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PERFORMANCE ANALYSIS OF MIMO TECHNOLOGY USING VBLAST MAXIMUM A POSTERIORI (MAP)

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Abstract— Recent research shows that multiple antenna at both transmitter and receiver offers higher data rates compared to single antenna system. The information-theoretical capacity of MIMO grows linearly with the smaller of transmit and receive antenna in rich scattering environment with sufficient high SNR. In this paper, V-BLAST and maximum a-posteriori (MAP) is used improve the performance of the MIMO system. The original V-BLAST algorithm is a multi-layer symbol detection scheme, which detects symbols transmitted at different transmit antennas successively in a certain data-independent order. The proposed V-BLAST-MAP algorithm differs from V-BLAST only in the ordering strategy of the symbols detected. The complexity of the V-BLAST-MAP is higher than that of V-BLAST. The performance improvement is also significant. In this paper, MATLAB Based simulation result are discussed

***Keywords**: MIMO, V-BLAST, V-BLAST-MAP*

I. INTRODUCTION

Multiple Input and Multiple Output (MIMO) wireless communication system, shown in Figure 1, has been shown to provide high capacity in a rich scattering environment. In MIMO receiver the algorithm called BLAST (Bell Laboratories Layered Space Time) algorithm which was developed by Foschini had fetched great attention in recent few years [1]. However, it suffers from many drawbacks like its computational complexity is still large for many applications and also the algorithm BER performance is degraded by the effect of error propagation. The diagonal (D-BLAST have some disadvantages in implementation complexities which makes it unsuitable for initial implementation

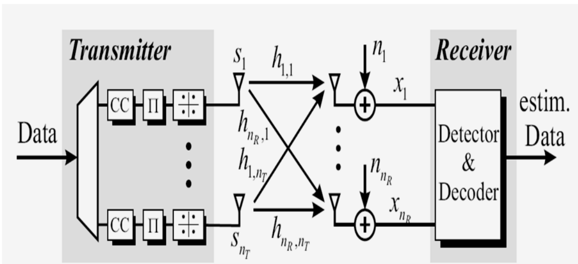

Figure 1. MIMO Architecture

In this paper, we use simplified version of BLAST known as vertical BLAST or V-BLAST, which has been implemented in real-time in the laboratory. The V-BLAST architecture is one of such a MIMO system, as shown in Figure 2, which is attractive from the implementation standpoint. When operated in rich multipath environment and with sufficient high SNR It has been observed that the theoretical capacity linearly increases with the minimum numbers of transmitting and receiving antennas[1].

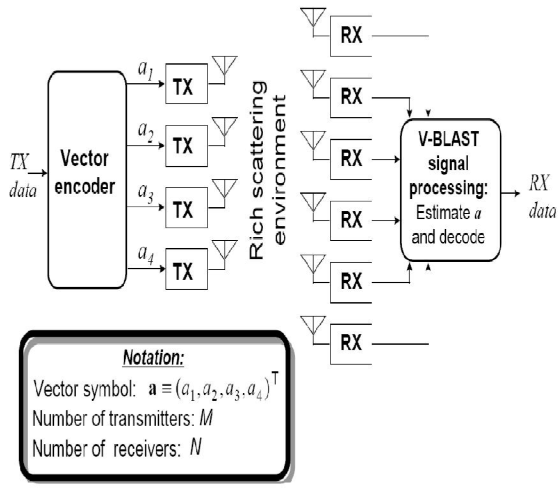

Figure 2. VBLAST high level system architecture detection Algorithm

The V-BLAST detection algorithm is a recursive process that extracts the components of the transmitted vector ‘a’ according to a certain ordering $(k_1,k_2,\ldots,k_M)$ of the indices of the elements of ‘a’. Thus, $(k_1,k_2,\ldots,k_M)$ is a permutation of (1,2,...,M). In V-BLAST, this permutation depends on H (which is known at the receiver by assumption) but not on the received vector ‘r’.

