OPTIMIZATION OF V-BLAST AND C-BLAST USING GENETIC ALGORITHM

Dissertation submitted in the partial fulfilment of requirement for the award of degree of

Master of Engineering
in
Wireless Communication

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DECLARATION

I, hereby declare that the dissertation entitled **"Optimization of V- BLAST and C-BLAST Using Genetic Algorithm"** is an authentic record of my study carried out as requirement for the award of degree of M.E. (Wireless Communication Engineering) at Thapar University, Patiala, under the supervision of **Dr. Sanjay Sharma**, Head of the Department, Professor, Electronics and Communication Engineering Department. The matter presented in this dissertation has not been submitted in any other University/ Institute for the award of any other degree.

Date: 18·7·2014

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It is certified that the above statement made by the student is correct to the best of my knowledge and belief.

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ABSTRACT

Multiple Input Multiple Output (MIMO) systems have been extensively studied in the context of wireless communications, promising both increased capacity and link level reliability. MIMO systems uses an array of transmit and receive antennas for enormous gains in spectral efficiency by exploiting a rich multipath fading environment.

Following the proposal by Foschini at Bell Labs, a family of architectures emerged for systems employing multiple antenna arrays at transmit and receive end, collectively known as Bell Labs Layered Space-Time (BLAST) architectures. BLAST (Bell Labs Layered Space-Time) is a multiple antenna communication scheme to improve the performance of wireless communication by increasing data rate. This dissertation gives a proposed method to increase the throughput by 10% if we use the combination of V-BLAST and C-BLAST. This dissertation reviews the essential aspects of two of the best known members of the family, namely C-BLAST, V-BLAST. V-BLAST improves the performance at the cost of increased computational complexity. In V-BLAST, instead of jointly detecting all the transmit signals, the detection is done iteratively. At each symbol time, for each subcarrier, it first detects the strongest layer (depending on the channel matrix) and then cancels the effect of this strongest layer from each of the received signals, considered as interference. The detection continues with the strongest remaining layer, and so on.

An extension of the open-loop V-BLAST transmission structure referred to as the closed-loop V-BLAST. The closed-loop V-BLAST differs from the open-loop V-BLAST in respect that there exists a feedback channel that enables the receiver to send to the transmitter the optimized transmit adaptation based on the instantaneous channel realization, which is assumed to be perfectly known at the receiver.

Further, improvement can be done in the performance characteristics like bit error rate , SNR and power allocation for V-BLAST and C-BLAST by using genetic algorithms which based upon creation of top point in the population which reaches an optimum solution by creating a population of points at every iteration. So if genetic algorithm is used, throughput increases and bit error rate decreases. On the other hand if genetic algorithm is not used in combination with V- BLAST then throughput will decrease and

bit error rate will go high. Finally, discussion of results has been explained in end of the dissertation.

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LIST OF ABBREVATIONS

MATLAB	Matrix Laboratory
BLAST	Bell Laboratories Layered Space-Time
MIMO	Multiple Input Multiple Output
HSDPA	High Speed Downlink Packet Access
UMTS	Universal Mobile Telecommunications System
WCDMA	Wideband Code Division Multiple Access
STC	Space Time Coding
CDMA	Code Division Multiple Access
SISO	Single-Input Single-Output
PDA	Personal Digital Assistant
ZF	Zero Forcing
MMSE	Minimum Mean Square Error
SNR	Signal To Noise Ratio
GA	Genetic Algorithm
VBLAST	Vertical Bell Labs Layered Space Time
CBLAST	Closed-Loop Vertical Bell Labs Layered Space Time
D-BLAST	Diagonal Bell-Labs Layered Space-Time BLAST
LINPACK	Linear System Package
EISPACK	Eigen System Package
STBC	Space Time Block Coding
HR	Hybrid Receiver

ISI	Inter Symbol Interference
BER	Bit Error Rate
SIC	Successive Interference Cancellation
MRC	Maximal Ratio Combining
ML	Maximum Likelihood
AWGN	Additive White Gaussian Noise
LDPC	Low Density Parity Check

CHAPTER 1: INTRODUCTION

1.1 EXISTING WIRELESS SYSTEM

With the increase use of wireless communication there is a need for more bandwidth and error free communication. The utilization of multiple antennas at both closures of a wireless link transmitting information over the identical bandwidth assurances noteworthy improvements in spectral efficiency and link reliability without requirement for increasing the power or expanding bandwidth. This innovation is called as Multiple-Input Multiple-Output (MIMO) system, as one for consumption of High Speed Downlink Packet Access (HSDPA) protocol past the third generation (3G) of mobile system. Physical constraints of the wireless medium give a technical dare for dependable wireless communication. Methods that enhance spectral efficiency and overcome different channel deteriorations as in signal fading and interference have brought a vast benefaction to the development of the wireless communication. Also, the requirement for high speed wireless Internet access has induced need for technologies conveying higher capacities and link reliability than that accomplished by present systems.

For third generation (3G) Universal Mobile Telecommunications System (UMTS) networks form on Wideband Code Division Multiple Access (WCDMA), the High Speed Downlink Packet Access (HSDPA) is constantly acquainted with take care of this demand and enhances spectral efficiency. Multiple Input Multiple output combined with HSDPA is capable of attaining either of larger capacities and link dependability.

The capacity gain and link dependability of MIMO systems could be maximized under the presumption that channels between sets of transmit and receive antennas are individualistic of each other. This independency between channels emerges because of multipath linking source and destination [1, 2]. Liberty of channels likewise tells that the receiver will possess more than one separate duplicate of the transmitted signal. This phenomenon is called as “diversity” is used by Space Time Coding (STC) to give reliable communication.

