HYBRID MULTILAYER SCHEMES FOR ACHIEVING THE MAXIMUM POSSIBLE DIVERSITY GAIN

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ABSTRACT

This paper proposes a novel signal scheme called “Hybrid BLAST STBC approach” this combines MIMO (multiple-input multiple-output) and STBC (space time block code) to generate a system functionally superior to MIMO and STBC systems. This paper compares and investigates the capacity of high data rate wireless local area network systems using MIMO techniques. In particular, two different algorithms—V-BLAST and STBC, are described. A third hybrid approach, which incorporates elements of both V-BLAST and STBC (Hybrid BLAST STBC), is also introduced. The focus of the study is to compare the information capacity of hybrid systems with V-BLAST and STBCs. Hybrid can balance transmit diversity gain and spatial multiplexing gain. All three techniques are compared using both theoretical Shannon capacity analysis and by simulation results for the bit error ratio and capacity performance of the three methods. The result of this study shows that hybrid method attains superior diversity gain performance to V-BLAST and can out form V-blast at spectral efficiencies of practical interest. Furthermore, at low SNRs and low outage probabilities, hybrid is more spectrally efficient. Thus, it is more suitable for low power high data rate wireless applications. Finally, we compare the performance of our proposed system with the conventional scheme by computer simulations which validate the analytical results.

Keywords: Hybrid BLAST STBC, MIMO, V-BLAST, STBC.

1. INTRODUCTION

Digital communication exploiting MIMO processing has emerged as a breakthrough for revolutionary wireless systems can offer high data rates through spatial multiplexing, interference cancellation techniques and they can improve the link reliability[1-4]through diversity. VBLAST [5] is a spatial multiplexing scheme that transmits independent layers of information through a MIMO channel. In general, all these gains cannot be achieved simultaneously, as they are dependent on antenna configuration and scattering environment. Hence, good knowledge of the characteristics of the propagation environment is crucial for maximizing the achievable MIMO gains. In fact, the very demanding performance targets set for next-generation systems are virtually impossible to reach without an efficient utilization of multiple antennas both at transmitter and receiver side. However, it has poor energy performance and doesn’t fully exploit the available diversity. The V-BLAST algorithm aims to maximise the capacity by using combination of spatial processing and subtractive cancellation to remove co-channel interference, provided that the number of antennas at the receiver is greater or equal to that of the transmitter. Conversely, the STBC[6] or Alamouti scheme exploits the diversity against fading that is available from employing multiple antennas at the transmitter and possible at the receiver but with a maximum code rate of one which is achieved at two transmit antennas.

Combining V-BLAST and STBC results in a layered architecture with transmit diversity in each layer. This can be called a “Hybrid BLAST STBC approach” to try to exploit the advantages of both higher data rates and increased diversity gain of the MIMO system at low SNRs and at low outage probabilities. The idea of this scheme is to demultiplex a single user’s data into parallel layers of information. Then, each layer is encoded by a STBC. Each code is called a group, because the total number of transmit antennas are divided into groups and each group is assigned a STBC. This architecture was first considered in [6] where they used space time trellis codes (STTC) as the component codes. In a multi-user environment, a multi-user STBC system with minimum mean-squared error (MMSE) detection was studied in [7]. In [8], different decoding algorithms for HBSC were compared over flat fading MIMO channels. One advantage of using STBC over STTC is that the orthogonal structure and the short code length can be exploited at the receiver to reduce the minimum required number of receive antennas [7]. For
HBSC [6,9], the number of receive antennas should be at least equal to the total number of transmit antennas. However, for Hybrid BLAST STBC, it is equal to the number of layers. In this paper, the Shannon capacity of the three techniques will be investigated theoretically. Then the analysis will also be complemented by detailed simulation studies of the algorithms, investigating the bit error ratio performance of the three receivers. The result will show that in some cases the Hybrid BLAST STBC algorithms can significantly outperform the V-BLAST and STBC techniques. The rest of the paper is structured as follows. Section 2 of the paper will describe the system model that is used in the paper. Section 3 will describe the algorithms to be compared. Section 4 will present simulation results and finally section 5 present the conclusion to the paper.

