PERFORMANCE EVALUATION FOR V-BLAST MIMO SYSTEMS WITH ADAPTIVE POWER AND ADAPTIVE MODULATION

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ABSTRACT

V-BLAST system is detection algorithm of the MIMO (Multiple-Input Multiple Output) systems that is designed to achieve good multiplexing gain. In the C-BLAST system, every antenna transmits its own independently coded with power control / adaptive power. Beside that adaptive modulation is promising technique to increase the data rate that can be reliably transmitted over fading channel. For this reason some form of adaptive power and adaptive modulation is being proposed or implemented in many next generation wireless systems. In this paper we use M-QAM modulation in V-BLAST MIMO systems. Simulation results show that the adaptive power and adaptive modulation in V-BLAST MIMO system can increase BER performance and spectral efficiency system

Key Word: Adaptive modulation, C-BLAST, Transmit Power Allocation.

1. INTRODUCTION

Multiple - Input Multiple Output (MIMO) techniques can provide significant performance enhancements in wireless communication systems. Vertical-Bell Laboratories Layered Space Time(V-BLAST) is technique of data processing in MIMO to get the transmission signal that has simple coding and simple detection structure compared with the system in Diagonal- Bell Laboratories Layered Space Time (D-BLAST). In this letter to improve the transmission quality of V-BLAST we use transmit power allocation to minimize the error rate and it need feed back channel information. That system called C-BLAST(Close loop) system. It is different by convensional V-BLAST that use uniform power in each antenna. In this system transmit power allocation depend on channel condition[1]

2. MODEL, ANALYSIS, DESIGN, AND IMPLEMENTATION

In MIMO systems there are M transmit antennas and N receive antennas. In the transmitter, a data stream is demultiplexed into M independent substreams, and then each substream is encoded into transmit symbols using same modulation scheme. In this system we use 4 QAM. Based on the feedback information the transmit power Pi is the assigned to the data symbol xi and the symbol is transmitted through the i-th transmit antenna. In the receiver the C-BLAST detector estimated the receive signal from M antenna transmit and determines SNR and transmit power Pi. The baseband equivalent of the N dimensional received signal vector may be expressed as

\[ Y = H P x + n. \] (1)

H is the MIMO channel model. The MIMO channel model is the quas-static, frequency non-selective, Rayleigh fading channel model. Under the quasi-static assumption, the channel remain constant over the length of frame, changing independently between consecutive frames. The channel undergoes frequency non-selective fading when the coherence bandwidth of the channel is large compared to the bandwidth of the transmitted signal. In equation (1) \( x = [x_1 \ x_2 \ \ldots \ a_J]^T \) denotes the transmit symbol vector with each element having the unit average power, and H denotes the N x M channel matrix, whose element h_{mn} at the n_{th} row and m_{th} column is the channel gain from the m_{th} transmit antenna to the n_{th} receive antenna, H matrix are Gaussian random variables. The elements of the
N-dimensional noise vector \( n = [n_1 \ n_2 \ \ldots \ n_N]^T \) are assumed to be i.i.d. complex Gaussian random variables with zero mean and variance of \( \sigma_n^2 \). It is assumed that the channel estimation at the receiver is perfect. The transmit power \( P_i = (1,2,\ldots,M) \) for M transmit antennas with the total power constraint \( \sum_{i=1}^M P_i = M \) and sends the power to the transmitter through an error-free feedback channel. In C-BLAST system, a diagonal matrix \( P = \text{diag}(\sqrt{P_1}, \sqrt{P_2}, \ldots, \sqrt{P_M}) \) represent the transmit power. In V-BLAST without feedback \( P_i = 1 \) for all i and thus \( P \) is identity matrix \( I_M \). This picture is the C-BLAST system with feedback of channel information by power allocation in the transmitter[1].

Inisialization: \( i \leftarrow 1 \) \hspace{2cm} (2a)  
\[ y_1 = y \] \hspace{2cm} (2b)  
\[ G_1 = (HP)^+ = P^4H \] \hspace{2cm} (2c)  
\[ k_1 = \text{argmin}_j ||<H^+>_j||^2 \] \hspace{2cm} (2d)  
Recurtion \( w_{ki} = <G_i> \) \hspace{2cm} (2e)  
\[ z_{ki} = w_{ki} y_i \] \hspace{2cm} (2f)  
\[ x_{ki} = Q(z_{ki}) \] \hspace{2cm} (2g)  
\[ y_{i+1} = y_i - x_{ki} [HP]_{ki} \] \hspace{2cm} (2h)  
\[ G_{i+1} = (HP)_{ki}^+ (HP)_{ki}^+ + \sigma_n^2 I_M)^{-1} \] \hspace{2cm} (2i)  
\[ k_{i+1} = \text{argmin}_{j \neq k_1, \ldots, k_i} \|<[H]_{ki}^+>|\|^2 \] \hspace{2cm} (2j)  
\[ i \leftarrow i + 1 \] \hspace{2cm} (2k)  

where \((.)^+\) denotes Moore-Penrose pseudo inverse, \(|.||\) is the norm of the vector, \(<,>\) is the \(j\)th row of matrix and \([.]\) the \(j\)th column of a matrix, and \([.]_{ki}\) is a matrix formed by zeroing the \(k_1,k_2,\ldots,k_i\). \(Q(\cdot)\) is the slicing operator associated with a modulation scheme, and \(\hat{x}_{ki}\) is the estimated value of \(x_{ki}\), \(ki\) symbol index detected at the \(i\)th stage, detection order is determined based on the signal-to-interference-plus-noise ratio (SINR) of transmit symbols with \(P=I_N\). The nulling vector in (2e) can be rewritten as:

