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A Review on the Performance of MIMO OFDM Systems with VBLAST Technique

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Abstract: **Wireless communication is one of the most demanding areas of the communication. It is the transfer of the user information between two points that are not physically connected. Quality of this transmission depends upon the number of errors at the receiver. There must be minimum number of errors. These errors are caused by interference between transmitted data. Multiple Input Multiple Output Orthogonal Frequency Division Multiplexing (MIMO OFDM) systems increase capacity of link to a great extent. Vertical Bell Labs Layered Space Time (VBLAST) associated with MIMO OFDM system increases the performance of system in terms of Bit error Rate (BER). It also reduces overall computational complexity at the receiver. Minimum Mean Square Error (MMSE) equalizer with VBLAST at the receiver increases performance of the system.**

In this paper we present a review on performance of Vertical Bell Labs Layered Space Time architecture for different single antenna and multiple antenna Orthogonal Frequency Division Multiplexing systems. We will study which antenna configuration provides minimum Bit Error Rate (BER).

Keywords: **MIMO, OFDM, Equalizer, VBLAST, MMSE, BER, ISI, Fading.**

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) has the most promise as a future high data rate wireless communication system due to its advantage of high bit rate transmission over a frequency selective fading channel [9]. Also it provides minimum errors and mitigates Inter-symbol Interference (ISI). The main factors which are considered for the OFDM universality are (a) the acquirement of a high data rate realization due to the provision of spectral efficiency in comparison to previous modulation schemes, such as Code Division Multiple Access (CDMA) and (b) the proficient adaptation to the frequency selectivity of the channel, due to the orthogonality principle [9]. Also the quality of service is an important parameter of communication. In OFDM interference at the receiver causes signal to be distorted and increases errors. Moreover any other single effect, interference can lead to quite catastrophic results at a typical OFDM receiver [9], [10].

VBLAST is the technique applied at the receiver side in communication system. It gives an ordered successive cancellation receiver in which the stream with highest SNR is decoded at every stage. [1]

In V-BLAST schemes, a filter matrix is multiplied to the signal received and then detected layer by layer. The channel with maximum Signal to Noise Ratio is then selected and the effect of the channel is nullified for that stream. Now the effect of detected stream is cancelled from the received signal. A new channel matrix is created then by replacing the columns corresponding to the detected stream with zeros and the whole process is repeated with the new channel matrix until all the streams are detected layer by layer [1], [3].

In this paper we are studying VBLAST associated OFDM systems with MIMO. The study mission the traditional single-antenna and the multiple-antenna OFDM transceiver modes for SIC reception. Different equalizer like MMSE, ZF and ML are also combined with VBLAST for reducing complexity. Finally we are concentrating on the parameter BER. We are studying BER for various MIMO OFDM systems with MMSE, ZF and ML receiver.

II. STUDY OF VBLAST

Mostly, OFDM provides strong spectrum efficiency by allowing adjacent sub channels to spectrally overlap, yet remain orthogonal in time [11]. Multiple antenna technology is used when increased capacity of the link is required. It provides increased throughput also. Multiple-antenna adjustment controls the premise of achieving expressive performance improvement and capacity enhancement in such systems [12]. MIMO OFDM systems are increasing data rate as well as capacity of the link in communications.

MIMO-OFDM system using Vertical Bell Lab layered Space Time (V-BLAST) is grown-up by considering Minimum Mean Square Error (MMSE) and Zero Forcing (ZF) detector mechanisms for various modulation schemes and antenna configurations [1]. The performance parameter of MIMO-OFDM in terms of BER was decided and an analyzed for two different detector schemes such as MMSE and ZF. From the simulation results they verified that MMSE had better BER performance than that of ZF detection technique. Further 2x5 antenna configuration achieves better BER at lesser SNR value compared to that of 2x3 antenna configuration.

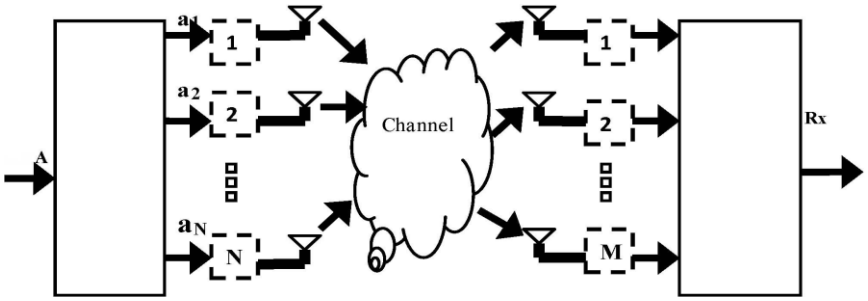

Fig: 1. MIMO OFDM System with VBLAST [1]

In fig [1], MIMO OFDM system with VBLAST is shown. At the receiving side VBLAST algorithm is applied for receiving vector.

The different detector system performance is compared based on the bit error rate [2]. The VBLAST MIMO system architecture with ZF, MMSE, and Ordered SIC detectors was studied and simulated this architecture in Rician fading channel. Also compared the performances of MIMO system with different modulation techniques in scattering environment. Finally concluded that ZF and MMSE receivers with successive interference canceller (SIC) give better performance than the traditional non-linear ZF and MMSE receivers. And also with the increase of number of antennas in MIMO system MMSE-SIC give significantly better BER performance than that of ZF-SIC.

