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MU-MIMO OFDM Channel Estimation Using Precoding And Adaptive Least Square Technique

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Abstract: *Multi-user multiple input multiple output technology has number of users with multiple antennas or without multiple antennas. Orthogonal frequency division multiplexing (OFDM) is the special case of multi-carrier transmission and it can have capacity for high data rate requisite of multimedia based wireless systems. Nowadays Wireless communication systems are facing major challenges – interference, fading, path loss, noise which deteriorates its performance. To overcome this problem the aim is to optimize the performance of multi-user MIMO-OFDM system by the introduction of channel estimation. The proposed ADLS (Adaptive Least Square or ALS) along with VLM Precoding estimator is applied in order to reduce the complexity for the optimal estimation results.*
Keywords: *OFDM, channel estimation, MU-MIMO, ALS, VLM*

I. Introduction

In the past decade .multiple input multiple output technology has been adopted successfully. This MIMO technology provides robust result and high throughput. MIMO is supported with IEEE802.11 specifications. The number of data streams for MIMO system in IEEE 802.11n is four. Moreover, IEEE 802.11 ac supported downlink multi user multiple input multiple output system (DL MU-MIMO). In downlink MU-MIMO access point with multiple transmit antenna is sending multiple data to multiple station and also to four users. The 802.11 ac specifications improve the quality of signal with high throughput but still it requires improving the uplink throughput to assure this requirement. Nowadays, mobile devices became increases day by day and have become predominant user of wifi, but still the antennas are very limited. This has increase the demand for supporting uplink MU-MIMO.

II. MU-MIMO

Multiple input and multiple output techniques can significantly enhance performance of wireless systems through multiplexing or diversity gain. For a given transmit energy per bit, multiplexing gain provides a higher data rate whereas diversity gain provides a lower BER in fading. The multiple input multiple output MIMO system has gained importance. Multi-user multiple input multiple output technology has number of users with multiple antennas or without multiple antennas. Multi-user depends on beam forming. Beam forming may be divided into two parts. Single-user and multi-user. Single user MIMO considers a single multi-antenna transmitter communicating with a single multi-antenna receiver. In multi user there are multiple users with multi antenna or single antenna transmitter communicating with a multiple multi-antenna or single antenna receiver. MU-MIMO systems with multiple antennas at the transmitter and receiver improve the spectral efficiency and energy efficiency largely. The capacity is also shown to enhance the linearly with transmit and receive antenna. But the biggest challenge is the interference introduced by the channel that makes it difficult for the receiver to detect the exact transmitted signal. For this reason the need for channel estimation arises.

III. Precoding

Precoding algorithms are used to minimize the number of errors occur at the receiver output. In MU-MIMO data is transmitted through multi antenna transmitter to the numerous receivers. Precoding supports multi-layer transmission in multi-antenna wireless communications. It is generalization of beam forming to support multi-user transmission. Many of the researchers in the field of channel estimation are using precoding techniques to depreciate the errors at the receiver side. Basically precoding is useful in case of multi layer transmission where multiple number of transmitters, with the multiple antennas which is used to transfer data to the multiple receivers and the need is not that much in case of single stream beam forming because there is the single antenna which is used to transmit signal and it has proper gain and phase.

IV. Channel Estimation

In channel, it is essential to transmit the data from transmitter to receiver but sometimes noise adds to the data that has to be transmitted and that noise is called the interference .To minimize the computational complexity, used the latest channel estimate to approximate the IAI (inter antenna interference) effect. In the standard LS method was applied to obtain the new channel estimates from IAI cancelled data. So the purpose is to reduce the interference by estimating the channel. The channel can be estimated by the different techniques like LS, MMSE etc.

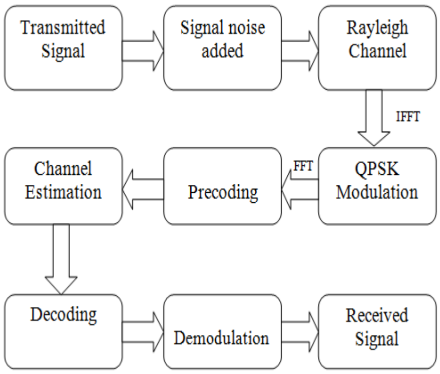

Fig. 1: MU-MIMO System model

V. Literature Review

Nirav Shahet al. [1] proposed carrier frequency offset estimation. In this work, uplink MU-MIMO also studied for Wi-Fi. In this several distributed station send multiple data streams to a common access point with multiple receive antenna. This proposed system uses joint phase estimation which is for carrier frequency synchronization. It take benefit of existing pilot signal to transfer better result and having low complexity the simulation results is provided to indicate that the presented approach incurs negligible performance loss due to carrier frequency offset.