2. SYSTEM MODEL

A MIMO channel is a wireless link between $M_T$ transmits and $N_R$ receive antennas. It consists of $M_T \times N_R$ elements that represent the MIMO channel coefficients. The multiple transmit and receive antennas could belong to a single user modem or it could be distributed among different users. The later configuration is called distributed MIMO and cooperative communications. Fig.1(a) shows conceptual diagram of MIMO channels.

Statistical MIMO channel models offer flexibility in selecting the channel parameters, temporal and spatial correlations. MIMO channel simulation tools are implemented based on these models. Several statistical MIMO channel models were proposed in [10] and [11]. Both models introduced spatial correlation by multiplying a matrix of uncorrelated random variables by a square root of a covariance matrix and both are based on similar assumptions. However, they differ in their approach. In [12], the authors validate the statistical model of [10] based on measurements in picocells and microcells. They showed that the eigenvalue distribution of the model matches the measurements.

$$r(k) = \sqrt{\frac{P_T}{M}} H s(k) + \eta(k)$$

where $P_T$ is the power at the transmitter and $k$ denotes the time index. The vector $r(k)$ is the size $N$ received signal vector $\{r_1(k), r_2(k), ..., r_N(k)\}^T$, Where $r_{NR}(k)$ denotes the received signal at receiving antenna $N_R$. $s(k)$ is the quadrature amplitude modulation (QAM) transmission vector $\{s_1(k), s_2(k), ..., s_M(k)\}^T$ of size $M$. Where $s_{MT}(k)$ denotes the transmitted QAM symbol at antenna $M_T$. The matrix $H$ is the $M \times N$ channel matrix where the element at row $n$ and column $m$, $h_{mn}$ denotes the channel response at receiver $N_R$ due to transmitter $M_T$. The summary chart of MIMO communication systems is shown in Fig.1(b).
3. NOVEL FULL-DIVERSITY FULL-MULTIPLEXING SYSTEMS

In this section the three main algorithms will be introduced and explained in turn. These are V-BLAST algorithms, STBC scheme and hybrid BLAST STBC (multilayer STBC) scheme. This paper focuses on bandwidth efficient advances for MIMO systems, covering three major areas. The first area considers a layered architecture that has transmit diversity at each layer [13], termed a multi-layered space time code. This architecture combines spatial multiplexing and transmits diversity and it bridges the gap between these two MIMO systems. The focus in this part is to how the multi-layered system compares to other MIMO systems, such as V-BLAST and space time block codes. Furthermore, we propose and compare hybrid BLAST STBC detection algorithms which are based on multi-user detection theory.

3.1 V-BLAST:

The first high data rate architecture was the Bell-labs layered space time architecture (BLAST) and it was proposed by G. J. Foschini [14]. V-BLAST is a suboptimal algorithm that can reach a large fraction of its Shannon capacity under some proper propagation environments. In BLAST, multiple parallel data streams are spatially multiplexed and transmitted simultaneously on the same frequency through all transmit antennas. With rich multipath propagation, these different streams are separated at the receiver based on their distinct spatial signatures. However, this architecture is a full spatial multiplexing scheme and it doesn’t provide any transmit diversity while receive diversity is achieved on some streams depending on the receiver architecture. It achieves high spectral efficiencies by spatially multiplexing coded or uncoded symbols over the MIMO fading channel.

The architecture (Fig. 2) of V-BLAST consists of $M_T$ specially multiplex data streams at the transmitter, which are measured at $N_R$ receiver antennas. Each sub-stream is encoded into symbols and fed to a separate transmitter. The modulation method in these systems usually is M Quadrature Amplitude Modulation (MQAM). QAM combines phase modulation with amplitude modulation, making it an efficient method for transmitting data over a limited bandwidth channel. BLAST’s receivers operate co-channel, each receiving the signals emanating from all $M_T$ of the transmitting antennas. For successful operation of the algorithms, it is usually required that $N_R > M_T$. 

