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Review On Channel Estimation For MIMO-OFDM SystemPayal Arora

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Abstract

The intention of this paper is to review the work that has been already done in the field of channel estimation in MIMO-OFDM system. With the continuous growth and the improvement of communication system, our aim is to review the current best techniques available for channel estimation and provide a comparative analysis. In order to achieve this objective, a simulation has been performed for using various channel estimation techniques. The main emphasis is laid on selection of a channel through which the signals are to be transmitted. This paper reviews the different types of channel estimation in MIMO system by varying the precoding and modulation techniques.

Keywords*:error rate, interference, MIMO, Channel estimation*

1. Introduction

MIMO is a system which has multiple inputs and multiple outputs, it is used to send and receive the multiple signals at the same time by using the multiple antennas at the transmitter and receiver side. The use of multiple antennas at the sender and receiver side will abolish the problem caused by multipath fading. The system also need the modulation techniques to send the signal, here the OFDM modulation technique is discussed. The system requires modulation technique because the message signal or voice signal cannot travel long distance because of the low frequency. Modulation technique is a technique where the change in characteristics of the carrier signal occurs with the respect to the instantaneous properties like message/voice signal. If we talk about the generation of multiple signals at the same time it drop us towards the signal interference, so whenever MIMO comes in forefront, it is preferred with orthogonal frequency division multiplexing (OFMD) technique. Peculiar techniques like OFDM and MIMO stand as promising choices for prospect high data rates [1] [2]. It shows robustness for multipath fading and interference. The precoding techniques can be used to transmit the signal and to receive the signal with the minimum errors at the receiver side. There are two kinds of precoding techniques one is linear and another is non linear. In [3] the author has tried to minimize the imperfection of CSI by proposing a precoder design. The intend design has achieved the improvement in error rate representation when evaluated with other precoding schemes. In [4], Saeed and Witold considered a channel that is multi user Gaussian broadcast. They have applied the block diagonalization zero forcing pre-coding technique to achieve the better optimized channel and proved this scheme is indeed optimal multi-user zero forcing pre-coding under total sum of power constraint.

2. MIMO System

Multiple input and multiple output techniques can substantialy amend the performance of wireless systems through multiplexing or diversity gain. For a provided transmit energy per bit, multiplexing gain gives a higher data rate whereas diversity gain gives a lower

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BER in case of fading. The combination of MIMO with OFDM has gained considerable interest and taken as one of the most promising techniques for present and future wireless communication systems[5][6].The multi-user MIMO has gained more capacity and improve the link performance as compare to single user MIMO.

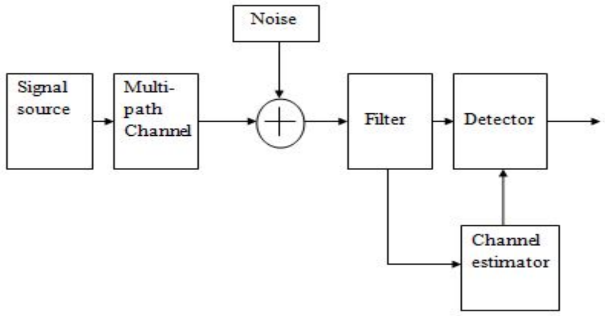

Figure 1. Block Diagram for Noise Corrupted System [7]

In [7] the author has considered the problem of exploitation of multi-user diversity with zero-forcing linear receivers in MIMO system. There is comparison of various scheduling disciples in terms of average throughput as a function of various antennas and users. The result show that the TxD technique shows improved result for gain comparison to OLSM in terms of BER but in case of SNR OLSM gives a better performance than TxD in terms of throughput.

The different MIMO formats are as follow
- SISO
- SIMO
- MISO
- MU-MIMO

3. MIMO OFDM System

With the help of several narrowband channels, the signal is splitted and distributed into these channels at different frequencies. This technique helps to reduce the effect of interference that is caused among channels which is close to each other in the form of frequency. It transmits the signal into same time period but at different frequencies. Orthogonal frequency division multiplexing (OFDM) with the multiple-transmitting antennas can give improved quality and capacity for broadband.