1.2 CHANNELS IN WIRELESS COMMUNICATION

Wireless communication channel is logical connection over a medium such as air that connects data source to data sink. There are many different paths between the transmitter and the receiver results in receiving different versions of the transmitted signal at the receiver. These separate versions experience different path loss and phases. To depict such channel model, different possible paths for the received signals are needed to study. If there is a direct path between the transmitter and the receiver, it is called the line of sight (LOS). A LOS is not the only path that an electromagnetic wave can take from a transmitter to a receiver. An electromagnetic wave may reflect when it meets an object that is much larger than the wavelength. Through reflection from many surfaces, there are different paths resulting in power strengths and phases other than those of the LOS path. Another way that electromagnetic waves propagate is diffraction. Diffraction occurs when the electromagnetic wave hits a surface with irregularities like sharp edges. Finally, scattering also occurs where there are a large number of objects smaller than the wavelength between the transmitter and the receiver. This result in scattering of wave and many copies of the wave propagate in many different directions. There are also other phenomenon's that affect the propagation of electromagnetic waves like absorption and refraction.

Power of the received signal reduces in different ways because of these propagation mechanisms. There are two general aspects of such a power reduction that require separate treatments. One aspect is the large-scale effect which corresponds to the characterization of the signal power over large distances or the time-average behaviors of the signal. This is called attenuation or path loss and sometimes large-scale fading. The other aspect is the small-scale fading, or just fading which corresponds to the characterization of the signal over short distances or short time intervals. In the next sections, explanation of model of behavior of large-scale and small-scale fading is illustrated.

1.3 ATTENUATION

Attenuation is caused by many factors including propagation losses, antenna losses, and filter losses. The average received signal, or the large-scale fading factor, decreases logarithmically with distance. The logarithm factor, or the path gain exponent, depends on the propagation medium and the environment between the transmitter and the receiver. For example, for a free space environment, like that of satellite communications, the exponent is two. In other words, the average received power P_R is proportional to d^{-2}, where d is the distance between the transmitter and the receiver. For other propagation environments, like urban areas, the path loss exponent is usually greater than 2. In other words, if the average transmitted power is $\mathrm{P_T}$, average received power given by [10]

$$\mathrm{P_R} = \beta d^{-\nu} \mathrm{P_T} \tag{1.1}$$

Here ν is the path loss exponent and β is a parameter that depends on the frequency and other factors. This is sometimes also called the log-distance path loss model as the path loss and the distance have a logarithmic relationship.

1.4 RAYLEIGH FADING CHANNEL

Fading is caused by interference between two or more versions of the transmitted signal which arrive at the receiver at slightly different times. These signals, called multipath waves, combine at the receiver. The randomness of multipath effects and fading results in the use of different statistical arguments to model the wireless channel. Therefore, statistical models are needed to investigate the behavior of the amplitude and power of the received signal. Narrowband systems are considered, in which the bandwidth of the transmitted signal is smaller than the channel’s coherence bandwidth, which is defined as the frequency range over which channel fading process is correlated. This type of fading is called as flat fading or frequency non-selective fading. For this Rayleigh distribution is commonly used to describe the statistically time-varying nature of the received envelope of a flat fading channel. For a typical mobile wireless channel in indoor and urban areas, it is assumed that the direct line of sight is obstructed and the receiver obtains only reflected waves from the surrounding objects. The probability density function of the Rayleigh distribution is given by [10].

$$\mathrm{P(r)} = \begin{cases} \frac{r}{\sigma^2}\, e^{-\frac{r^2}{2\sigma^2}} & r \geq 0 \\ 0 & r < 0 \end{cases} \tag{1.2}$$

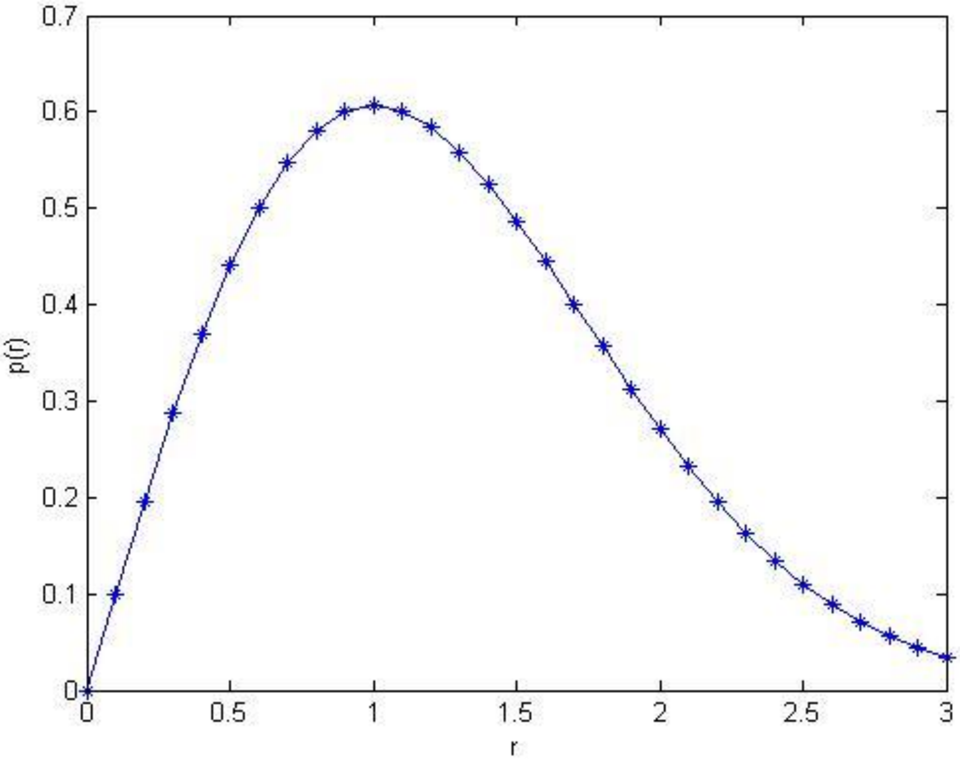

Figure 1.1: Rayleigh Distribution with σ= 1.

