Compare The Effect of V-Blast and Turbo-Blast Using MIMO System Based on Modulation Diversity

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Abstract - Increasing capacity in wireless communications in world wide is highly in demand, driven by cellular mobile, Internet and multimedia services. The communication capacity needs cannot be met without a significant increase in communication spectral efficiency. Multiple-input and Multiple-output, or MIMO is the use multiple antennas at both the transmitter and receiver side to improve communication performance. The vertical Bell Laboratories Layered Space Time V-BLAST system proposed to achieves high spectral efficiency of min symbols per channel use by transmitting independent information symbols simultaneously through the MIMO system is equal to the product of number of transmit and receive antennas. T-BLAST is Iterative decoding system hat performance is also noticeable in Coded communication.[1]

Keywords – MIMO, V-BLAST, T-BLAST.

I. INTRODUCTION

MIMO: MIMO technology has created attracted attention in wireless communications. It increases data throughput and link range without additional bandwidth or transmit power. We can achieve this by higher spectral efficiency that means more bits per second per Hertz of bandwidth and link reliability or diversity which is reduced fading.

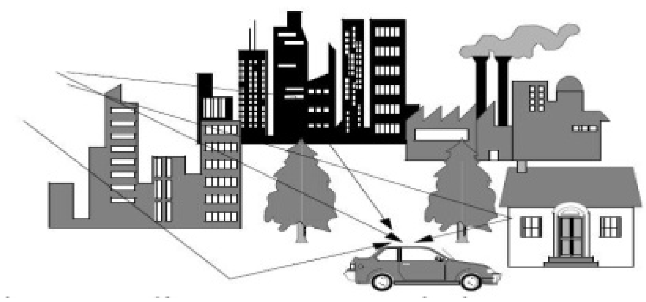

Fig 1 Multipath Propagation

MIMO is a current theme of international wireless research. The major limitation encountered when developing wireless technologies that increases capacity, so too must the spectrum and transmitting power. To reduced this problem, the use of multiple antennas at both ends has been proposed popularly known as a multiple-input-multiple-output MIMO wireless system.[1]

In wireless communication the propagation channel is characterized by multipath propagation due to scattering on different obstacles.

These obstacles produce reflected waves with attenuated amplitudes and phases. If a modulated signal is transmitted, multiple reflected waves of the transmitted signal will arrive at the receiving antenna from different directions with different propagation delays. These reflected waves are called multipath waves. Due to the different arrival angles and times, the multipath waves at the receiver site have different phases. When they are collected by the receiver antenna at any point in space, they may combine either in a constructive or a destructive way, depending on the random phases.[3]

The sum of these multipath components forms a spatially varying standing wave field. The mobile unit moving through the multipath field will receive a signal which can vary widely in amplitude and phase. When the mobile unit is stationary, the amplitude variations in the received signal are due to the movement of surrounding objects in the radio channel. The amplitude fluctuation of the received signal is called signal fading.

MIMO is an acronym that stands for Multiple Input Multiple Output. It is an antenna technology that is used both in transmission and receiver equipment for wireless radio communication. There can be various MIMO configurations. For example, a 2x2 MIMO configuration is antennas to transmit signals (from base station) and 2 antennas to receive signals (mobile terminal).[3

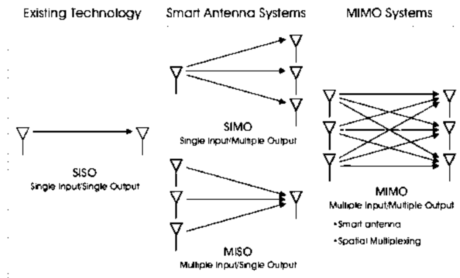

Fig 2 Multiple-Input Multiple-Output (MIMO) systems

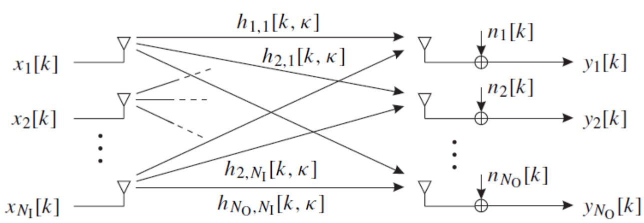

Fig 3 General structure of frequency-selective MIMO channel

As a consequence, NI signals xμ[k], 1 ≤ μ ≤ NI, form the input of our system at each time instant k and we obtain NO output signals yν [k], 1 ≤ ν ≤ NO. Each pair (μ, ν) of inputs and outputs is connected by a channel impulse response hν ,μ[k, κ] as depicted in Figure 1.15. Therefore, the ν-th output at time instant k can be expressed as,

$$y_\nu[k] = \sum_{\mu=1}^{N_I} \sum_{\kappa=0}^{L_t-1} h_{\nu,\mu}[k,\kappa] \cdot x_\mu[k-\kappa] + n_\nu[k]$$