![Fig 1(b): Summary chart of MIMO communication systems.](image-url)
The V-BLAST signal processor operates using M detection cycles, one for each transmitter antenna. The ordering algorithm selects the antenna with the strongest SNR, followed by the next strongest, until every antenna signal has been detected. Reconstructed signals for the detected antennas are then subtracted from the received signal to remove interference to the remaining undetected antennas. During the detection process, except for the antenna signal to be detected, the interference from antennas yet to be detected must be suppressed. The operation is performed by linearly weighting the received signal to satisfy the maximum likelihood (ML) criterion. ML receiver is a method that compares the received signals with all possible transmitted signal vector which is modified by channel matrix H and estimates transmit symbol vector x according to the Maximum Likelihood principle. The ML detector is defined as

$$G_1 = \arg\min_{x_i \in \{x_1, x_2, \ldots, x_N\}} \|r - Hx_k\|^2 \ldots (2)$$

Where, $G_1$ indicates that this matrix is used in the first detection cycle. This $M_T \times N_R$ matrix $G_1$ pre-multiplies the received signal to separate specially each antenna signal from all others. This means that data detection can be performed independently on each of the $M_T$ outputs from the multiplications. In order to determine which transmit antenna has the best SNR at the $i^{th}$ iteration; the following formula for the $m^{th}$ antenna is used:

$$SNR_i(m) = \frac{\lambda_i^2 E(\lambda_m^2)}{\beta_i} \ldots (3), \quad \text{where, } \alpha = G_i(m)H(m) \ldots \ldots \ldots \ldots (4)$$

$$\beta_i = |G_i(m)|^2 \sigma^2 + \sum_{p=1}^{M} |G_i(m)H(p)|^2 E(\lambda_p^2) \ldots \ldots (5)$$

The vector $G_i(m)$ is the $m^{th}$ row of $G_i$ calculated after $i-1$ detection cycles. Similarly the vector $H(m)$ is the $m^{th}$ column of $H$. The optimal ordering for detection and symbol cancellation makes V-BLAST different from the conventional linear combinatorial nulling. Let $S = \{k_1, k_2, \ldots, k_M\}$ be a permutation of integers from 1 to M specifying the order of detecting the symbol vector $a$. The soft decision statistic for the $m^{th}$ antenna at iteration $i$ can be formed by multiplying the nulling vector and received signal:

$$y(k_i) = G_i(k_i) \times r_i \ldots \ldots (6)$$

where $r_i$ denotes received signal after subtracting $(i-1)$ previously detected signals. The detection statistic is then quantized in accordance to the constellation in use: $\hat{a}(k_i) = Q[y(k_i)] \ldots \ldots \ldots \ldots (7)$

Where, the $Q[ ]$ is the slicer to its respective constellation in used. The detected data are subtracted from the received signal while the column vectors of $H$ due to the detected symbols are nulled. Finally, the received signal is updated for the next iteration as follows: $r_{i+1} = r_i - \hat{a}(k_i) \times H_i(k_i) \ldots \ldots \ldots (8)$

Where, $H_i(k_i)$ denotes $k_i^{th}$ column of $H_i$ after zeroing $(i-1)$ columns matching the $(i-1)$ previously detected signals. The subtraction of the detected data from the received signal aims to minimize errors in the subsequent detection.
process, provided the detected data possesses a certain degree of accuracy at the end of the i\textsuperscript{th} detection cycle. The matrix $H_{i+1}$ is formed by setting column $k_i$ of the matrix $H_i$ to zero. The ML matrix $H_{i+1}$ must then be re-calculated using equation (2) with $(H_{i+1})$ used in place of $H$.