1.5 DIVERSITY

Fading makes it extremely difficult for the receiver to recover the transmitted signal unless the receiver is provided with some form of diversity, i.e. replicas of the same transmitted signal with uncorrelated attenuation. In fact, diversity combining technology has been one of the most important contributors to reliable wireless communications. Ways to achieve diversity include:

(i) *Temporal Diversity*: In this scheme, channel coding in conjunction with time interleaving is used. Thus replicas of the transmitted signal are provided to the receiver in the form of redundancy in the temporal domain. However, in slow fading channels, temporal diversity is not an option for delay-sensitive applications.

(ii) *Frequency Diversity*: In this scheme, the fact that signals that are transmitted on different frequencies tend to experience different fading effects is exploited. Thus replicas of the transmitted signal are provided to the receiver in the form of redundancy in the frequency domain. However, this scheme is not bandwidth-efficient.

(iii) *Spatial Diversity*: In this scheme, spatially separated antennas are used to provide diversity in the spatial domain. Diversity combining technique is then used to select or combine the signals that have been transmitted or received on different antennas.

Spatial diversity is attractive as diversity can be obtained with no penalty in bandwidth efficiency. It can be implemented by deploying multiple antennas at the transmitter and/or the receiver. Depending on the location of the antennas, wireless communication system employing spatial diversity can be classified into the following three configurations. *Single Input Multiple Output (SIMO):* When there are single transmit antenna but multiple receive antennas, i.e. receive diversity. *Multiple Input Single Output (MISO):* When there are multiple transmit antennas but one receive antenna, i.e. transmit diversity. *Multiple Input Multiple Output (MIMO):* When there are multiple transmit antennas and multiple receive antennas, i.e. both transmit and receive diversity are used. Besides providing spatial diversity, it has been shown that the capacity of a wireless channel grows linearly with the number of transmit and receive antennas, hence a MIMO system can be used to boost the capacity of wireless channel too.

1.6 SIGNAL MODEL FOR MIMO SYSTEM

MIMO systems utilizes an arrangement of transmit and receive antennas for enormous gains in spectral efficiency by using a rich and abundant multipath fading environment. The systems part a single user's data stream into various sub-streams and utilize an array of transmit antennas for at the same time transmit the streams within the same frequency band utilizing various codes. At the receiver, an array of antennas gets the various transmitted sub streams. Utilizing the MIMO method, the rate of transmission is expanded in extent to the number of antennas utilized to transmit the signal.Consider a wireless communication system with two users. One is the transmitter and the other is the receiver. The transmitter has T transmit antennas and the receiver has R receive antennas as illustrated in Figure 1.2. There exists a wireless channel between each pair of transmit and receive antennas. The channel between the t-th transmit antenna and the r-th receive antenna can be represented by the random propagation coefficient h_{tr}, which are

Rayleigh distributed.

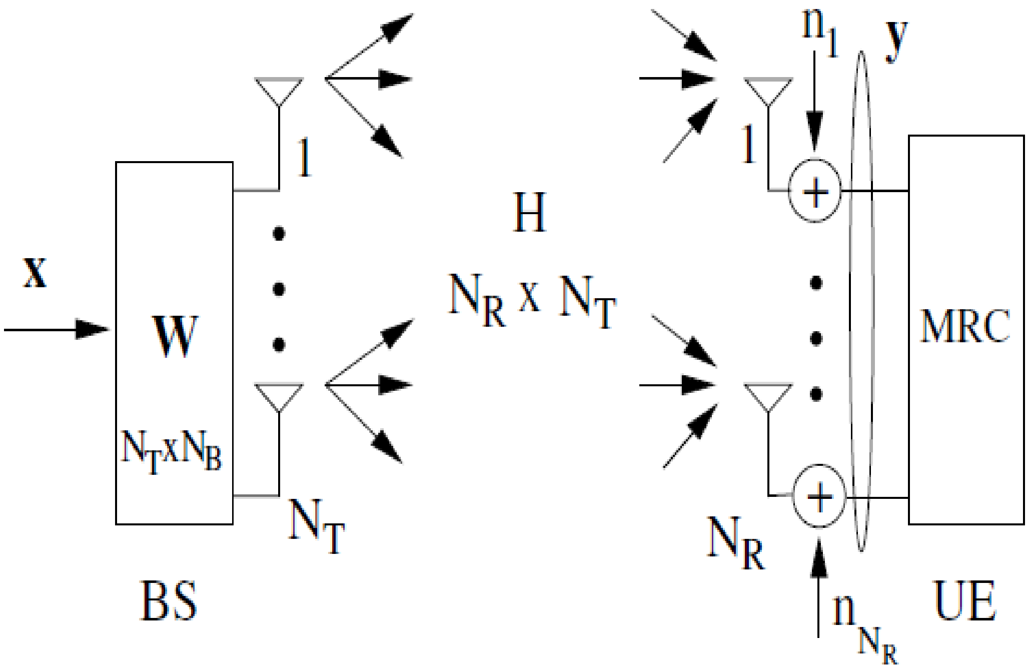

Figure1.2: Multiple antennas communication system.