Where Lt denotes the largest number of taps among all the contributing channels. Exploiting vector notations by comprising all the output signals yν [k] into a column vector y[k] and all the input signals xμ[k] into a column vector x[k], becomes,

$$\mathbf{y}[k] = \sum_{\kappa=0}^{L_t-1} \mathbf{H}[k,\kappa] \cdot \mathbf{x}[k-\kappa] + \mathbf{n}[k].$$

The channel matrix has the form,

$$\mathbf{H}[k,\kappa] = \begin{bmatrix} h_{1,1}[k,\kappa] & \cdots & h_{1,N_I}[k,\kappa] \\ \vdots & \ddots & \vdots \\ h_{N_O,1}[k,\kappa] & \cdots & h_{N_O,N_I}[k,\kappa] \end{bmatrix}.$$

Finally, we can combine the Lt channel matrices H[k, κ] to obtain a single matrix

H[k] = [H[k, 0] · · ·H[k,L_t − 1]].

With the new input vector,

$_xL_t$ [k] = [x[k]^T · · · x[k − Lt − 1]^T]^T

we obtain,

y[k] = **H**[k] · **x**Lt [k] + **n**[k].

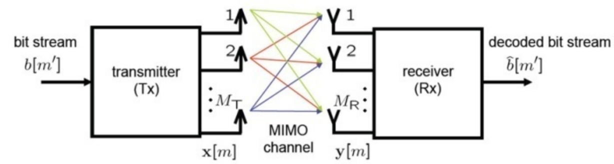

Fig 4 Matrix Channel

A transmitter sends multiple input streams by multiple transmit antennas. The transmit input streams go through a matrix channel which have multiple paths between multiple transmit antennas at the transmitter and multiple receive antennas at the receiver. Then, the receiver gets the received signal vectors by the multiple receive antennas and decodes the received signal vectors into the original information.

BLAST

BLAST Bell Labs Layered Space-Time is a multiple-antenna communication scheme. Its outage capacity in a Rayleigh fading environment grows linearly with the minimum of the number of transmits and receives antennas, with no increase in bandwidth or transmitted power. Based on its knowledge of the matrix of propagation coefficients, the receiver performs two critical operations: nulling and cancellation that in effect create independent virtual sub channels.**[2]**

The message bits to be transmitted are divided equally along with the M transmit antennas, and the modulation and coding for each transmit antenna occur separately the modulation and coding for the other transmit antennas. The message is sent at some encoded rate. Thus the scheme is characterized by an outage probability, while the actual value of the propagation matrix may not support the transmission rate. Assume that the receiver has perfect knowledge of the propagation matrix H. The receiver performs a QR factorization of the propagation matrix, and then it implements two operations: nulling and cancellation.

Types of BLAST:

I. D-BLAST

II. V-BLAST

III. T-BLAST

- Application Of Blast:

1. Wireless radio communication system.
2. Wireless internet access.

- Advantage:

1. Entire Sub Streams are Transmitted in the same frequency band**.**
2. Spectrally efficiency

2. SYSTEM MODEL

V-BLAST

Theoretical investigations have shown that the multipath wireless channel is capable of huge capacities, provided that the multipath spreading is sufficiently rich and is properly broken through the use of an appropriate processing architecture. The diagonally layered space-time architecture now known as diagonal BLAST (Bell Laboratories Layered Space-Time) or D-BLAST, is one such approach.

D-BLAST utilizes multi element antenna arrays at both transmitter and receiver and an elegant diagonally layered coding structure in which code blocks are distributed across diagonals in space-time. In an independent Rayleigh scattering environment, this processing structure leads to theoretical rates which grow linearly with the number of antennas. Assuming equal numbers of transmit and receive antennas with these rates approaching 90% of Shannon capacity. However, the diagonal approach has some drawbacks from certain implementation complexities which make it unsuitable for initial implementation.