3.2. STBC/Alamouti Scheme:

Space-time coding is coding technique designed for use with multiple transmits antennas. Coding is performed in both spatial and temporal domains to introduce correlation between signals transmitted from various antennas at various time periods. The spatial temporal correlation is used to exploit the MIMO channel fading and minimize transmission error sat the receivers. Space-time coding can be achieve transmit diversity and power gain over spatially un-coded systems without sacrificing the bandwidth. A basic space time code is Alamouti space time codes. The approach is outline in Fig.3.

![Block Diagram of Alamouti Space Time Encoder](image-url)

Fig 3: A block diagram of the Alamouti space time encoder

This particular scheme is restricted to using $M_T = 2$ antennas at the transmitter but can any number of receive antennas $N_R$. Two QAM symbols $S_1$ and $S_2$ for transmission by the Alamouti scheme are encoded in both the space and time domain at the two transmitter antennas over the consecutive symbol periods as shown in equation (9). The information bits are first modulated using a modulation scheme (for example QPSK). The encoder then takes a block of two modulated symbols $s_1$ and $s_2$ in each encoding operation and gives to the transmit antennas according to the code matrix,

$$
S = \begin{bmatrix} s_1 & s_2 \end{bmatrix}
= \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{bmatrix} \ldots \ldots (9)
$$

In the above matrix the first column represents the first transmission periods and the second column, the second transmission period. The first row corresponds to the symbols transmitted from the first antenna and second row corresponds to the symbols transmitted from the second antenna. It means that during the symbol period, the first antenna transmits $s_1$ and second antenna $s_2$. During the second symbol period, the first antenna transmits $-s_2^*$ and the second antenna transmits $s_1$ being the complex conjugate of $s_1$. This implies that we are transmitting both in space (across two antennas) and time (two transmission intervals). This is space time coding.

Hence, $S_1 = [s_1 \quad -s_2^*]$ and $S_2 = [s_2 \quad s_1^*]$

Moreover a close look reveals that sequences are orthogonal. The inner product is given by:

$$
S_1 \ast S_2^* = s_1s_2^* + s_2s_1^* = 0 \ldots \ldots (10)
$$

In order to decode the signal, the received signal can be expressed as

$$
r' = \frac{Pr}{2}H_A s_1 + \eta' \ldots \ldots (11)
$$

where

$$
\begin{bmatrix}
\hat{r}_1 \\
\hat{r}_2 \\
\vdots \\
\hat{r}_N
\end{bmatrix} = \frac{Pr}{2}
\begin{bmatrix}
H_{A,1} \\
H_{A,2} \\
\vdots \\
H_{A,N}
\end{bmatrix}
\begin{bmatrix}
s_1 \\
\eta_1 \\
\vdots \\
\eta_N
\end{bmatrix} \ldots \ldots (12)
$$

$$
\begin{bmatrix}
r_1 \\
\vdots \\
r_N
\end{bmatrix} = \begin{bmatrix}
n_1 \\
\vdots \\
n_N
\end{bmatrix} \ldots \ldots (13)
$$

and

$$
H_{A,n} = \begin{bmatrix}
h_{n,1} & h_{n,2} \\
h_{n,2}^* & h_{n,1}^*
\end{bmatrix} \ldots \ldots (15)
$$

Decoding the data is achieved be done by multiplying the received signal with the Hermitian transpose of the channel matrix $H_A$ as:

$$
S_1 = [s_1 - s_1^*]
$$

$$
S_2 = [s_2 s_1^*]
$$
\[
\mathbf{S}_1 = H_A^H \mathbf{r}' = \sqrt{\frac{P_T}{2}} H_A^H H_A s_1 + H_A^H \eta' = \sqrt{\frac{P_T}{2}} \begin{bmatrix} \gamma & 0 \\ 0 & \gamma \end{bmatrix} \begin{bmatrix} s_1 \\ s_2 \end{bmatrix} \ldots \ldots (16)
\]

In this equation
\[
\gamma = \sum_{m=1}^{n} |h_{(n,m)}|^2 \ldots (17)
\]

### 3.3 Hybrid BLAST STBC

The Architecture of Hybrid BLAST STBC system is shown in Fig.4. In the previous section on the Alamouti scheme, It is seen that for 2 transmitter antennas to achieve full diversity, the spectral efficiency of the system is the same as that of a single transmitter antenna.