To send information to the receiver, at every transmission time, the transmitter feeds signals (S_1, S_2….., S_T) to its *T* transmits antennas respectively. The antennas then send the signals simultaneously to the receiver. Every receive antenna at the receiver obtains a signal that is a superposition of the signals from every transmit antenna through the fading coefficient. The received signal is also corrupted by noise. If the noise at the r-th receive antenna is denoted by N_r, the received signal at the r-th receive antenna is

$$x_r = \sum_{t=1}^{T} h_{tr} S_t + n \tag{1.3}$$

In vector form, above equation is represented as

$$\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_R \end{bmatrix} = \begin{bmatrix} h_{1,1} & h_{1,2} & .. & h_{1,R} \\ h_{2,1} & h_{2,2} & .. & h_{2,R} \\ \vdots & \vdots & .. & \vdots \\ h_{T,1} & h_{T,2} & .. & h_{T,R} \end{bmatrix} \begin{bmatrix} S_1 \\ S_2 \\ \vdots \\ S_M \end{bmatrix} + \begin{bmatrix} n_1 \\ n_2 \\ \vdots \\ n_R \end{bmatrix} \tag{1.4}$$

So, system equation can be written as, x = HS + n

1.7 MOTIVATION

The addition of multiple antennas at the transmitter and the receiver combined with advanced signal processing algorithms yields significant advantage over traditional smart antenna systems - both in terms of capacity and diversity advantages. In 1996, Raleigh, Cioffi and Foschini presented new methods for increasing the efficiency of MIMO systems, which motivated various more contributions for two acceptable architectures for its realization known as Vertical Bell Laboratories Layered Space Time (V-BLAST) and Diagonal Bell Laboratories Layered Space Time BLAST (D-BLAST) algorithm, which have an ability of getting a substantial part of the MIMO capacity. The Vertical Bell-Labs Layered Space-Time can be used with different kinds of detection algorithms such as ZF, LLSE, LLSE/MAP and other new methods. Therefore, MIMO systems for different architecture can be significantly improved using the principle of iterative.

1.8 OBJECTIVES

This thesis encompasses a set of objectives that is associated with a set of objectives that is associated with milestone of this process. The objectives are mentioned below.

1. To implement the V-BLAST algorithm.
2. To implement the C-BLAST algorithm.
3. Then problem of V-BLAST algorithm is solved by optimize it with genetic algorithm.
4. To evaluate the performance when only V-BLAST is applied.
5. To evaluate the performance when both V-BLAST and Genetic Algorithm is combined.
6. To evaluate the performance on the basis of throughput and bit error rate.

1.9 TOOLS USED

The full form of MATLAB is Matrix Laboratory. MATLAB was written originally to give easy access to matrix software made by the LINPACK (linear system package) and EISPACK (Eigen system package) methods. MATLAB is a highly capable language for specialized technical calculations. It combines calculation, visualization, and programming environment. Moreover, MATLAB is a new programming language domain: it has refined data structures, having inbuilt editing and debugging tools, and aid to object-oriented programming. These aspects make MATLAB an outstanding tool for education and research. MATLAB has many benefits compared to normally used computer languages (e.g., C, FORTRAN) for computing technical calculations. MATLAB is a collective system in which the fundamental data element is an array which does not need dimensioning. The software package has been commercially accessible since 1984 and is now used as a basic tool at most universities and industries worldwide. It contains strong inbuilt routines that allow a very large variety of calculations. It also has easy utilization of graphics commands that make the visualization of answers instantly available. Specification applications are gathered in packages known as toolbox. There are toolboxes on signal processing, symbolic computation, control theory, simulation, and optimization.

After logging into your account, you can gain access to MATLAB by double-clicking on the MATLAB shortcut icon (MATLAB 7.0.4) on your Windows desktop. When you begin MATLAB, a notable window called the MATLAB desktop appears. The desktop is a window that holds other windows. The major tools within or available from the desktop are:

- The Command Window
- The Command History
- Workspace
- The Current directory
- Help browser
- Start button

1.10 ORGANISATION OF DISSERTATION

This dissertation consists of 6 chapters including the introduction. The concept of usage of V-BLAST and C-BLAST in MIMO systems has been discussed.

Chapter 2 gives Literature review, in this chapter the study on layered architectures namely V-BLAST and C-BLAST which come under BLAST architectures are discussed. The concept of genetic algorithm has also been discussed.

Chapter 3 provides methodology on V-BLAST and C-BLAST which has been discussed systematically.

Chapter 4 apply genetic algorithm in V-BLAST and C-BLAST architecture to improve their performance.

Chapter 5 highlights results and analysis of graphs.

Chapter 6 gives conclusion and future scope.

CHAPTER 2: LITERATURE SURVEY

E. Telatar *et al.* [1] investigated the use of multi-antennas at both ends of a point-to-point communication system over the additive Gaussian channel. We have considered a system with t transmit antennas and r receive antennas in which the received vector $v \in C^{\tau}$ depends on the transmitted vector $u \in C^{\tau}$ via: $v = H u + w$ where $H \in C^{r \times t}$ is the channel transfer matrix and w is zero-mean complex circular symmetric Gaussian noise. We assume that $E [ww] = \sigma^2 I_r$. The transmitter is constrained in its total power, i.e., $E [uu] \leqslant E_s$. We assume that the channel matrix H is known at both ends of the communication system, and that the waveform channel is flat over the bandwidth of interest.