Han Zhanget al. [2] presented superimposed pilot for channel estimation in order to deal with the effect of pilot contamination. This work deals with the uplink of MU-MIMO systems and presented a superimposed uplink channel estimation approach. In the scheme, it is studied that there are two kinds of antennas which grows to infinity. One is known's as cross contamination and is due to effect of correlation between superimposed pilot and data of different cells and other is self contamination which is due to the dependency of channel estimation and estimation error. This self contamination is exceptional for the superimposed pilot-aided approach. The result indicates that the proposed scheme can minimize the effect of channel estimation contamination but enhance the data frame size. Aldo this proposed method attains a significantly improvement on the spectral efficiency.

Leonel et al.et al. [3] presented an iterative detection and decoding (IDD) scheme for the uplink of coded multiuser multiple-input multiple-output (MU-MIMO) systems. This approach is relying on the multi branch lattice reduction-SIC and is used for soft bit information exchange between detector and decoder. In order to reduce the residual interference soft cancellation mean square error scheme is used. The performance of proposed approach demonstrate that it provide better results as compared to existing scheme and moreover it requires only three iteration to get good BER performance.

Haifn Yin et al.et al. [4] in this paper coordinated approach has been presented for channel estimation in multiple antenna system. In this paper, the issue of channel estimation in multi-cell interference-limited cellular networks has been discussed. Massive MIMO system is concerned with multi-cell interference by cell beam forming which is applied to each base station. In order to resolve this problem, novel scheme has been presented which enables low rate coordination between cells during channel estimation. This pilot contamination can be eliminating completely with multiple antenna system.

Roimendezetal.et al. [5] Presented an adaptive multi user (MU) single-cell hybrid precoding scheme. This scheme designs the precoders/combiners develop the reciprocity of time division duplex (TDD) millimeter wave systems. To design the combiners MMSE technique is used that is based on the second order statistics of the channel. The novel approach helps to reduce the training over head and it also attain sum spectral efficiencies. Furthermore, this scheme avoids the explicit estimation of the channel matrix associated to each user and covariance is also estimated from compressed measurements. The result indicates that the novel approach obtains block diagonalisation and improves the covariance estimation with respect to least squares.

Bien Quoe Ngo et al. [6] in this paper, an eigen value-decomposition-based approach has been proposed. In this work, MIMO system has been consider having large antenna array at the base station. This proposed approach blindly estimates the channel from the received data. In this work, asymptotic orthogonality has developed in very large multiple input multiple output system. Estimation of channel has been done for each user from the covariance matrix of the received signals. In order to resolve this ambiguity, a short training sequence is necessary. Moreover to improve the performance, proposed approach is combined with the iterative least-square with projection (ILSP) algorithm.

JieXu, ling qiuet al. **[7]**Novel optimization scheme has been presented in this paper. It consider a power model which sending power independently and related to number of active transmit antennas. The novel approach transmit covariance which is optimized under fixed active transmit antenna sets. In this paper, ATAS has been developed. This ATAS (active transmit antenna selection) is used to determine the active transmit antenna set.Active transmit antenna selectioncan discover the optimal tradeoff curve and also develop the EE. In between optimization, energy efficient iterative water-filling approach has been proposed that helps to solving a problem of series of concave-convex fractional programs depending on the block-coordinate ascent algorithm.Optimal exhaustive search and low- complexity norm based ATAS schemes are developed.

NafisehShariati [8] proposed a large scale MIMO technique. This technique considers a pilot based estimation in massive MIMO system. In this system, there are number of antennas at one side of the link. The main challenge for this type of system is computational complexity. A set of low-complexity Bayesian channel estimators, PEACH estimators, are introduced for channel and interference statistics. The proposed estimators considerably minimize this to square complexity by approximating the inverse by a -degree matrix polynomial. To reduce the MMSE, coefficient of polynomial is optimized. In this work, computational complexity has been derived in terms of floating-point operations (FLOPs). This Flop indicates that the proposed technique performs better as compared with other conventional estimators in large scale MIMO system.

Peter Hammarberg et al. [9]in this paper, the trade-off between complexity and performance for uplink receivers in a MU MIMO-OFDM system has been studied. In this paper, three different MUD algorithms has been discussed, two suboptimal approaches based on PIC and one optimal depend on MAP. Three algorithms were determined for channel estimation, one optimal joint MMSE based estimator, a low complexity Krylov subspace based version of the same, and one sub-optimal based on SAGE.