In order to improve the spectral efficiency of the system, a 4 transmitter structure is now considered, where the Alamouti scheme is applied separately to two pairs of antennas. This means that two data streams are spatially multiplexed on two different pairs of antennas. The received signal for this transmitter configuration may be written as

\[
\mathbf{r}' = \sqrt{\frac{P_T}{4}} H_A \mathbf{s}_1 + \eta' \ldots (18)
\]

\[
\begin{bmatrix}
\eta_1 \\
\eta_2 \\
\vdots \\
\eta_N
\end{bmatrix} = \sqrt{\frac{P_T}{4}} \begin{bmatrix}
H_{A,1} & H_{B,1} \\
H_{A,2} & H_{B,2} \\
\vdots & \vdots \\
H_{A,N} & H_{B,N}
\end{bmatrix} \begin{bmatrix}
s_1 \\
s_2 \\
\vdots \\
s_N
\end{bmatrix} + \begin{bmatrix}
\eta_1 \\
\eta_2 \\
\vdots \\
\eta_N
\end{bmatrix} \ldots \ldots (19)
\]

In this equation, the vector \( \mathbf{S}_1 = [s_1, s_2, s_3, s_4]^T \), where the quantities \( s_3 \) and \( s_4 \) represent the QAM symbols for the second Alamouti-encoded data stream which is transmitted simultaneously with \( s_1 \) and \( s_2 \).

\[
H_{B,n} = \begin{bmatrix}
h_{n,3} & h_{n,4} \\
-h_{n,4} & h_{n,3}
\end{bmatrix} \ldots \ldots (20)
\]

Unlike equation (16) the two symbol pairs (\( s_1, s_2 \)) and (\( s_3, s_4 \)) interfere with one another, so simple linear decoding is no longer optimum. However, the form of equation (18) means that the V-BLAST algorithm can be applied directly to detect the data symbols \( s_1 \ldots s_4 \). As with the Alamouti scheme the structure of the dual Alamouti scheme means that \( s_1 \) and \( s_2 \) do not interfere with one another, which is also the case for \( s_3 \) and \( s_4 \). The dimension of \( \mathbf{r}' \) in equation (17) is \( 2N \), which means that the transmissions of 4T antenna can be successfully decoded with only 2R_t antennas.
3.4. Shannon Capacity Comparisons:

In this section, Shannon capacity results for the three algorithms under consideration will be revised. Under assumption of unit bandwidth, the Shannon capacity of the MIMO system shown in equation (1) is given by the formula [14]:

\[ C_{V-\text{BLAST}} = \log_2 \det \left( I_M + \frac{P_T}{M \sigma^2} H^T H \right) \text{ (bits/sec/Hz)} \ldots \ldots \ldots \ldots \ldots \ldots \ldots (21) \]

In this formula \( \det( ) \) denotes the matrix determinant operation. This formula assumes that the transmitter possesses no knowledge of the channel matrix \( H \). In order to calculate the capacity of the Alamouti scheme, we can notice that equation (12) has the same general form as (1). So equation (21) can also be applied to this system. However, the vector \( r' \) is measured over two consecutive symbol periods. For consistent results, the effective bandwidth of the system must be divided by two in compensation. So, the following result is obtained

\[ C_{\text{ALAMOUTI}} = \frac{1}{2} \log_2 \det \left( I_2 + \frac{P_T}{2\sigma^2} H_A^T H_A \right) = \log_2 \left( 1 + \frac{P_T \gamma^2}{2\sigma^2} \right) \ldots \ldots \ldots \ldots \ldots \ldots \ldots (22) \]