G. Foschini *et al.* [2] considered a multi-element antenna system that utilizes M and N transmit and receive antennas [an (M, N) wireless link] weakened by additive white Gaussian noise in a quasi-static flat-fading channel environment. The transmitter linked to a power constraint, doesn’t know the random result of the matrix channel but knows the channel characteristics. The link works with a probability of outage constraint. Proposed is a novel architecture utilizing stratified space-time diagonals showing a message for an efficient and better communication. The special message setting which is named as stratified-diagonal BLAST (SD-BLAST), allows receiver signal processing that considerably mutes self- interference caused due to multipath without having loss of space-time. Investigated the proposed communication formation in important downlink categories, revealing that, in theory, the message architecture is optimum and logical for all (M, 1) systems and very efficient when M >>N. We calculate the capacity performance of SD-BLAST utilizing empirically created complementary cumulative distribution functions (CCDFs) for (16, 5), (8, 3), and (4, 2) systems to get near optimal performance most especially for the (16, 5) system.

P. Wolniansky *et al.* [4] presented a description of a wireless communication architecture known 11s vertical BLAST (Bell Laboratories Layered Space- Time) or V-BLAST, which has been implemented in real time in the laboratory. Using our laboratory prototype, we have demonstrated spectral efficiencies of 20 - 40 bps/Hz in an indoor propagation environment at realistic SNRs and error rates. To the best of our knowledge, wireless spectral efficiencies of this magnitude are unprecedented, and are furthermore unattainable using traditional techniques.

W. K. Wai *et al.* [5] presented a replacement for the optimal decoding order by a suboptimal one and the utilization of Gram-Schmitt Orthogonalization (GSO) to substitute the computation of pseudo-inverse in finding the weight vectors. The V-BLAST architecture has been proposed as an extremely spectral efficient tool for wireless communications. However, owing to the intensive computation involved, it may be difficult to implement this architecture for high data rate communication system.. These modifications significantly reduce the total number of arithmetic operations required to obtain the weight vectors and the decoding order in V-BLAST with virtually no performance degradation. In slowly time-varying fading channels, the presented method can further reduce the amount of computation required by exploiting the time correlation between the channel gains.

J. Benesty *et al.* [6] presented a very elementary and efficient algorithm that lessens the complexity by a factor of M. Bell Labs layered space-time (BLAST) wireless systems are multiple-antenna communication schemes that can attain very high spectral efficiencies in scattering environments with no raise in bandwidth or transmitted power. The most famous and, by far, the most feasible architecture is the so-called Vertical BLAST (V-BLAST). The signal detection algorithm of a V-BLAST system is commutatively very thorough. If the number of transmitters is M and is same as the number of receivers, this complexity is equivalent to M^4 at each sample time.

Z. Luo *et al.* [7] gave a novel quick recursive minimum mean square error successive interference cancellation (MMSE-SIC) algorithm with optimal detection sequence for vertical Bell Labs layered space-time (V-BLAST) systems. In this algorithm, the MMSE alter matrices and the optimal detection sequence are successively calculated from the previously taken filter matrices according to elementary recursive pseudo inverse formulas, so that the algorithmic complexity is decreased significantly, especially for the active number of transmit/receive antennas.

J. Chen *et al.* [8] presented a reduced complexity algorithm for detecting such architecture with respect to the minimum mean square error (MMSE) criteria as theoretical and experimental studies had shown that layered space-time architectures like the Vertical Bell laboratories layered space-time (V-BLAST) system can use the capacity benefit of multiple antenna systems in rich-scattering environments.. This algorithm bases on the conventional successive interference cancellation (SIC) detection algorithm, but selects several layers with sufficiently large signal to interference plus noise ratio (SINRs) instead of the layer with largest SINR at each stage of successive cancellation, and utilizes the Gram-Schmitt orthogonalization (GSO) to substitute the computation of pseudo-inverse in finding the weight vectors. Therefore the computational complexity of the proposed detection algorithm is significantly reduced but the performance degradation is little.

B. Hassibi *et al.* [9] presented a Bell Laboratories Layered Space-Time (BLAST) that is a scheme for sending information over a rich-scattering wireless environment utilizing multiple receive and transmit antennas. The principal computational bottleneck in the BLAST algorithm is a “nulling and cancellation” advance, where the optimal sequencing for the sequential estimation and detection of the received signals is set. To decrease the computational cost of BLAST, we make an efficient square-root algorithm for the nulling and cancellation advance. The main features of the algorithm contain efficiency: the computational cost is decreased by 0.7 M, where M is the number of transmit antennas, and numerical stability: the algorithm is division less and utilizes only orthogonal transformations. In a 14-antenna system developed for transmission of 1 Mbit/s over a 30 kHz channel, the nulling and cancellation computation is decreased from 190 MFlops/s to 19 MFlops/s, with the over-all computations being decreased from 220 MFlops/s to 49 MFlops/s. The numerical stability of the algorithm also makes it appealing for implementation in fixed-point (preferable than floating-point) architectures.

D. Wubben *et al.* [10] designed Layered space-time codes to use the capacity benefits of multiple antenna systems in Rayleigh fading environments. A new more efficient decoding algorithm based on QR decomposition is proposed, which needs only a fractional part of computational effort as compared to the normally used decoding algorithm needing the multiple calculations of the pseudo inverse of the channel matrix.

R. Bohnke *et al.* [11] presented a new more efficient algorithm for finding such architectures w.r.t the MMSE criterion. Theoretical and experimental studies have given that the layered space-time architectures like the BLAST system can use the capacity benefits of multiple antenna systems in rich-scattering environments. This algorithm uses a sorted out QR decaying of the channel matrix and takes to a simple and easy successive detection structure. The algorithm needs only a fractional part of computational work as compared to the normally used V-BLAST algorithm and gets the same bit error performance.