A. V-BLAST-ZF Detection Algorithm

The V-BLAST-ZF algorithm is a variant of V-BLAST derived from Zero-Forcing (ZF) rule. V-BLAST-ZF Detection Algorithm:

***Initialization**:*

(A.1)
(A.2)

Recursion:

$$k_i = arg_{j\in\{k_1 \ldots k_{i-1}\}} min \left\|(W_i)_j\right\|^2 \qquad (A.3)$$

$$y_{k_i} = (W_i)_{k_i} r_i \qquad (A.4)$$

$$\hat{a}_{k_i} = Q(y_{k_i}) \qquad (A.5)$$

$$r_{i+1} = r_i - \hat{a}_{k_i} (H)_{k_i} \qquad (A.6)$$

$$W_{i+1} = H^+_{k_i} \qquad (A.7)$$

$$i = i + 1 \qquad (A.8)$$

$where, H - Channel\ Transfer\ Matrix$

$H^+ - Moore - Penrose\ Pseudoinverse\ of\ H$

In the above algorithm, Equ (A.3) determines the order of channels to be detected; Equ (A.4) performs nulling and computes the decision statistic; Equ (A.5) slices computed decision statistics and yields the decision; Equ (A.6) performs cancellation by decision feedback, and Equ (A.7) computer the new pseudo-inverse for the next iteration. In V-BLAST-ZF may be seen as a successive-cancellation scheme derived from ZF scheme.

B. *V-BLAST-LLSE Detection Algorithm*

The V-BLAST-LLSE algorithm is a variant of V-BLAST derived the weighting matrix is chosen according to the Linear Least Squares Estimation (LLSE) rule. V-BLAST-LLSE detection Algorithm:

Initialization:

$$W_1 = \frac{\rho}{M} H^\dagger \left(\frac{\rho}{M} HH^\dagger + N_0 I_N\right) \qquad (B.1)$$

$$i = 1 \qquad (B.2)$$

Recursion:

$$k_i = arg_{j\in\{k_1 \ldots k_{i-1}\}} min \left\|(W_i)_j\right\|^2 \qquad (B.3)$$

$$y_{k_i} = (W_i)_{k_i} r_i \qquad (B.4)$$

$$\hat{a}_{k_i} = Q(y_{k_i}) \qquad (B.5)$$

$$r_{i+1} = r_i - \hat{a}_{k_i} (H)_{k_i} \qquad (B.6)$$

$$W_{i+1} = \frac{\rho}{M} H^\dagger_{k_i} \left(\frac{\rho}{M} H_{\overline{k_i}} H_{\overline{k_i}}^\dagger + N_0 I_N\right) \qquad (B.7)$$

$$i = i + 1 \qquad (B.8)$$

C. *V-BLAST-ZF-MAP Detection Algorithm*

Initialization:

$$W_1 = H^\dagger \qquad (C.1)$$

$$i = 1 \qquad (C.2)$$

Recursion:

$$y_{k_i} = W_i r_i \qquad (C.3)$$

$$s_i = Q(y_i) \qquad (C.4)$$

$$P_{ij} = \frac{f_{ij}(y_{ij}|s_{ij})}{\sum_{s' \epsilon A} f_{ij}(y_{ij}|s')},$$

$$j \notin \{k_1, k_2, \ldots, k_{i-1}\} \qquad (C.5)$$

$$k_i = \underset{j\in\{k_1 \ldots k_{i-1}\}}{\arg max} \{P_{ij}\} \qquad (C.6)$$

$$\hat{a}_{k_i} = s_{i\,k_i} \qquad (C.7)$$

$$r_{i+1} = r_i - \hat{a}_{k_i}(H)_{k_i} \qquad (C.8)$$

$$W_{i+1} = H^\dagger_{k_i} \qquad (C.9)$$

$$i = i + 1 \qquad (C.10)$$

The V-BLAST-MAP algorithm is identical to V-BLAST-ZF except for the ordering in which symbols are detected. Instead of selecting the next symbol to be detected to the rule (A.3), here the set of all potential symbols decision are ranked with respect to their a-posteriori probabilities of being correct, as estimated by P_{ij}. Thus, it is important to emphasize that P_{ij}'s are not true MAP probabilities but approximations to how probable it is that Sij = aj. The approximation is due to the omission in calculations of the cross-correlations between the noise terms

