Performance Evaluation Of Modified V-Blast In Mimo System

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Abstract

The MIMO system (multiple Antennas at the transmitter and receiver)is a capable of very high theoretical capacities, the most popular architecture is so called vertical VBLAST. V-BLAST is an effective detection method for MIMO communication system, but has large computational complexity due its successive iteration . In this paper we used modified V-BLAST to lessen its computational complexity reducing the number of successive iterations. As a result of this simplification, the computational complexity of the detection is lowered significantly. Simulation results show that the proposed V-BLAST reduces calculation complexity by about 30% while achieving a very close BER performance s the original one.

Index Terms—*BER, MIMO, MMSE,* Successive iteration-Blast.

I. INTRODUCTION

The multiple input and multiple output(MIMO)system can increase the spectral efficiency greatly through multiple element antenna array at both the transmit and receive ends so as to meet high bit rate demand in wireless communications and attract more and more attention of communication community. Many approaches have been proposed to combat the frequency-selective fading in MIMO channel. Such as MIMO-DFE, MIMO turbo eualization, MIMO single carrier frequency-domain- equalization and MIMO OFDM etc.In the MIMO OFDM approach proposed V-BLAST is frequently employed in the signal detection of the system's subcarrier channel.

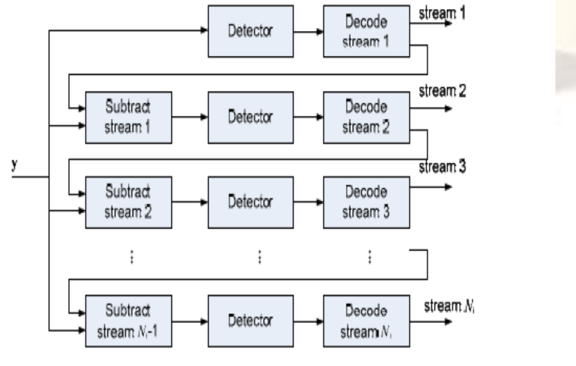

Fig.1 The architecture of the successive interference cancellation(SIC) detecting algorithm for V-BLAST

Fig.1 shows successive interference cancellation process for an VBLAST, n a VBLAST system, a data stream is split into M uncorrelated sub streams each of which is transmitted by one of the M transmitting antennas, the M sub streams are picked up by N receiving antennas after being perturbed by a channel matrix H. In this the sub stream signal with the highest SNR is detected first and this the calculation of pseudo inverse of H using Zero forcing(ZF)or the calculation of minimum mean square error(MMSE). The effect of the detected symbol as well as effect of corresponding channel is subtracted from the N received antennas. The process repeats with the next strongest sub stream signal among the remaining undetected signals. Thus this algorithm detects the M symbols in M iterations and it is proven in [1]. The complexity required to achieve this performance is very high, which it difficult to implement in real time systems.

When symbol cancellation is used the order in which the components detected becomes important to the overall performance of the system. We focus on this property of V-BLAST to reduce the number of successive cancellations process. Normally the ordering is based on channel matrix which has the signal to interference and noise ratio (SINR) information.

VBLAST signal detection, which reduces the complexity by an order of magnitude when the number of antennas is large[2]. How ever the quite small number of antennas is in practice. So, In this paper we are using a modified VBLAST algorithm that is more efficient than the existing methods.

II. V-BLAST SYSTEM MODEL

The main idea of the V-BLAST architecture is to split the information bit stream into several sub streams and transmit them in parallel using a set of transmit antennas at the same time and frequency; the number of sub streams equals to the number of transmit antennas. At the receiver end, receive antennas obtain the sub streams, which are mixed and superimposed by noise, due to the nature of the wireless propagation channel. Applying proper signal processing procedure, the receiver can separate the transmitted sub streams so that the matrix wireless channel is transformed into a set of virtual parallel independent channels, given that multipath is rich enough. Although there exists an optimal detection scheme, maximum likelihood (ML) detection that can produce higher diversity gain by detecting multiple sub streams simultaneously and minimize the error probability, its implementation complexity grows exponentially with the transmit symbols' constellation size and thenumber of transmit sub streams. Successive interference cancellation (SIC), or sequential interference suppression, is another decoding approach that is more popular since it provides a reasonable balance between performance and complexity.