S.Loyka *et al.* [14] presented a new geometrical perspective of the V-BLAST and tells a bit of its properties in a entire and rigorous form, comprising a statistical examination of post-processing signal-to-noise ratios for a $2 \times n$ system (where n is the number of receive antennas). A geometrically built analytical approach to the performance examination of the V-BLAST algorithm has been proposed in this paper, which is built on the analytical model of the Gramm–Schmidt process.. Closed-form analytical expressions of the vector signal at ith processing step and its power are proposed. A rigorous evidence that the diversity order at ith step (without optimal ordering) is ($n - m + i$) is given (where m is the number of transmit antennas). It is shown that the optimal ordering is built on the minimum correlation criterion and that the after-processing signal power is given by the channel correlation matrices in a fashion same as to the channel capacity. Closed-form analytical expressions are found for outage probabilities and average BER of a $2\times n$ system. The result of the optimal ordering is shown to be to grow the first step SNR by 3 dB (rather than to grow the diversity order as one might intuitively anticipate built on the selection combining argument) and to grow the second step outage probability twice.

Y. Jiang *et al.* [15] presented an asymptotic investigation of the V-BLAST scheme at large signal-to-noise ratio (SNR) region. Considered a point-to-point MIMO communications over Rayleigh flat fading channel with n transmitting antennas and m receiving antennas. Both the zero-forcing V-BLAST (ZF-V-BLAST) and minimum mean-squared-error V-BLAST (MMSE-V-BLAST) are examined with respect to their diversity gains and BER values. We find that the diversity gain of V-BLAST, including ZF-V-BLAST and MMSE-V-BLAST, with optimal ordering is m - n + 1, i.e. using the optimal ordering technique does not enhance the diversity gain. Contrary to the normal perception that the MMSE and ZF estimators have asymptotically similar post-processing SNR for large input SNR, we find that the distinction between the post-processing SNRs of the two estimators does not disappear for large SNR. We also quantify the extraordinary BER performance benefit of the MMSE-V-BLAST over the ZF-V-BLAST for large SNR.

R. Xu *et al.* [18] analyzed the performance operation of the V-BLAST multi-input multi-output systems with two transmit antennas. Based on the characteristics of Wishart matrices, obtaining the precise SNR distributions is done in the first and second detection steps when optimal detection ordering is utilized. Closed-form analytical expressions for the bit error rates are then depicted. The effect of optimal ordering on the diversity order and SNR is found. The results are evaluated to be consistent with those published previously by all the other researchers.

S. H. Nam *et al.* [20] presented a modification of Vertical Bell Labs Layered Space–Time (V-BLAST), and proposed a successful transmit power allocation (TPA) scheme for the modified system. The given TPA scheme reduces the un-coded bit-error rate (BER) averaged over all detection phases and needs less feedback overhead. Simulation answers depict that the modified V-BLAST system with the presented TPA scheme gives a significant decrease in the un-coded BER as compared with the conventional V-BLAST system. When the minimum mean-square error nulling is used, the modified V-BLAST system is found to achieve the un-coded BER performance compared to that of the maximum-likelihood detection for the conventional V-BLAST architecture.

N. Wang *et al.* [21] developed a modified AMBER algorithm that reduces error propagation in interference cancellation. Pre-coding for multiple-input multiple-output (MIMO) spatial multiplexing generally needs large feedback overhead and/or large-complexity processing. Simultaneous decrease in transmitter complexity and feedback overhead is presented by giving a diagonal structural constraint to pre-coding, i.e., power allocation. Minimum bit-error rate (MBER) is used as the enhancement criterion, and an near approximate MBER (AMBER) power-allocation algorithm is presented for a variety of receivers, comprising zero-forcing (ZF), successive interference cancellation (SIC), and ordered SIC (OSIC). While previously presented pre-coding schemes either need ZF equalization for MBER, or utilize a minimum mean-squared error (MMSE) criterion, we give a unified MBER answer to power allocation for ZF, SIC, and OSIC receiver structures. Enhanced error-rate performance is given both analytically and by simulation. Simulation results also indicate that SIC and OSIC with AMBER power allocation give superior performance over earlier proposed MBER pre-coding with ZF equalization, as well as over MMSE pre-coding/decoding. Performance under noisy channels and power feedback is analyzed.. Compared with now existing pre-coding methods, the presented schemes significantly decrease both transmit processing complexity and feedback overhead and enhance error-rate performance.

V. Kostina *et al.* [24] developed an analytical framework for performance analysis and optimization of coded V-BLAST. Average power and/or rate allocations to minimize the outage probability as well as their robustness and dual problems are investigated. Compact, closed-form expressions for the optimum allocations and corresponding system performance are given. The uniform power allocation is shown to be near optimum in the low outage regime in combination with the optimum rate allocation. The average rate allocation provides the largest performance improvement (extra diversity gain), and the average power allocation offers a modest SNR gain limited by the number of transmit antennas but does not increase the diversity gain. The dual problems are shown to have the same solutions as the primal ones. All these allocation strategies are shown to be robust. The reported results also apply to coded multiuser detection and channel equalization systems relying on successive interference cancelation.

R. Narasimhan *et al.* [27] presented expressions that are given for the symbol error rate (SER) of the Vertical Bell Labs Layered Space–Time (V-BLAST) system, taking into account error propagation because of channel-estimation errors. In addition to error propagation, suboptimal sub-stream ordering because of imperfect channel estimates is accounted for. First, the conditional SER is given using the distribution of the signal-to-interference-plus-noise ratio in each sub-stream, used on the channel estimate. Then, the average SER as a characteristic of the channel estimation error-to-signal ratio (ESR) is upper leaped by averaging over the distribution of the channel estimates. The upper leap on the SER is tighter than previous leaps in the literature. Comparisons with same simulations demonstrate the accuracy of the SER expressions for a high range of ESRs.