\[ w_{ki} = <G_i>_{ki} = <(\mathbb{H}^+)^{ki}>_{ki} >_{ki} = v_{ki} / \sqrt{P_{ki}} \]

where the vector \(v_{ki} = <(\mathbb{H}^+)^{ki}>_{ki}\) corresponds to the nulling vector of the \(i\)th detection stage, when \(P=I_N\). The postdetection SINR, which determines the performance of each stage, as the SINR of the decision statistic \(z_{ki}\). The interference component is zero for zero-forcing (ZF), but nonzero for minimum mean-square error (MMSE). The postdetection SINR \(\rho_{ki}\) for the \(k\)th symbol can be calculated as:

\[ \rho_{ki} = \frac{1}{\sigma_{ki}^2} = \frac{P_{ki}}{\sigma_{ki}^2} \] \hspace{2cm} (3)  
\(\rho_{ki}\) adalah variabel random, \(v_{ki}\) adalah bobot vektor dan \(P_{ki}\) adalah daya transmisi untuk simbol ke-\(k\). Performansi rata-rata dari tingkat deteksi ke-i ditentukan dari \(\rho_{ki}, v_{ki}\).

Unlike the ZF nulling that removes the interference components completely but results in noise enhancement, the MMSE nulling compromises interference suppression and noise enhancement, such that the mean-square error (MSE) between the transmit symbol and estimate of the receiver is minimized. In the case of MMSE, (2c) dan (2i) should be changed as:

\[ G_i = (HP)^+ (HP)^+ + \sigma_n^2 I_M)^{-1} \] \hspace{2cm} (4)  
\[ G_{i+1} = (HP)_{ki}^+(HP)_{ki}^+ + \sigma_n^2 I_M)^{-1} \]  
where \((.)^\dagger\) denotes the conjugate transpose.

\[ k_i = \arg\max_j \\|G_{ij}\|^2 \] \hspace{2cm} (5a)  
\[ k_{i+1} = \arg\max_{j \neq k_1, \ldots, k_i} \|G_{ij}\|^2 \] \hspace{2cm} (5b)  
\(G'_i = G_i\ |_{P=I_N}\) is the nulling matrix, \(P=I_N\) the post detection SINR for the \(k\)th symbol is[1]:
Transmit power allocation can be derived by post detection SNR from channel matrix. Note that in Zero Forcing and MMSE detection algorithm ZF this detection order is determined based on the signal-to-interference-plus-noise ratio (SINR) of transmit symbols with $P = I_M$ in initial condition

$$P = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Transmit power allocation can be different in each sub channel depend on channel condition. And the total power is as much as transmit antennas. This power will different for the new channel matrix, for new burst. \[1\].

System with detection ordering is system by order of detection is decided by SNR, transmit antenna with largest SNR is selected in each iteration. System without ordering is order of detection is selected randomly and without consider SNR post detection $k = 1, 2, 3, .., M-1, M$

$$k_i = \arg \max_{k} \frac{|g_i(H_i)|}{\sigma^2|g_i|^2 + \sum_j |g_j(H_j)|^2}$$

In this paper we use M-QAM modulation and the BER performance can be shown from the fig. 2.

<table>
<thead>
<tr>
<th>Modulation</th>
<th>SNR(dB)</th>
</tr>
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<tbody>
<tr>
<td>M/ No transmit</td>
<td>SNR &lt; 7.9166</td>
</tr>
<tr>
<td>BPSK</td>
<td>7.9166 &lt; SNR &lt; 12.6879</td>
</tr>
<tr>
<td>4 QAM</td>
<td>12.6879 &lt; SNR &lt; 16.3677</td>
</tr>
<tr>
<td>8 QAM</td>
<td>16.3677 &lt; SNR &lt; 19.6776</td>
</tr>
<tr>
<td>16 QAM</td>
<td>SNR &gt; 19.6776</td>
</tr>
</tbody>
</table>

we can see that the best BER performance is BPSK and the worst BER performance is 16 QAM.

To get the efficiency spectral of the C-LAST MIMO system we determine modulation depend on SNR post detection.

![Fig 2. BER performance M-QAM modulation](image_url)

We have known from that table that the maximum SNR use the maximum constellation and if the SNR is small it cause the data no transmitted.

### 3. RESULT

From the fig 3. we can see that V-BLAST with MMSE detection can achieve performance than V-BLAST detection by Zero Forcing detection. The adaptive power can achieve good performance compare without adaptive power because the transmit data depend on channel condition and SNR post detection. In BER $10^{-3}$ it can be increasing SNR as 3dB in C-BLAST and V-BLAST with MMSE detection algorithm. In fig 4 we can see that the smaller modulation level it make the performance of error rate is better because smaller constellation can make smaller error rate happen. In fig 5. denote the analyzing of spectral efficiency of C-BLAST with variety of modulation level and by using adaptive modulation. Spectral efficiency describe of average bit per second can be transmitted of the system. It can shown that higher constellation it can improve the spectral
efficiency. And the adaptive modulation can reach the maximum efficiency spectral of the system. But in the fig 6. that the adaptive modulation is bad to achieve the BER performance. It can be cause that there is a trade off between capacity and spectral efficiency. The adaptive modulation is the best system can be applied to achieve spectral efficiency not to achieve BER performance.

4. CONCLUSION

In this paper we have shown that C-BLAST with adaptive power have better performance compared with V-BLAST without adaptive power. We have also derived the spectral efficiency of C-BLAST with adaptive modulation.

REFERENCE