This model can also be interpreted as 'M' users each has one antenna; all these users are transmitting data streams at the same time in the same frequency band to a base station, which is equipped with 'N' receive antennas. The MIMO system is assumed to under goes flat fading channel . the System model of the o/p signal is given by

$$Y= Hx+n \qquad (1)$$

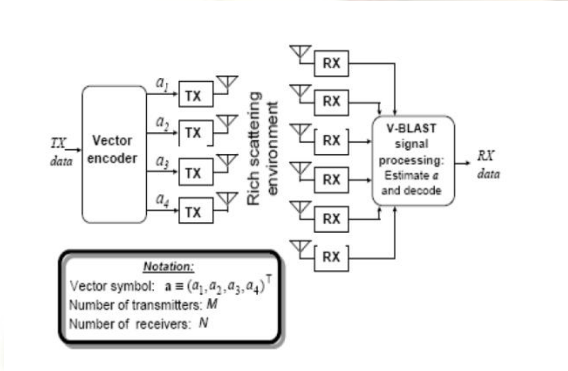

Fig 2. Structure for VBLAST system

At each time, we have a received vector y = [y1, y2, · · · , y_N]^T where the entry yi corresponds to the obtained signal from receive antenna i. The M×N channel matrix H can be represented as H = [h1, h2, · · · , h_M] where hi denotes the ith column of H, hi = [h1i, h2i, · · · , h_{Ni}]^T . Elements of H, hji, are modeled as independent identically distributed (i.i.d.) complex Gaussian random variables with zero mean and unit variance[6]; thus the fading environment is Rayleigh rich-scattering. The channel is assumed to be quasi-static random, that is, h_{ji} is fixed for every frame of information bits but varying from frame to frame. We also assume the channel matrix is perfectly known at the receiver. x = [x1, x2, · · · , x M]T is the transmitted signal vector; each component xi of x is an M-arry modulated symbol, or xi S, S = {s1, s2, · · · , s_M}; the average energy contained in each symbol is assumed to be Es. The noise vector n = [n1, n2, · · · , n_N]T is modeled as white Gaussian – entries of n are i.i.d. complex Gaussian random variables with mean being zero and variance equal to N0/2 . The transmitted data symbols xi, the channel gains h_{ji} and the noise ni are independent of each other.

III. VBLAST DETECTION ALGORITHM

The V-BLAST detection algorithm is a recursive procedure that extracts the components of the transmitted vector a according to a certain ordering($k1;\ k2;\ :::;\ kM$) of the indices of the elements of a. Thus, ($k1;\ k2;\ :::;\ kM$) is a per-mutationof ($1;\ 2;\ :::;M$). In V-BLAST, this permutation depends on H (which is known at the receiver by assumption) . where H$^+$ denotes the Moore-Penrose pseudo inverse of H, $(Wi)_j$ is the j 'th row of W_i, $Q(.)$ is a quantizer to the nearest constellation point, $(H)_{ki}$ denotes the k_i'th column of H, H_{ki} denotes the matrix obtained by zeroing the columns$k1;\ k2;\ :::;\ k_i$ of H, and H^+_{ki} denotes the pseudo-inverse of H_{ki} .In the recursive phase, nulling slicing, cancelling and the ordering process are performed sequencely, we can estimate the symbols at the slicing process, and make a new received signal r_{i+1} by subtracting the estimated symbols at the cancellation process.

Initialization:

$$r_1 = r$$
$$G_1 = (H^+)^T$$
$$k_1 = \arg\min_j \|(G_1)_j\| \qquad \text{: ordering}$$

Recursion :

$$w_{k_i} = (G_i)_{k_i}$$
$$y_{k_i} = w_{k_i}^T r_i \qquad \text{: nulling}$$
$$\hat{a}_{k_i} = Q(y_{k_i}) \qquad \text{: slicing}$$
$$r_{i+1} = r_i - \hat{a}_{k_i}(H)_{k_i} \qquad \text{: canceling}$$
$$G_{i+1} = (H^+_{\bar{k}_i})^T$$
$$k_{i+1} = \arg\min_{j \notin (k_1,\ldots,k_i)} \|(G_{i+1})_j\| \qquad \text{: ordering}$$

In the V-BLAST algorithm described above, it is consisted of M- iterations and for each iteration ,the strongest sub- stream signal among the remaining sub-stream signals is found and the corresponding weight vector is obtained . this means that the process for finding the decoding order and finding the weight vectors are mixed together. The algorithm is summarized as follows
i.e Steps for detection algorithm are