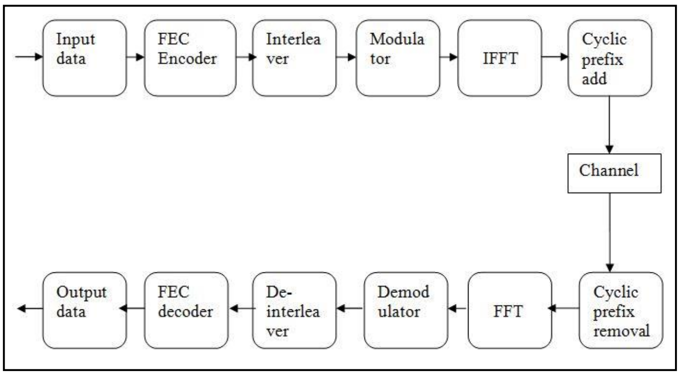

Figure 2. OFDM System

MIMO OFDM is easy and efficient in dealing with multipath. OFDM is a modulation technique which has multiple carrier, it retain various carriers, within the allotted bandwidth, to convey the data from source to destination. It uses a multiple parallel narrow band sub carriers rather than single wide band carrier to transit information. In [8] MIMO system has been proposed which incorporates less ISI when used with OFDM and also results in less fading and increased data rates. But as a result of noisy channel estimation done with frequency selective fast-varying channels, it results to the degradation of performance of MIMO system. The authors Chuang, and Sollenberger [9] studied space–time coding delay, permutation and transmitter multiplicity combined with two branch receiver multiplicity for OFDM used in high information rate wireless networks. Space–time coding transmitter multiplicity is the prime approach to contribute high peak data rates. The delay transmitter multiplicity system using QPSK modulation along interference suppression is the robustious and provides QoS with a minimal retransmission feasibility. Downlink beam forming is further more demonstrated to be an effective approach for increasing both QoS and throughput once the environment sanctions this technique. Wireless network system using downlink beam forming composed with adaptive antenna arrays can bring higher capacity than those retaining delay or space–time coding transmitter multiplicity systems with two sender and two receiver antennas.