Here, a simplified version of BLAST known as vertical BLAST or V-BLAST is described, which has been implemented in real time in the laboratory. We have demonstrated spectral efficiencies of 20 - 40 bps/Hz at average SNRs ranging from 24 to 34 dB. while these results were obtained in a relatively benign indoor environment, we believe that spectral efficiencies of this magnitude are unique, regardless of propagation environment or SNR, and are simply unachievable using traditional techniques.[4]

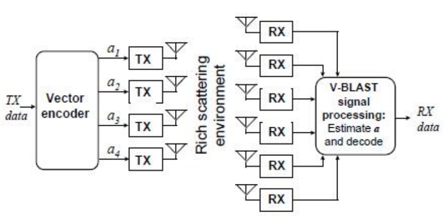

Fig 5 Architecture of V-BLAST

Vector symbol: $\mathbf{a} \equiv (a1,a2 ,a3,a4)^T$
Number of transmitters: M
Number of receivers: N
The fundamental difference between D-BLAST and VBLAST lies in the vector encoding process. In BLAST, redundancy between the subs streams is introduced through the use of specialized inters sub stream block coding. The D-BLAST code blocks are organized along diagonals in space-time. It is this coding that leads to D-BLAST's higher spectral efficiencies for a given number of transmitters and receivers. In V-BLAST, however, the vector encoding process is simply a de-multiplex operation followed by independent bit-to-symbol mapping of each sub stream.[6]

V-BLAST detection Technique:

This detection technique take a discrete-time baseband view of the detection process for a single transmitted vector symbol, assuming symbol-synchronous receiver sampling and ideal timing.

a = (a1 , a2 , . . . ,aM) T , denote the vector of transmit symbols, then the corresponding received N vector is,

r1 = Ha + ν

Where ν is a noise vector with components drawn from wide-sense fixed processes with variance σ2. One way to perform detection for this system is by using the adaptive predictable antenna array (AAA) techniques that is linear combinational nulling conceptually, each sub stream in turn is considered to be the desired signal, and the remainder are considered as "interferers". Nulling is performed by linearly weighting the received signals so as to satisfy some performance-related principle, such as minimum mean-squared error (MMSE) or zero-forcing (ZF).[6]

ZF (Zero forcing)

Zero Forcing refers to a technique of linear equalization algorithm. This is used in the world of telecommunications that involve inverse of the frequency response of a particular channel. The ZF scheme applies the inverse of the frequency response of channel to the symbol received, so that the original signal can be detected to an optimum level.

ZF is the one of the best linear receiver detection method having low computational complexity, but it suffers from unexpected noise enhancement. At high SNR, it gives optimum result. Now, the estimated result is given by:

$$\dot{X} = (H^* H)-1H^* \hat{y}$$

Where, H* represents the pseudo-inverse of H .

MMSE (Minimum Mean Square Error)

Minimum Mean Square Error (MMSE) is an estimator which follows an estimation method, through which it minimizes the mean square error for the fixed values of various dependent variables.

MMSE receiver suppresses both interference as well as noise components, but as far as the ZF receiver is concern, it only eliminates the interference or the noise. From this we can conclude that the Mean Square Error (MSE) is minimized. To overcome the disadvantage of noise enhancement of ZF, the concept of MMSE is introduced. So, we can say that, MMSE is pretentious to ZF in the existence of noise and interference. Now the Linear Minimum Mean Square Estimator for the MIMO System is.[5]

$$\hat{X} = P_d H^{\#}(H \quad ^{\#} + s_{n}^{2})^{-1}\bar{y}$$

Where,

Pd =Power of each diagonal element.

Ϭ2 =Power of noise component.

T-BLAST

T-BLAST is based on the Turbo principle, which was later generalized by the Threaded Space-Time Architecture (TST).

Forward-error-correcting (FEC) channel codes are generally used to improve the energy efficiency of wireless communication systems. On the transmitter side, an FEC encoder adds redundancy to the data in the form of parity information. Then at the receiver, a FEC decoder is able to develop the redundancy in such a way that a realistic number of channel errors can be corrected. Because more channel errors can be tolerated with than without an FEC code, coded systems can afford to operate with a lower transmit power, transmit over longer distances, tolerate more interference, use smaller antennas, and transmit at a higher data rate.[5]

there is a theoretical lower limit on the amount of energy that must be expended to convey one bit of information. This limit is called the channel capacity or Shannon Cpacity, named after Claude Shannon One of the most interesting characteristics of a turbo code is that it is not just a single code. It is, in fact, a combination of two codes that work together to achieve An energy that would not be possible by merely using one code by itself. In particular, a turbo code is formed from the parallel concatenation of two constituent codes separated by an interleaver. Each constituent code may be any type of FEC code used for conventional data communications.[4]