W. Chen *et al.* [31] presented a mobile robot-based virtual V-BLAST cooperative MIMO transmission scheme and an efficient approximately close maximum likelihood (ML) detection algorithm, aims at the requirements of large-speed data transmission and less energy consumption in energy constrained Wireless Sensor Networks (WSNs). Mobility of robot can decrease the communication distance between the sensor nodes, MIMO-based WSNs can utilize its diversity gain to reduce fading effects and can also use its multiplexing gain to improve the data transmission rate. As for the detection algorithm in mobile robot based virtual V-BLAST transmission scheme, joined with traditional decoding OSIC algorithm, the vectors have to be detected in approximate ML algorithm are decreased. Mobile robot can receive by its own multi-antenna or utilizing collaborative nodes, and the energy efficiency analysis of the two cases are all debated. Simulation results give that the presented scheme effectively decreases network energy consumption, and the efficient approximate ML detection algorithm further enhances energy-efficiency.

H.J. Lee *et al.* [32] analysed some mathematical properties of ergodic capacity and outage capacity functions of the layers in Bell labs layered space-time (BLAST) architectures employing successive decoding and interference cancellation. We then present statistical rate allocation and power allocation methods that optimize the asymptotic performance of BLAST architectures. Since the methods are developed by using ergodic capacity and outage capacity functions of the layers, the allocated rates and powers depend only on a given channel statistic. Finally, we prove that the rate allocation yields a better asymptotic performance than the power allocation. Numerical results show that BLAST architectures with the rate and power allocation perform better by 4 dB and 3 dB, respectively, than a BLAST architecture with the same rate and power in all layers.

R. Zhang *et al.* [33] studied the capacity-approaching transmission schemes for the multiple-input multiple-output orthogonal frequency-division multiplexing (MIMO-OFDM) channel, taking the assumption that the channel state information (CSI) is completely known at the receiver but only partially available at the transmitter via a limited-rate feedback channel. A vertical Bell Laboratories layered space-time (V-BLAST)-based transmission structure is considered, where multiple data streams are independently encoded at the transmitter (i.e., horizontal encoding) and successively decoded at the receiver by the zero-forcing-based generalized decision feedback equalizer. A closed-loop V-BLAST extension is presented whereby transmit powers, rates, and antenna mappings for multiple data streams at different OFDM tones are jointly optimized at the receiver and then returned to the transmitter via the feedback channel. Two low-complexity algorithms for optimization of feedback parameters are proposed: one is based on the Lagrange dual-decomposition method and the other is a greedy algorithm. Antenna and tone grouping techniques by exploiting the MIMO-OFDM channel space-frequency correlations are also proposed to reduce the feedback complexity. Simulation results show that by only a moderate amount of feedback, the proposed closed-loop V-BLAST scheme improves substantially the throughput of the conventional open-loop V-BLAST scheme without feedback and, furthermore, approaches closely the MIMO-OFDM channel capacity achievable by the eigenmode transmission that requires the complete CSI at the transmitter.

J. Hu *et al.* [34] presented a belief propagation (BP) based detection algorithms for Bell laboratories layered space-time (BLAST) architectures. First developed a full complexity BP algorithm, and give that the detector gets a near optimal performance even when the number of receive antennas is less than the number of transmit antennas. We also have three different extensions that give a good complexity/performance trade off. Being soft-input-soft-output in nature, we also argue that the presented detectors can be suited for use in turbo processing which can further improve the system performance when there is an outer code. In addition to the simulation results, we also study the convergence behaviour of the presented detectors by using the measure of average mutual information.

E. Biglieri *et al.* [35] introduced a coding/decoding scheme matched to a vertical-BLAST architecture; a code has its words evenly distributed among the transmit antennas. The sub-codes so transmitted by each antenna are decoded in steps to leave the spatial interference while a final decoding step is done on the whole code. We also check the behaviour of zero-forcing (ZF) and minimum-mean square error (MMSE) BLAST by comparing their error probabilities with those coming from optimum, i.e., maximum-likelihood (ML), processing. Since, with vertical BLAST, ordering of the columns of the channel-gain matrix is important, we also learn the performance of algorithms intended to detect an optimal (or mildly suboptimal) ordering.

M. Sellathurai *et al.* [36] studied about TURBO-BLAST. It is a novel multi transmit multi receive (MTMR) antenna scheme for high-throughput wireless communications. It uses the following ideas: the Bell Laboratories layered space time (BLAST) architecture; random layered space-time (RLST) coding scheme by utilizing independent block codes and random space-time interleaving; sub-optimal turbo-like receiver that does iterative decoding of the RLST codes and estimation of the channel matrix in an iterative and most important in simple fashion. The net answer is a new transceiver that is not only computationally efficient compared with the optimal maximum likelihood decoder, but it also gets a probability of error performance that is orders of magnitude lesser than traditional BLAST schemes for the same operating conditions. This paper also presented experimental results using real-life indoor channel measurements showing the high-spectral efficiency of TURBO-BLAST.

N. Boubaker *et al.* [37] presented a less complex multicarrier V-BLAST based on the utilization of a subcarrier grouping, an innovative sub-optimal decoding ordering method, and the Gram-Schmitt Orthogonalization (GSO) method instead of the pseudo-inverse operation used in V-BLAST Space division multiplexing (SDM) is a promising method for significantly increasing the bandwidth efficiency and wireless transmission capacity. Vertical Bell Laboratories Layered Space-Time (V-BLAST) is a scheme which uses the rich scattered wireless channel by utilizing multiple transmit and receive antennas. In order to make V-BLAST more robust against the detrimental effects of frequency selective and time varying channels, we join V-BLAST with Orthogonal Frequency Division Multiplexing (OFDM) transmission and Reed-Solomon coding. Owing to the needed intensive computation involved. It is depicted that the presented system can greatly decrease the computational complexity needed with a minimal penalty in performance compared with the exhaustive multicarrier V-BLAST.