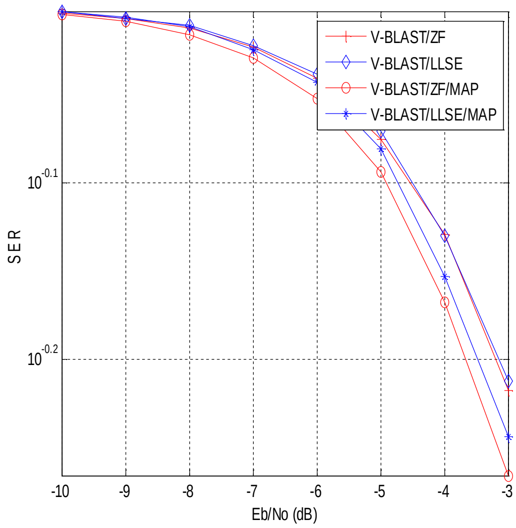

Figure 3. Symbol Error Rate (SER) of V-BLAST-ZF-MAP receiver, V-BLAST-LLSE-MAP receiver, V-BLAST-ZF receiver and V-BLAST-LLSE receivers, simulated for (M, N) = (4, 10) and QAM-16 modulation.

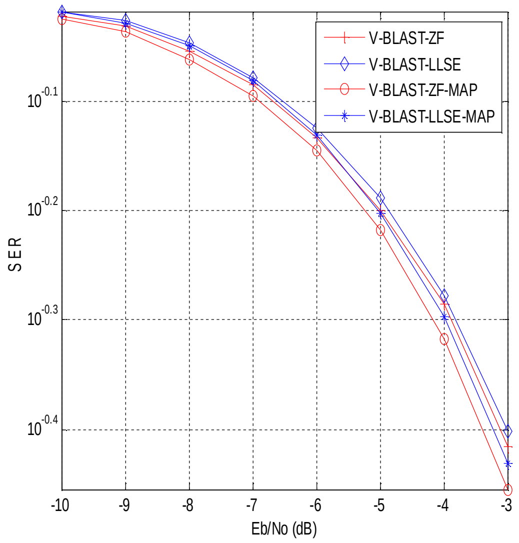

Figure 4. Symbol Error Rate (SER) of V-BLAST-ZF-MAP receiver, V-BLAST-LLSE-MAP receiver, V-BLAST-ZF receiver and V-BLAST-LLSE receivers, simulated for (M, N) = (6, 10) and QAM-16 modulation

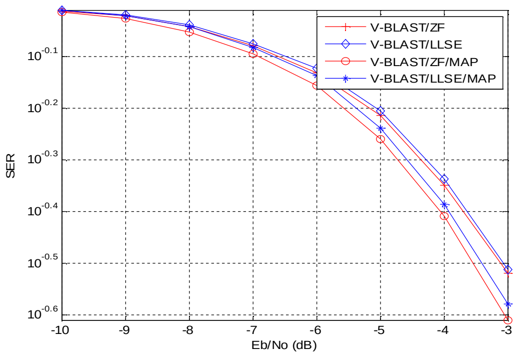

Figure 5. Symbol Error Rate (SER) of V-BLAST-ZF-MAP receiver, V-BLAST-LLSE-MAP receiver, V-BLAST-ZF receiver and V-BLAST-LLSE receivers, simulated for (M, N) = (6, 12) and QAM-16 modulation

D. V-BLAST-LLSE-MAP Detection Algorithm

Initialization:

$i = 1$ (D.1)

$W_1 = \frac{\rho}{M} H^{\dagger} \left(\frac{\rho}{M} H_i H_i^{\dagger} + N_0 I_N\right)$ (D.2)

Recursion:

$y_{k_i} = W_i r_i$ (D.3)

$s_i = Q(y_i)$ (D.4)

$P_{ij} = \frac{f_{ij}(y_{ij}|s_{ij})}{\sum_{s' \epsilon A} f_{ij}(y_{ij}|s')},$

$j \notin \{k_1, k_2, \ldots, k_{i-1}\}$ (D.5)

$k_i = \arg max_{j \notin \{k_1 \ldots k_{i-1}\}} \{P_{ij}\}$

(D.6)

$\hat{a}_{k_i} = s_{i\,k_i}$ (D.7)

$r_{i+1} = r_i - \hat{a}_{k_i} (H)_{k_i}$ (D.8)

$W_{i+1} = \frac{\rho}{M} H_{\overline{k_i}}^{\dagger} \left(\frac{\rho}{M} H_{\overline{k_i}} H_{\overline{k_i}}^{\dagger} + N_0 I_N\right)$

(D.9)

$i = i + 1$ (D.10)

The MATLAB based simulation result of this algorithm is shown in Figure 3, Figure 4 and Figure 5 .The results are estimation of the V-BLAST algorithm for a system with (M,N)=(4,10), (M,N)=(6,10), and (M,N)=(6,12) respectively with 16-QAM modulation, Eb/No ranges from -10 dB to -3 dB with step size of 1 dB. The symbol error rate SER is calculated by performing 10,000 trials at each Eb/No point.