Encoder:

A Random Layered Space-Time (RLST) coding scheme is employed before transmission. The information bit stream is also de-multiplexed and sub streams obtained thus are independently encoded with the same block FEC, as in D-BLAST.[6]

Then the sub streams bit interleaved in space using a diagonal interleaver. Finally, the “mixed” streams are mapped to symbols and transmitted. Each symbol can have bits coming from more than one stream, and therefore a symbol error spreads the bit errors across streams, thus making the error correction easier for the block decoders. The encoder is shown in fig. The inter-stream bit interleaver is similar to the diagonal scheme in D-BLAST, but it has no space time wastage.

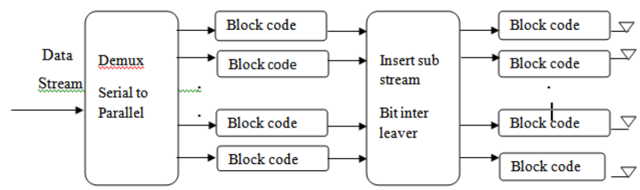

Fig.6 Turbo Blast Encoder

Decoder

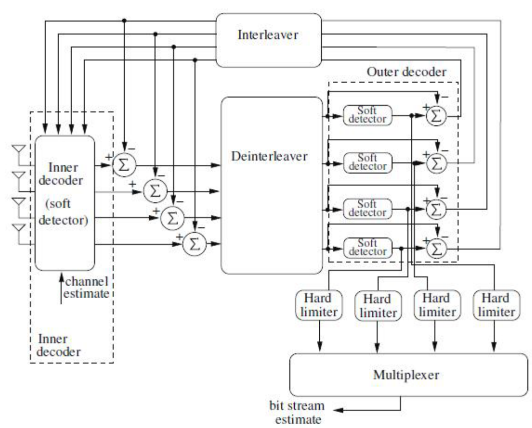

Fig 7 Turbo-BLAST iterative detection and decoding scheme

The idea is based on the interpretation of the Turbo-BLAST encoder as a group of block codes[4]

“Outer coder” connected with an “inner coder” through parallel interleavers. Thus, the inner decoder is supposed to cope with Inter Symbol Interference (ISI) coming from

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multipath fading in the channel, and the outer decoder aims to correct symbol errors occurred during the transmission over the first channel path. Both decoders output soft decisions, which are ultimately sent to hard limiters after the required iterations.[7]

The principle is to feed the output of one encoder called the outer encoder to the input of another encoder, and so on, as required. The final encoder before the channel is known as the inner encoder. The resulting composite code is clearly much more complex than any of the individual codes. However it can readily be decoded: we simply apply each of the component decoders in turn, from the inner to the outer.

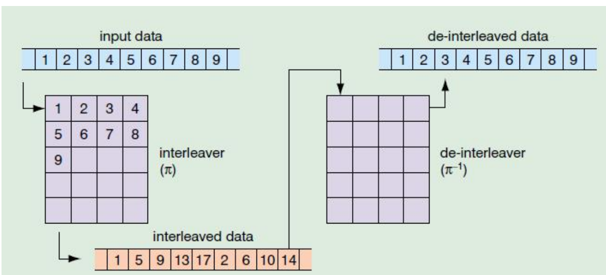


Fig 8. Operation of interleaver and de-interleaver

This simple scheme suffers from a number of encoder 1 encoder 2 encoder n outer code inner code channel decoder 1 decoder 2 decoder n. Principle of concatenated codes drawbacks, the most significant of which is called error propagation.

3. PREVIOUS WORK

Previously V-BLAST implementation Using ZF and MMSE detector is created with different modulation system. Like QAM, BPSK, 16 QAM etc.

But Comparative analysis is not implemented previously. This paper is try to find the comparison between V-BLAST and T-BLAT.

Here, V-BLAST is implemented Both the ZF -V-BLAST and MMSE-V–BLAST respect to their SNR and BER performances. In VBLAST MIMO algorithm with MMSE is proposed for the V-BLAST System which can be achieved by the Diversity.

4. PROPOSED METHODOLOGY

The vertical Bell Laboratories Layered Space Time V-BLAST system proposed to achieves high spectral efficiency of min symbols per channel use by transmitting independent information symbols simultaneously through the MIMO system is equal to the product of number of transmit and receive antennas. While different multiplexing gains up to min can be easily realized by the V-BLAST architecture, additional diversity schemes are required to achieve the maximum diversity order in V-BLAST system. Try to comparative analysis of performance of V-BLAST and T-BLAST by using modulation Diversity.