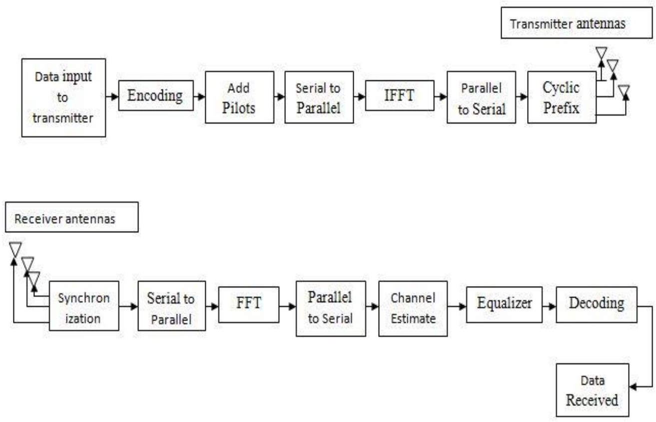

Figure 3. MIMO OFDM System

4. Channel Estimation

Channel estimation is a decisive approach used in wireless mobile network systems where the switching of wireless channel is along with particular time instant, prevalently produced by mobile transmitter or receiver at a particular speed of automobile. Wireless mobile communication is reluctantly influenced by the multi-path obstructions as a result of reflections and surrounding elements such as mountains, infrastructures and another obstructions. An explicit evaluation of the channel varying according to time is required by the system to procure reliable and enhanced data rates at the receiving end. The basic LS method and ALS method can be applied to attain the new channel estimates. Data is transmitted from transmitter to the receiver through channel but sometimes there is interference due to addition of noise. In order to reduce the noise we need estimated channel, [10, 11] utilized the correlation of channel parameters at adjoining subcarriers to eradicate interference among antennas. In [10, 11], the definitive LS is assigned to accomplish the distinct channel estimates from IAI eliminated data. In conducive to investigate a less complexity channel estimation for a system that is OFDM with space–time coding in time-varying along multipath fading channels. In particular, the author's incentive was to scale down the problem in the desired matrix-inversion for every OFDM data symbols. The approach is developed based on a channel with relatively inadequate delay spread. By decoupling the channel responds from different transmit antennas proceeds to the reduction of complexity. This transformed method brings about a substantial amendment without any added complexity [10]. J.A Wu and K.G Wu worked on a minimal complexity algorithm for decision-directed channel estimation in transmit-diversity OFDM systems. The proposed algorithm cut-off antenna interference to abstract the estimation of each channel reverberation by extortionate the correlation of subcarrier channel coefficients to extinguish the data. The authors have also worked on the latest estimation of channel response to scale down residual inter antennas interference [11]. In order to identify the DDCT contaminated estimation complexity, the author has asserted M and GM estimators, which are effective in mitigating error propagation. DDCT of modest computational complexity is possible over large frame lengths even at high fade rates, provided one uses the mathematical theory appropriate for tackling the problem [12]. The author in [13] introduces a special category of codes termed as the Space time codes for transmitting data using various transmit antennas instead of Rayleigh or Rician wireless channels. Different sub categories of space–time codes have also been assembled. These codes present an estimable performance and for the decoding intricacy proportionate to the codes used in utility on Gaussian channels. Due to the lucid architecture of these codes they can be readily implemented in DSP and VLSI.

In [14] the author has simplified the channel estimation complication with auto-correlation and zero cross correlation to construct a training sequence that is single with impulse like auto-correlation. Christina compared the distinct training sequence for system having multiple transmit antennas with frequency selective channels.

In [15] the author has proven that MIMO-OFDM has gain interest as the prominent technique to increase the channel capacity. In this research pilot symbols are added and then decoded. STBC comprises one of the dominant techniques for enhancing channel capacity. In [16] the author has recommended a method to figure out the minimum energy consumed for channel estimation when it is predominated to delay and the error in case of transmission of symbols. According to the author when the hardware is reduced, minimum energy will be carried by the usage of low rank equalization at the receiving end.

The work done in [17] discussed the algorithm of channel estimation for MIMO-OFDM. Bellido in this paper discusses the pilot design rule and has used the same for estimation of channel matrices. The pilot design rules that ensure a bounded error level for estimation has been used by Bellida in this paper.

To abolish the effect of interference we need strong channel estimation and it can be done by using

Least Square (LS) algorithm, proposed by Widrow and Hoff, it is used for system identification. On the other hand there are algorithms with faster rates of convergence like, least mean square (LMS) methods are prominent because of its low computational costs, robustness and ease of implementation.

The author has used a recursive least square estimator (LSE) to improve the (DDCE) performance in transmit-diversity OFDM systems. The authors Chang and Wu used a regularized least square (LS) estimator to get the better DDCE depiction in transmit-diversity OFDM systems. The intended usage amalgamate the current channel estimate as a priori information to alleviate the complexity of the basic LS method. The regularization criterion derivative is to be altered with the MSE of last and current standard LS estimate. On other hand where the standard LS method at degraded SNR values tends to suffer severely due to error propagation problem.

The work done in [18] upgraded the channel estimation problem considerably. In [19] the author has discussed least squares estimation in recursive case, the exponential weighted least squares, recursive-in-time solution, recursion for MSE paradigm for instance such as Noise omiter, channel equalization, and reverberation abandonment.

In [20] author has shown the simulation results for BER performance analysis for 2x2 MIMO OFDM system for various channel tapping lengths like L=4, 8, 16 over AWGN channel by using LS estimation technique.