The RHS of this equation may be obtained from the LHS by noticing the orthogonal structure of the matrix product \( H_A^T H_A \) in equation (16). Again, the capacity of the Hybrid-Blast scheme may be obtained by noticing that equation (19) has the same general form as (1). As with the Alamouti scheme, the bandwidth must be scaled by a factor of two to compensate for \( r' \) being measured over two consecutive symbol periods. This time, the resulting capacity equation is:

\[ C_{\text{HYBRID-BLAST}} = \frac{1}{2} \log_2 \det \left( I_4 + \frac{P_T}{4\sigma^2} H_D^T H_D \right) \ldots \ldots \ldots \ldots \ldots \ldots \ldots (23) \]

The matrix \( H_{\text{HYBRID-BLAST}} \) is defined in equation (19). The equations for \( C_{V-\text{BLAST}} - C_{\text{HYBRID-BLAST}} \) may be evaluated to compare the achievable Shannon capacities of the three systems.

<table>
<thead>
<tr>
<th>Multi-Layer System</th>
<th>Transmit Diversity</th>
<th>Number of Received Antennas</th>
<th>Diversity Advantage Over Quasi-Static Fading Channels</th>
<th>Receiver Complexity Increase With Increasing Number of Transmit Antennas or /and Transmission Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLAST</td>
<td>No</td>
<td>( N_R \geq M_T )</td>
<td>( 1 \times (1, 2 \ldots N_R) ) Earlier detected symbols have lower advantage than later ones</td>
<td>Cubic</td>
</tr>
<tr>
<td>STTC</td>
<td>Yes</td>
<td>( N_R \geq 1 )</td>
<td>( M_T \times N_R )</td>
<td>Exponential</td>
</tr>
<tr>
<td>STBC</td>
<td>Yes</td>
<td>( N_R \geq 1 )</td>
<td>( M_T \times N_R )</td>
<td>Linear</td>
</tr>
<tr>
<td>HYBRID BLAST STBC</td>
<td>Yes</td>
<td>( N_R \geq 1 )</td>
<td>( M_T \times N_R )</td>
<td>Exponential</td>
</tr>
</tbody>
</table>

4. Simulation Results

This section compares the capacities of the detection algorithms of Hybrid BLAST STBC, V-BLAST and STBC (Alamouti). In addition, the optimal MIMO capacity is included as a reference. For Hybrid BLAST STBC, each component code is a rank two Alamouti STBC. The capacity of the different systems is estimated by generating
random complex Gaussian channel realizations from which the instantaneous capacity is calculated and then the bit error ratio (BER) vs SNR performance of the different schemes is compared with the capacity results. One main difference between Hybrid BLAST STBC and V-BLAST at the same number of transmit-receive antennas is that the earlier has more spatial diversity than the later while the later has more layers. For example, with a 4x4 MIMO system, Hybrid BLAST STBC has two layers and each layer has a transmit diversity of two. At the receiver, the first detected layer has a receive diversity of three. This is because the detector needs one antenna to null out one interfering layer and the rest provide diversity. On the other hand, V-BLAST has four layers and no transmit diversity. In addition, the first detected layer has no receive diversity because the algorithm needs three antennas to null out three interfering layers.

![SHANNON CAPACITY Vs. SNR PLOT](image1)

**Fig.5(a)**

![SHANNON CAPACITY Vs. SNR PLOT](image2)

**Fig.5(b)**

![SHANNON CAPACITY Vs. SNR PLOT](image3)

**Fig.5(c)**

Fig.5(a),5(b) and 5(c) : Shannon capacity for 1% outage vs. SNR performance of the three schemes under consideration for MIMO system.