Juanglang [10] proposed MC-CDMA MIMO systems having with quasi-orthogonal space–time block codes (QO-STBC). This approach includes 4 transmit antennas and multiple receiver antenna. The proposed scheme is depending on the first-order perturbation theory and MSE of channel estimation has been derived. Furthermore, Subspace-based blind channel estimation has also been presented. In this work, minimum output energy and eigen space has also been developed for the symbol detection. Also, the weight analyses are presented in order to reduce the computational complexity of the system In addition, the forward–backward averaging technique is being proposed in order to increase the performance of multiuser detection.

Davis linda [11] In this paper, we propose a method for user selection and channel estimation for the multiple-input multiple-output (MIMO) broadcast channel for the downlink of a cellular mobile or local-area wireless communication system. The results indicated that the proposed approach as a medium access technique for MIMO downlink broadcast with transmitter precoding and linear receiver processing.

VI. Methodology Used

The VLM transform is given by two confluent matrices:

$$\mathbf{V_1}(i,j) = \sqrt{\frac{2}{\mathrm{N}+1}}\left(\cos\left(\frac{(i-1)(j-1)\pi}{\mathrm{N}-1}\right)\right)$$

$$\mathbf{V_2}(i,j) = \sqrt{\frac{2}{\mathrm{N}+1}}\left(\cos\left(\frac{(i-1)\left(j-\frac{1}{2}\right)\pi}{\mathrm{N}}\right)\right)$$

Either of the transforms (V_1 orV_2) can be used to transform the input symbols. Transformations like VLM, are a rotation of phase of the signal vector in N-dimensional space. Therefore, the transformed signals will be very less likely aligned in-phase, which will reduce the high peak-power of the subcarriers.

Steps followed :

1. Implementation of OFDM system in MATLAB.
2. Working on various estimation techniques for improving accuracy of channel estimation, comparing the LS estimator with ALS estimator receiver which includes a feedback of output and improves the BER performance of system , closed to the ideal channel performance.
3. Based on the work done, graph of bit error rate(BER) and signal to noise ratio(SNR) would be plotted and results will be calculated where the comparison will be made based on number of bits received to total number of bits and actual signal to noise ratio.

The final estimated value of channel is:

$$\widehat{\mathbf{h_1}}[n] = \frac{\sigma_v^2}{\sigma_v^2 + \alpha(n)} \widehat{\mathbf{h_1}}^{LS}[n] + \frac{\alpha(n)}{\sigma_v^2 + \alpha(n)} \widehat{\mathbf{h_1}}[n-1]$$

where,

$$\alpha(n) = \sigma_v^2 \,.\, \sigma_{LS}^2(n) \,/\, \sigma_{\mathbf{h}}^2(n)$$

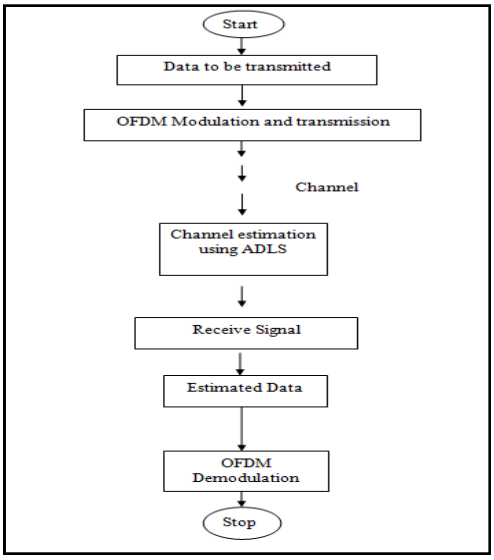

Fig. 2 Flow chart representing Implementation Model

It is found that MU-MIMO OFDM systems have the potential to fulfill the needs of the future wireless communication systems. MU-MIMO systems with multiple antennas at the transmitter and receiver improve the spectral efficiency and energy efficiency largely. The capacity is also shown to increase linearly with the number of transmit and receive antenna. But the biggest challenge is the interference introduced by the channel that makes it difficult for the receiver to detect the exact transmitted signal. For this reason the need for channel estimation arises.

VII. Results

The results for MU-MIMO system using channel estimation and precoding are presented below:

Figure 3 depicts the MU-MIMO system with MMSE channel estimation with and without VLM precoding technique and proves that the BER for VLM precoded MMSE MU-MIMO is better than the MMSE MU-MIMO. This figure tells that the precoding technique with channel estimation will give you better result.