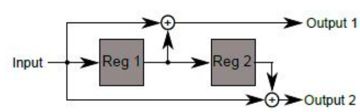
The V-BLAST detection process consist of main two operations:

1. Interference suppression (nulling): The suppression operation nulls out interference by projecting the received vector onto the null subspace (perpendicular subspace) of the subspace spanned by the interfering signals. After that, normal detection of the first symbol is performed.

2. Interference cancellation (subtraction): The role of the detected symbol is subtracted from the received vector.

Main Steps for V-BLAST detection

1. Ordering: Select the best channel.
2. Nulling: by using ZF, MMSE.
3. Slicing: Make a symbol selection
4. Cancelling: subtracting the detected symbol
5. Iteration: go for the first step to detect the next symbol.



T-BLAST Detection

Fig 9 Illustration of a convolutional encoder

$$output1[k] = input[k] + input[k-1]$$
$$output2[k] = input[k] + input[k-2]$$

the input bit is directly passed as part of the output, combined with a parity bit. Especially Turbo Codes can take advantage of this feature, since it will allow the Turbo Encoder, which consists of two rate 1/2 encoders, to be rate 1/3 instead of 1/4 due to the fact that the transmitted systematic bit can be used in both decoders with a simple use of the interleaver pattern in the decoder.

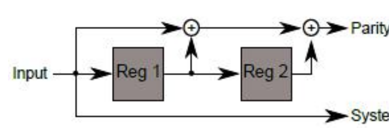


Fig 10 Illustration of a systematic convolutional encoder

systematic[k] = input[k]
parity[k] = input[k] + input[k − 1] + input[k − 2]

To a convolutional encoder a recursive part can be added, which indicates that one or more of the shift registers are connected in a feedback loop. Such an encoder is illustrated by the figure below Note that the encoder is also systematic, which is common for a recursive encoder, here by creating a RSC1 encoder, which is a main element in a Turbo encoder.

systematic[k] = input[k]

feedback[k] = input[k] + feedback[k - 2]

parity[k] = feedback[k] + feedback[k - 1] + feedback[k - 2]

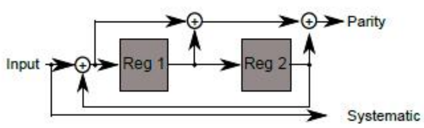


Fig 11 Illustration of a RSC encoder

Parameters when considering an RSC encoder is the constraint length k, denoted as the number of registers plus one, the rate being the input/output relation and n, which is the number of modulo 2 adders. From this, a complete convolutional encoder can be described by the use of a generator polynomial, that essentially is an array of the transfer functions from input to each output of the encoder. Thus in a RSC encoder, the first element of the array is 1, as the bit is directly passed to one output. The second element, being the recursive output, consists of a feed forward and feed backward polynomial, that govern show the interconnection is between the modulo 2 adders and the internal registers.

Turbo Decoder

Block diagram of a system employing turbo equalization Encoder and Decoder. A general architecture regarding the convolutional decoder in the receiver is illustrated by figure 3.8. A transmitted sequence is denoted by [U0 Z0 U1 Z1 ... UN−1 ZN−1], whereas the received sequence is denoted by [ri0 rp0 ri1 rp 1 ... ri N−1 rp N−1],

which is de-multiplexed into two separate sequences that feed into the decoder.

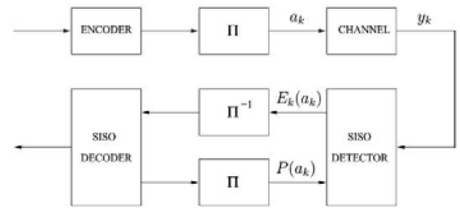


Fig 12 TURBO Decoder

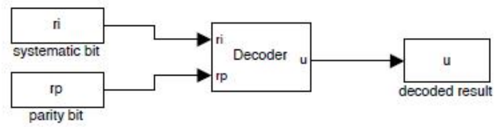


Fig 13 RSC feeds the decoder by the systematic ri and the parity bit rp

The first part of this section, describes the Viterbi algorithm which is an algorithm developed to decrease the complexity of the convolution decoding by taking advantage of the trellis diagram. The second part describes how performance can be increased by using soft decision bits in the decoding, instead of using just zeros and one.