In this section, the results obtained from evaluating the formulas for $C_{ALAMOUTI} - C_{HYBRID-BLAST}$ in section 4 are compared. This is done by generating 10,000 sample H matrices and using these two evaluate the channel capacity at different SNRs. The results are presented as 15 outage capacity – that is, the capacity exceeded for 99% of all channel realizations. The results for two receive antennas are presented in Fig.5(a). In this case it can be seen that the (4,2) Hybrid BLAST STBC scheme provides a distinct performance advantage over the (2,2) V-Blast or STBC(Alamouti) schemes at high SNRs. In part of the Fig 5(b) and 5(c) results for four receiver antennas are presented. It can be seen that at low SNR the (4,4) V-Blast and Hybrid BLAST STBC schemes achieve similar capacity results. However, at higher SNRs, (4,4) V-Blast begins to out-perform the Hybrid
BLAST STBC scheme. Both of these techniques perform better than (2, 4) STBC or V-Blast. Thus hybrid method attains superior diversity gain performance to V-BLAST and can outperform V-BLAST at spectral efficiencies of practical interest. Furthermore, at low SNRs and low outage probabilities, hybrid is more spectrally efficient depending on the increasing order of the antennas. The capacities of Hybrid BLAST STBC and V-BLAST first increase when adding more layers as expected but after a certain number of layers, a reduction in capacity occurs especially when $M_T = 2N_R$ in Hybrid BLAST STBC and when $M_T = N_R$ in V-BLAST. This is a result of receive diversity reduction caused by the nulling operation in the detection algorithms of both systems. In other words, the capacity could be maximized by selecting the best number of layers at a given SNR. As a heuristic rule inferred from the plots, if the intended region of operation is at high SNRs, set the number of layers ($K$) to $N_R - 1$. On the other hand, if the region of operation is at low and moderate SNRs, set $K$ to be equal to $N_R / 2$.

Fig 6: BER vs. SNR performance with 16 QAM modulation for different spectral efficiency.

Fig 7: BER vs. SNR performance with QPSK modulation for different spectral efficiency.

Fig 8: BER vs. SNR performance with different modulation for spectral efficiency of 4 bits/s/Hz.

Fig 9: BER vs. SNR performance with different modulation for spectral efficiency of 2 bits/s/Hz.
5. CONCLUSION

The paper has compared the unique outage capacity performances of V-BLAST, the STBC (Alamouti) and Hybrid BLAST STBC scheme. The goal is to examine the optimal performance and the spatial multiplexing and diversity tradeoffs and their relation with the detection algorithm. The results for the Shannon capacity of the three systems shows that for two receive antennas; Hybrid BLAST STBC provides the best performance. Also the results show that Hybrid BLAST STBC is more spectrally efficient at low as well as high SNR by simultaneously transmitting symbols through all transmit-antennas without introducing any structure at the transmitter to aid detection at the receiver and at low outage probabilities than VBLAST. Furthermore, since Hybrid BLAST STBC has more transmit-receive diversity, it is more power efficient but it suffers from poor power efficiency and error propagation. Using convolutionally coded modulation have also been presented for spectral efficiency of 2,4 and 8 bits/s/Hz (Fig.6 and Fig. 7) with the above architecture for different modulations(Fig 8 and Fig.9) to improve the power efficiency. The Space time coded systems jointly optimize the design of transmit-diversity, data rate and coding gain. They improve the error rate performance of the system by providing diversity. Schemes that don’t require channel estimation at the receiver are unitary space time modulation and differential space time modulation. These schemes directly modulate space time matrices that are drawn from space time constellations that satisfy certain design criteria. The decoding of these schemes increases exponentially with increasing rate or number of transmits antennas. They also show that for 2 receive antennas, Hybrid BLAST STBC similar bit error ratio performance to V-BLAST. Therefore, Hybrid BLAST STBC makes a good candidate in order to suppress and cancel interfering signals before detecting the desired signal and for low power high data rate wireless applications.

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6. REFERENCES


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