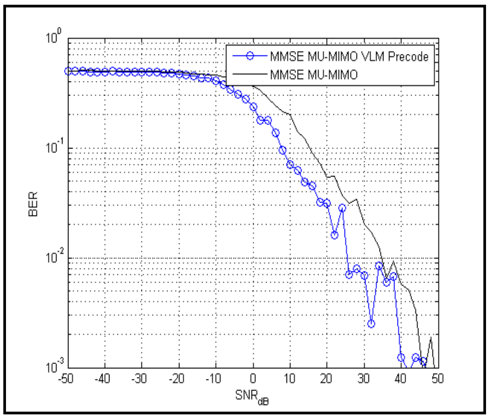

Fig. 3 Comparison of MMSE Channel Estimation in terms of BER with VLM and without VLM precoding

Figure 4 depicts the MU-MIMO system with MMSE channel estimation and ADLS channel estimation technique and proves that the BER for ADLS MU-MIMO is less than the MMSE MU-MIMO.

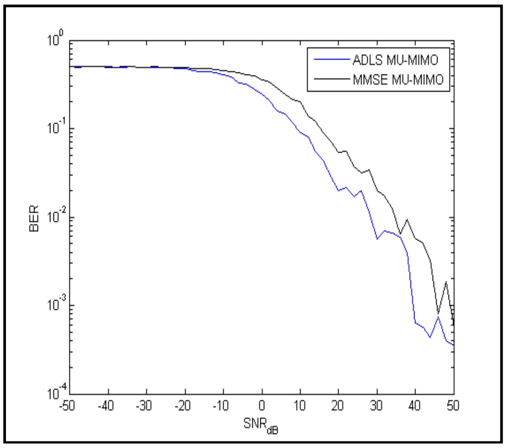

Fig. 4 Comparison of ADLS and MMSE channel estimation techniques for MU-MIMO System

Figure 5 depicts the MU-MIMO system with DCT precoded MMSE channel estimation and ADLS channel estimation technique and proves that the BER for DCT precoded MMSE is less than the DCT precoded ADLS technique.

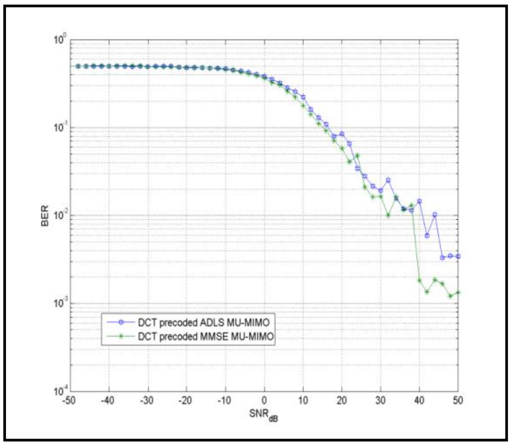

Fig. 5 Comparison of DCT precoded ADLS and MMSE channel estimation techniques for MU-MIMO System

Figure 6 depicts the MU-MIMO system with VLM precoded MMSE channel estimation and ADLS channel estimation technique and proves that the BER for VLM precoded ADLS is less than the VLM precoded MMSE technique.

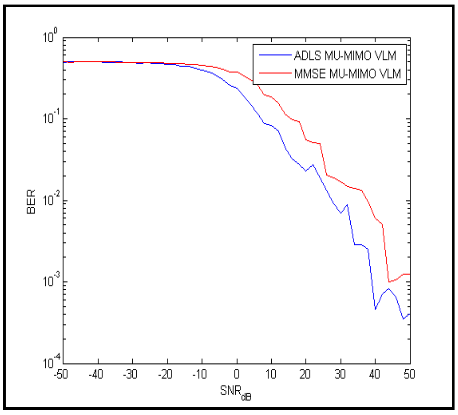

Fig. 6 Comparison of ADLS and VLM Precoding against MMSE Channel Estimation

VIII. Conclusion

In this work presented here, a new method with adaptive least square with VLM Precoding and various channel estimation techniques for MU-MIMO-OFDM are studied**.** Channel estimation algorithms have been compared and results show that ADLS is better and giving less bit error rate as compare to MMSE channel estimation. The adaptively regularized method improves upon the existing MMSE technique and also implements a less complex method. The ADLS and MMSE based MU-MIMO system is analyzed using precoding techniques and proved that the system with precoding gives better results in terms of BER and SNR. Hence the proposed method can be considered for practical implementation.

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