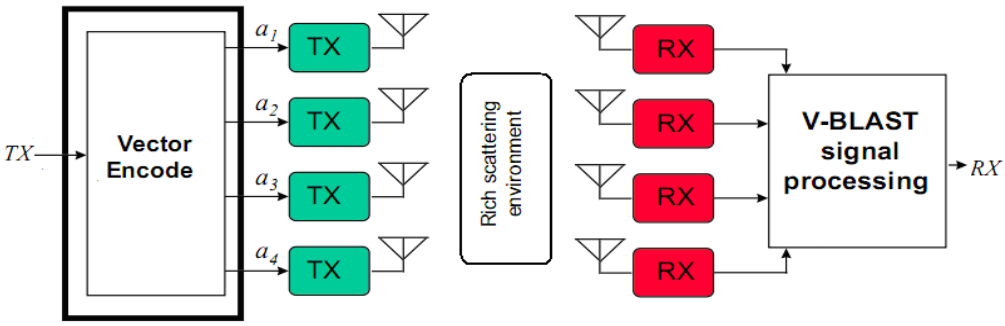

Fig: 2. Basic VBLAST System [2] In fig [2], basic VBLAST system for MIMO OFDM is shown.

The disclosure of transmitted symbols in a V-BLAST system using the minimum mean squared error criterion with successive interference cancellation (MMSE-SIC) was done [16]. This mechanism provides suitable bit error rate performance at the cost of bearable computational complexity. Here the Fast Recursive Algorithm proposed in previous papers was modified to figure out an ordered set of nulling vectors from the predicted channel information. Modified FRA can was used with the transformation based successive interference cancellation method to measure a V-BLAST frame that contains the preamble and payload. As compared to LDL^H approach in paper [13], they provided well-examined explanation for finding the inverse of a conjugate symmetric positive definite matrix. Finally they concluded by

employing their altered FRA in to figure out an order set of nulling vectors and employing the TBSIC procedure to process the payload, they achieve an implementation algorithm for the MMSE-SIC detection that has the lower complexity as compared to [17].

A novel fast recursive minimum mean square error successive interference cancellation (MMSE-SIC) algorithm with optimal detection order for vertical Bell Laboratories layered space-time (V-BLAST) systems was proposed [3]. In this algorithm, the MMSE filter matrices and the optimal detection order are successively computed from the previously obtained filter matrices according to simple recursive pseudo inverse formulas; so that the algorithmic complexity was reduced significantly, especially for the practical number of transmit/receive antennas. In this algorithm, the MMSE nulling vectors and the optimal detection order are successively calculated from the previous computational results via simple recursive algorithms. It was shown that the proposed algorithm has lower computational complexity than the other algorithms, especially for the practical small number of transmit/receive antenna

A comprehensive survey on the performance of SIC for single- and multiple-antenna OFDM and spread OFDM (OFCDM) systems was presented [4]. They focused on all the possible OFDM formats that have been developed. They studied the performance of SIC by examining closely two major aspects, namely the BER performance and the computational complexity of the reception process. They had shown results for ZF SIC, MMSE SIC and ML SIC for varying antenna configurations. From all parameters and study, they concluded that MMSE SIC provides better result in all above equalizers in terms of BER.

The fast recursive algorithm (FRA), developed by Benesty et al. [3] was modified [5]. They modified the FRA to figure out an ordered set of nulling vectors from the predicted channel information. This modified FRA can be used with the transformation based successive interference cancellation method to measure a V-BLAST frame that contains the preamble and payload.

They concluded that modified FRA was more robust since it was a well-examined solution for finding the inverse of a conjugate symmetric positive definite matrix.

From the all above papers we extracted a common algorithm for VBLAST. We can summarize most imperative steps of SIC based reception more respectively as [1]

1) Upon a signal reception, calculate the equalization N × N matrix J, where J could be either an ML, a ZF or an MMSE detector
2) Apply an optional detection ordering on J.
3) Calculate $< J, y >_l$ where $<.>_l$ denotes the l-th row of a matrix. The resulting term denotes an estimation of the detected symbol x, which can subsequently be decoded according to the modulation type which is used.
4) Subtract the decoded information from the remaining signal as y(new) = y(previous) − x$[G]_l$, where $[.]_l$ denotes the l-th column of a matrix
5) Relax the channel matrix in terms of interference contribution as G(new) =$G_{l'}$, where l' is the deflated version of a matrix whose 1,2,...,l-th columns have been zeroed
6) Now again repeat steps 1 to 5 until all the OFDM symbols have been decoded.

In all the studied papers that algorithm is common. The channel matrix is taken according to different assumptions and calculations. But the procedure is common.

III. COMPARATIVE ANALYSIS

Research Paper	Conclusion
[1]	In MMSE, BER of 10^{-3} is achieved for 2x5 and 2x3 antenna configuration. In ZF, BER of 10^{-2} is achieved for 2x5 and 2x3 antenna configuration with SNR of 32db.
[2]	BER of 10^{-5} is achieved for different MIMO receiver systems (ZF-SIC and MIMO-SIC) in Rician channel condition. Finally concluded that ZF and MMSE receivers with successive interference canceller (SIC) provide better

	performance than the traditional non-linear ZF and MMSE receivers.
[3]	Novel fast recursive MMSE-SIC algorithm achieved lower computation complexity than other algorithm.
[4]	BER was reduced to order of the 10^{-1}. Achieved fixed data rate for both single and multiple-antenna OFDM systems.
[5]	Obtain an implementation algorithm for the MMSE-SIC detection that has the lower complexity by applying modified FRA.

IV. CONCLUSION

Communication with minimum errors express one of the most remarkable considerations in latest receiver designs for wireless communication networks. In this paper we studied various aspects of signal receiving based on VBLAST, because it has shown most effectiveness in interference cancellation and performance improvement. I.e. OFDM is most effective modulation scheme. In order to study the performance of VBLAST at all the multi-carrier networks we analyzed VBLAST implementation strategies for MIMO OFDM systems, and also examined some equalization techniques and found that MMSE VBLAST gives better result in terms of BER.

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