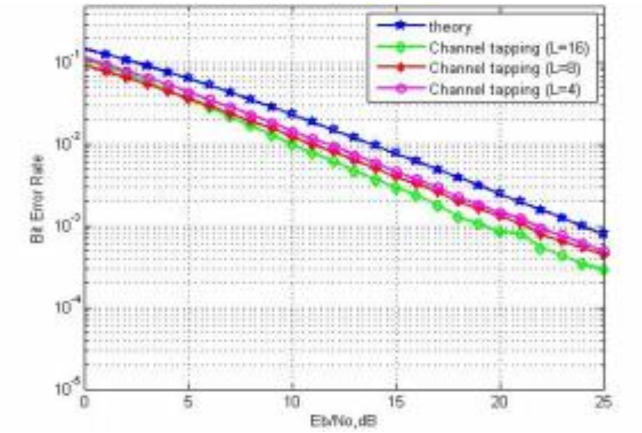

Figure 4. BER performance for 2x2 MIMO OFDM using LS Estimator [20]

Adaptive least square (ALS) algorithm **,** The Recursive least squares (RLS) is a robust filter which finds the coefficients recursively and thus helps to scale down a weighted through linear least squares cost function consolidating to the input signals. The ALS is repository fast convergence, and is set across maximum of its competitors. None the less, this for betterment at the cost of immense computational intricacy. The author has intended that how near the predicted value ought to be to the true value when the receiver emanates from the fade in order to reclaim correct tracking. Likewise, it is desirable to know how to approximate adaptively. The flat spectral shape was opted as a simple case. It is ascertained that the method used to solve this prediction complexity can be drawn-out to band limited processes of random spectral shapes. It is expected to extend the approach to more complex carrier tracking and adaptive equalization problems [21].

MMSE algorithm is used to minimize the average mean square error. This estimator is more complex than LS estimator but gives the better results. MMSE includes many multiplications and matrices inversions. MMSE faster than the LS estimator.

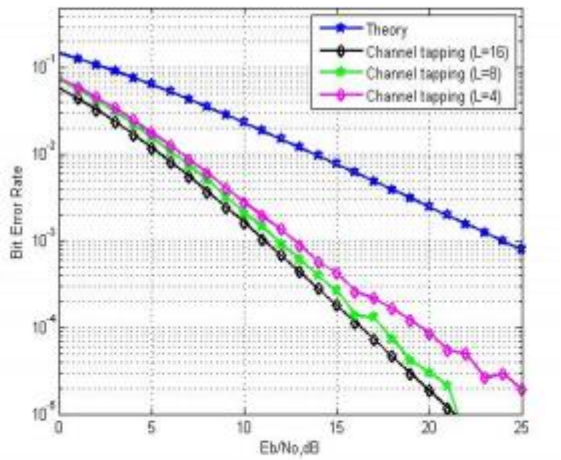

Figure 5. BER Performance for 2x2 MIMO OFDM using MMSE [20]

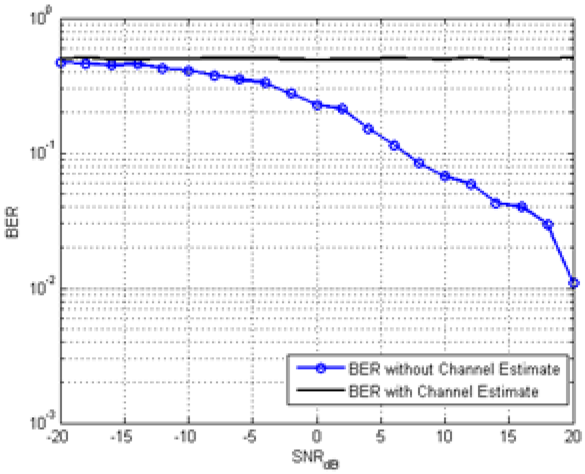

Figure 6. Shows the Comparison of the MIMO Technique without Using Channel Estimation and Using MMSE Channel Estimation. The simulations were performed using MATLAB.

5. Conclusion

On the basis of literature survey, it is found that MIMO-OFDM systems have the inherent to fulfill the demands of the future wireless communication systems by using the channel estimation techniques. MIMO systems including numerous antennas at the transmitting end and receiving end enhance the spectral efficiency and energy efficiency largely. The capacity is also shown to increase continuously with the increasing number of transmitting and receiving antennas. The challenge is to scale down the interference brought out by the channel which creates a difficulty for the receiver to discover the explicit broadcast signal. For this reason the need for channel estimation arises. The MMSE channel estimator is complex yet faster as compare to the LS estimator.

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