- ordering : choosing the best channel
- Nulling : using ZF or MMSE
- Slicing : making a symbol decision
- Cancelling : subtracting the detected symbols
- Iteration : going to the first step to detect the next symbol

IV. PROPOSED MODIFIED V-BLAST

In successive interference cancellation detection scheme, later iterations have lesser cancellation effect because most of interference and noise components have been cancelled during early stage of the iteration through the ordering step. Appling this property to V-BLAST detection, it can be interpreted as the bigger the difference the norm of $\|(G_{i+1})_j\|$ in early iterations , the lesser the efficiency of symbol cancellation in the late iterations. Considering this property, we propose a modified V-BLAST algorithm based on stopping the iteration if its effect of cancellation is small. This simplifies the calculation complexity. Modified v-blast compares the selected smallest norm value with the average of the remaining norm values. If the selected norm value is smaller than the average norm multiplied by a constant parameter C, it proceeds with the cancellation process. It means that the selected one is much smaller than others and it is well worth being cancelled. If the selected one is bigger it stops the iteration process & performs ZF or MMSE detection for the remaining received signals. The constant parameter various from 0 to 1 Where C becomes 1 the algorithm becomes the same as original V-BLAST detection. When C becomes 0 the algorithm becomes MMSE or ZF detection

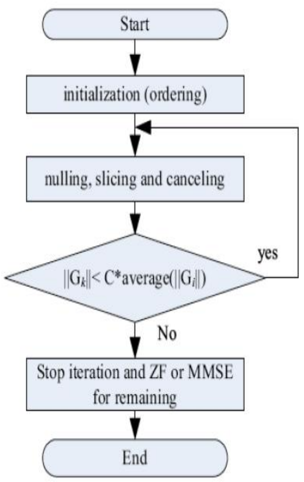

Fig 3. propose algorithm for modified V-BLAST

V. SIMULATION

Simulations were carried out using MATLAB, with different modulation techniques such as BPSK, 16QAM for transmission. These were adapted to different MIMO antenna configurations and their performance analyzed. A general successive interference cancellation was compared to the MIMO detectors such as ZF,MMSE,VBLAST-SIC discussed above to determine the high performance and complexity.

Fig 4 shows simulation for 2 x 2 MIMO system with BPSK modulation is used. BER performance for various detection Schemes i.e ZF, MMSE,VBLAST-SIC was observed, from simulation results it is observed that BER performance was improved with VBLAST-SIC algorithm.A flat fading Rayleigh channel is assumed in this simulation.

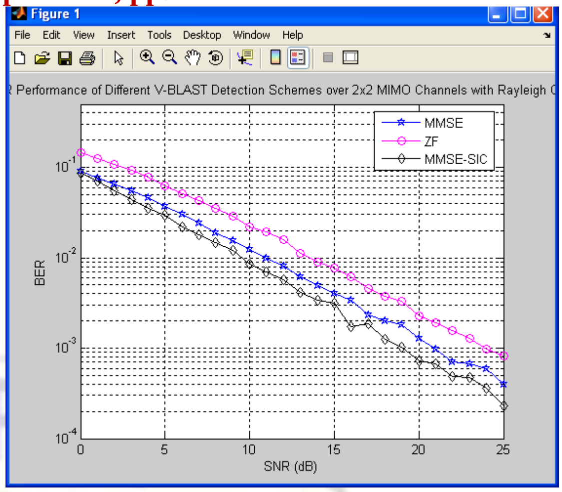

Fig4. BER performance for various VBLAST Detection Schemes for 2x2 MIMO Systems.

For a more realistic performance of the ZF receiver ,we shown Fig5. The simulation for(M<N) i.e (M,N)=(8,12) system with 16-QAM modulation. The Eb/No ranges between -10db & 0db in steps of 1db. The BER is calculated by performing 10,000 trails at each Eb/No pt. Assuming that channel is flat fading. so,H was chosen in each trail.