The SISO decoder that accepts a priori information inputs to generate a soft decision output as

L(ˆuk). The soft output is a probability of a bit being the correct estimate, thus generates a probability from 0 to 1.

When considering SISO decoders, in relation to Turbo Codes two variants are essential to cover

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- The BCJR algorithm proposed by [Bahl, Cocke, Jelinek and Raviv] which requires high computational power, but for which the output is very robust and well suited for a recursive convoluter.

- The SOVA was proposed by Hagenauer and is widely used in Turbo coding as a last step. It is less robust than the BCJR but requires less computational power.

Due to less complexity BCJR algorithm can be used and here, using BLAST MIMO is to reduced Complexity.

4. SIMULATION/EXPERIMENTAL RESULTS

BLAST Simulation Result

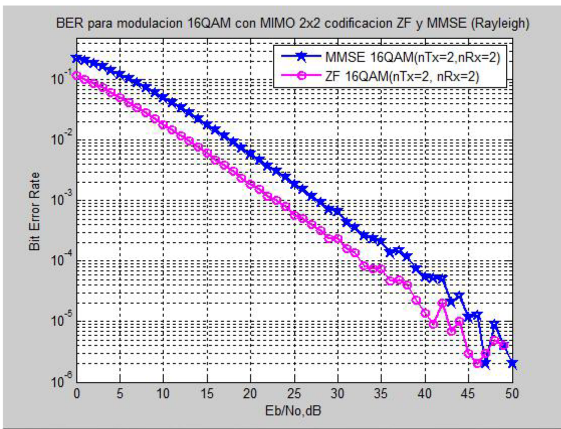

Fig 14 V-BLAST Result

Here, BER VS SNR performance is done using modulation 16QAM MIMO 2x2 antenna MTMR ZF and MMSE in Rayleigh Channel Fading.

Table-1: BER vs SNR of ZF and MMSE

SNR	ZF BER	MMSE BER (Times New Roman
5	0.062	0.1443
10	0.022	0.062
15	0.007	0.0225
20	0.002	0.0074
25	8.1X e-04	0.0023
30	2.32Xe-04	7.3Xe-04
35	7.8Xe-05	2.27Xe-04
40	2.5Xe-05	7.8Xe-05
45	6Xe-06	2Xe-05
50	5Xe-06	4X e-06

T-BLAST Simulation Result

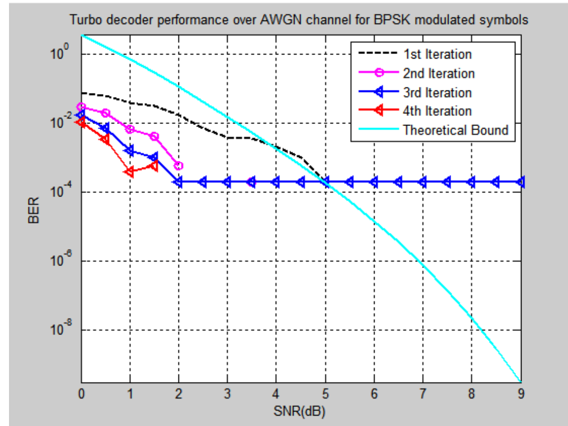

Fig 15 Turbo BLAST Result

The frame of reference is shown in figure It is also noted that for more iterations the BER decrease for the same value of Eb/N0, but the performance seems to stagnate around 4 iterations and becomes negligible. The algorithm lives up to the expectations stated. The BER of the tested algorithm is close to the expected values and from the figure in the appendix it can be seen that the data does not have a significant variation, which means that the algorithm has a high integrity.

Table-2: BER vs SNR for TBLAST

SNR	BER
1	3.45
2	0.70
3	0.11
4	0.015
5	0.0017
6	1.8 X e^{04}
7	1.04 X e^{-05}
8	7.69 X e^{-07}
9	2.2 X e^{-08}

6. CONCLUSION

According to figure 4.1 and 5.7 we can show that V-BLAST gives best BER vs SNR output but it cannot correct errors properly. While T-BLAST detect the error and correct the Error due to its Iterative process. In T-BLAST maximum Iterative process takes time. We can do maximum 10 to 11 Iterations and getting the error free outputs. T-BLAST has delay due to its Iterations so it is takes some time. But comparatively T-BLAST system is better then the V-BLAST in error free output.

6. FUTURE SCOPES

For future there is latest implementation research in process. Using MIMO we can increase the capacity of bandwidth channel. So using T-BLAST and V-BLAST system the proposal might be better now days and in future also.

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