDMA OFDM system, the BER will become lesser at very lower SNR values for MMSE. It can further reduce amount of transmitter power for the Mobile stations.

REFERENCES

[1] M. Jiang and L. Hanzo, "Multiuser MIMO-OFDM for next-generation wireless systems," *Proc. IEEE*, vol. 95, no. 7, pp. 1430–1469,Jul. 2007
[2] P. Vandenameele, L. V. D. Perre,M. Engels, B. Gyselinckx, and H. D. Man,B "A combined OFDM/SDMA approach",[IEEE J. Sel. Areas Communication., vol. 18, no. 11, pp. 2312–2321, Nov. 2000
[3] Robert W Chang, "synthesis of ban limited orthogonal signals for multichannel data transmission".1966.
[4] S. Verdu, Multiuser Detection. Cambridge,U.K.: Cambridge Univ. Press, 1998.
[5]L. Hanzo, M. Muenster, B. J. Choi, and T. Keller,"OFDM and MC-CDMA for Broadband Multi-User Communications WLANs and Broadcasting". Piscataway, NJ:IEEE Press/Wiley, 2003
[6]Proakis, J., Digital Communications, McGraw-Hill,
[7] Hefnavi. M, Sulyman A.I, "Investigation of multiuser detection schemes for multiple transmit multiple receive antenna aided OFDM SDMA Systems",Information Infrastructure symposium 2009,pp 1-4,2009