The performance curves in Figure 3, Figure 4 and Figure 5 shows that V-BLAST-MAP provides significant improvement in SER compared to ordinary V-BLAST, both for the Zero-Forcing (ZF) and Linear Least Squares Estimation (LLSE) versions.

In Figure 3, Figure 4 and Figure 5 the performance curve of the Maximum Likelihood (ML) detection algorithm is not provided, as it requires 16^8 likelihood ratios, for each simulation run, which is too large to include here. The SER of the ML, V-BLAST-ZF and V-BLAST-ZF-MAP are shown in Figure. 6.

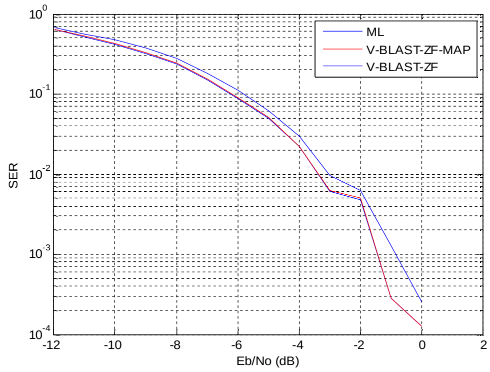

Figure 6. Symbol error rates (SER) of V-BLAST-ZF-MAP receiver, V-BLAST-ZF receiver and ML receiver, simulation is for (M, N) = (4, 12) and 4-QAM modulation

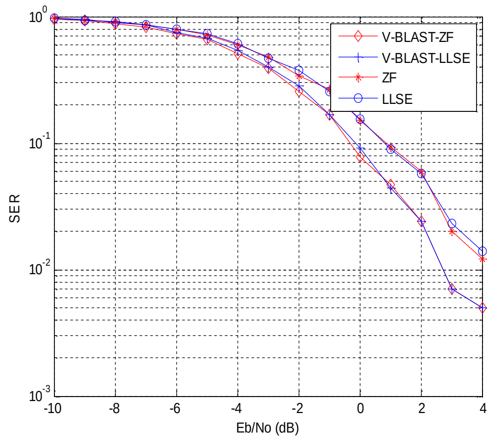

Figure 7. Symbol error rates (SER) of ZF, V-BLAST-ZF, LLSE, V-BLAST-ZF receive simulation for (M, N) = (8, 12) and 16-QAM modulation

Simply, we can say that V-BLAST-MAP is provides a quite better performance in terms of BER & SER compared to any other variation of V-BLAST.

II. RESULT AND DISCUSSION

The results of the variation of the V-BLAST algorithms are shown in Figure 3 to Figure 5. It can be easily seen that as (M, N) is increasing the performance in terms of SER is improving for V-BLAST-MAP.

The comparison of Maximum Likelihood (ML), Zero-Forcing (ZF) and Zero-Forcing MAP (ZF-MAP) is shown in Figure.6. It can be seen that ZF-MAP is better in terms of SER.

The comparison of ZF, V-BLAST-ZF, LLSE, V-BLAST-ZF is shown in Figure.7

III. CONCLUSION

In this paper we used the different detection algorithm for MIMO channels. This algorithm is an extension of VBLAST. The new algorithm VBLAST-MAP (maximum a-posteriori) combines the element of the VBLAST algorithm and the Maximum a-posteriori rule. In this paper, MATLAB based simulations are used to generate the result. VBLAST uses a layered structure, and offers highly better error performance than conventional linear receivers and still has low complexity. The result used in this paper, are based on (M, N) = (6, 10) and 4-QAM modulation with alphabet {±X ± i Y}. The comparison with and without VBLAST-ZF, VBLAST-LLSE and VBLAST-ML are compared under the many variation of different parameters of the system. We found the MAP provides us the best bit error rate result in all the case.

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