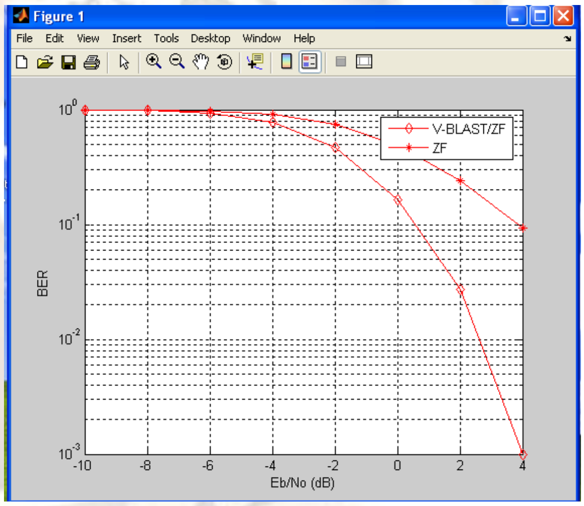

Fig 5. BER Performance for 16 QAM(8x12) MIMO System

Fig 6. Shows simulation for two transmit and two receive antennas(2x2) MIMO system, where Rayleigh flat fading channel and 16-QAM signals are used in this simulation. The channel state information is known to receiver. it compares the BER performance for different 'C' parameter values, it can be seen that theperformance graph approaches to the original VBLAST as 'C' value increases.

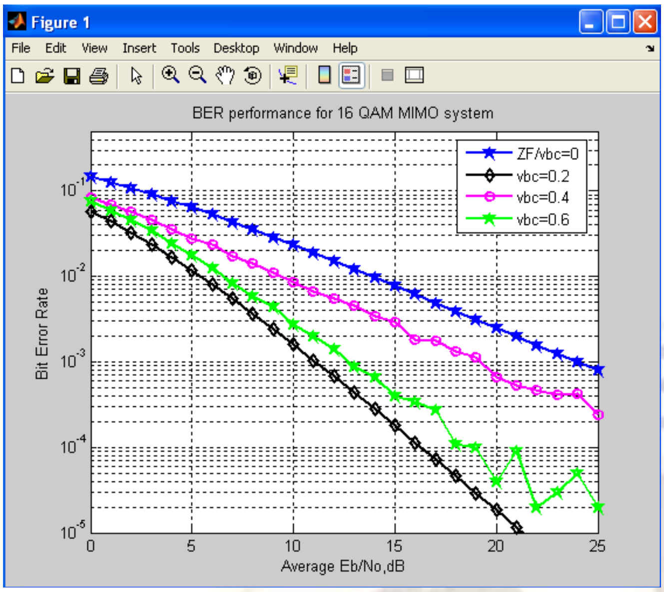

Fig 6. BER performance for 16QAM for two transmit and two receive antennas(2x2) in MIMO system.

Different proposed Algorithms have been proposed for V-BLAST Algorithm. Some of these are fast recursive, modified fast recursive for fast fading. Fig7. Shows the computational complexity of the modified VBLAST with its other algorithms as a function of Antenna pairs.

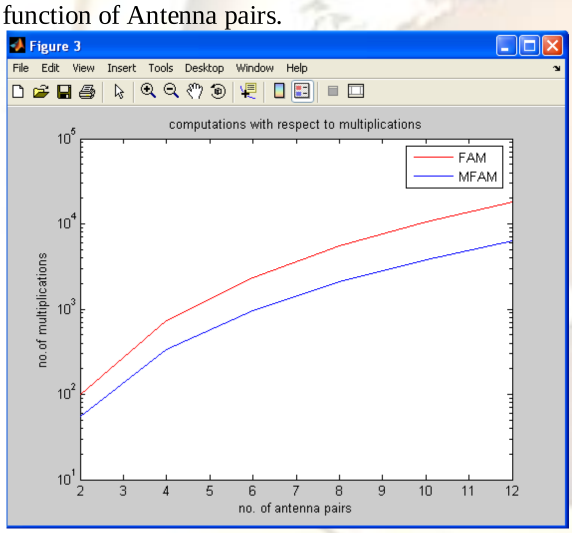

Fig 7. simulation for the complexity in multiplications as a function of number of antenna pairs

VI. CONCLUSION

A general V-BLAST system with M transmitting antennas and N receiving antennas was studied and an efficient algorithm with low computational complexity was developed. The proposed algorithm was simple and efficient that reduces the complexity by a factor of M. Compares BER performances with various detection schemes i.e ZF, MMSE and MMSE-SIC .From the above results, it has been observed that the MMSE -SIC detection has better BER performance than the MMSE and ZF detections. In Addition, the performance of MMSE detection is better than ZF detection by 2- 3 dB. Finally, by using the recursion algorithms the complexity order reduces and the computation becomes less compared to other techniques

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