A. Paulraj *et al.* [38] studied about the future wireless systems which would employ multiple antennas at both transmitter and receiver to take advantage of large capacity gains. Two competing spatial modulation technique6 for such systems are multiplexing, for high spectrum efficiency, and diversity, for high reliability. In this paper we show that the Demmel condition number of a MIMO (multiple-input multiple-output) channel characterizes its suitability for multiplexed transmission, over diversity transmission, based on a minimum Euclidean distance comparison. We examine the probability of obtaining channels suitable for multiplexing as a function of constellation, rate, and number of antennas, for flat-fading Rayleigh matrix.

W. Jiang *et al.* [39] gave a combining algorithm for structural optimization, which is based on genetic algorithm and gradient algorithm .There is a lot of research in genetic algorithm about structural optimization. But as far as the large multi-grid program is concerned here there is limited application of genetic algorithm because of its specialty and large calculation. In order to explore new resolution : Use gradient algorithm to superimpose, get a result, improve the herd of genetic algorithm with this result, then compare the superior one of genetic algorithm with the point of gradient algorithm, choose the best point to be the incident point of the next step of super position. With this method, it can keep the best root of all the courses, and also it can speed up searching, and keep the best global point. Numerical examples show that the combining algorithm possesses both the merit of genetic algorithm on strong global searching ability and gradient algorithm.

L. Junhua *et al.* [40] gave a new genetic algorithm with two species was proposed. Our dual species genetic algorithm (DSGA) composes of two subpopulation that constitute of same size individuals. The subpopulations have different characteristics, such as crossover probability and mutation operator. In one subpopulation, the parents with higher similarity are cross with higher rate; mutate with general mutation operator. So that, the new algorithm can obtains good exploitation ability. In the other subpopulation, the parents with smaller similarity are crossed with higher rate; mutate with big mutation rate, so that the new algorithm can get good exploration ability. The performance of our DSGA is compared to that of a single population genetic algorithm (SPGA) and Multi-population genetic algorithm with two populations (2PMGA). The experimental results show that the proposed method can gain higher global convergence rate and higher speed.

J. Cheng *et al.* [41] presented a hybrid genetic algorithm which combines genetic algorithm with complex method in order to find the best method to solve the problem of multi-objective function optimization. The algorithm first uses genetic algorithm to get an initial population and replaces original feasible points by the computation results of complex method, then it uses genetic algorithm to find the optimal solution. When termination conditions are met, complex method is used to get the final result. Experiment has been conducted to validate the proposed algorithm by taking optimization formula system as an example. The results shows that we got the best percentage of formula, and the proposed algorithm is more accurate than the simple genetic algorithm and complex method ,which has a good prospect of application in the area of optimization design.

P. Guo *et al.* [42] presented three different kinds of the novel improved genetic algorithm methods comprising the hybrid genetic algorithm, interval genetic algorithm and hybrid interval genetic algorithm. As the outputs of the proven systems give, the hybrid genetic algorithm can give the better optimum design than the traditional optimization algorithms and genetic algorithm. The interval genetic algorithm and hybrid interval genetic algorithm can stop calculating system slope in traditional interval analysis and give the optimum interval range of the parameters under allowable corresponding objective error boundary. It was the first time that genetic algorithm had been used on to interval optimization process.

T.P. Patalia *et al.* [43] presented a new algorithm known as genetic algorithm. Function optimization is the method of finding absolutely top values of the variables so that value of an objective function becomes optimal. Many optimization methods are available but if they work well on one class of problems then they may not perform at all on other classes of problems. Moreover function enhancement problems are a class of NP-complete problems so there is not a single algorithm that computes these problems in polynomial time. Genetic algorithm is probabilistic, heuristic, robust search algorithm premised on the evolutionary ideas of natural selection and genetic. Main idea in the design of genetic algorithm is to achieve robustness and adaptiveness in real world complex problems. Genetic algorithm can be seen as an optimization technique, which uses random search within a fixed search space to solve a problem, by some intelligence ideas of nature. Genetic algorithm can be utilized as a general function optimizer that can solve problems of any classes. Genetic algorithm is widely utilized in many applications but it has some weak points like selection pressure, balance between crossover and mutation, representation problems, stochastic nature of crossover etc... A new model of genetic algorithm called Guided model that is more deterministic, guided and utilizes less stochastic information. The presented Guided model is made such a way that it does not suffer from the problems of selection pressure, loss of top chromosomes, crossover rates, etc. Results depict that presented Guided model gives far better results as compared to Holland model and commonly used Common model.

CHAPTER 3: V-BLAST AND C-BLAST

3.1 INTRODUCTION

INFORMATION-THEORETIC considerations show that the multiple-input multiple-output (MIMO) communication architecture is able to provide extraordinary high spectral efficiencies in rich multipath environments, which are simply unattainable using conventional techniques [1]–[4]. Space-time coding and/or a special signal processing algorithm is to be implemented at the receiver in order to achieve at least part of the MIMO channel capacity. Diagonal Bell Labs Layered Space-Time (D-BLAST) algorithm has been proposed by Foschini for this purpose, which is capable of achieving a substantial part of the MIMO capacity [2]. However, a high complexity of the algorithm implementation is its substantial drawback. A simplified version of the BLAST algorithm is known as V-BLAST (vertical BLAST). It is capable of achieving high spectral efficiency while being relatively simple to implement.

3.2 V-BLAST

The Bell labs Layered Space-Time (BLAST) architecture was proposed by Foschini [5], and contains a multiple layer transmitter method that allows reaching spatial and temporal diversity. Coding of information data on all layers is non-mandatory. The received signal of concern is altered by data of the other layers generating interference and hence needing an interference canceller at the receiver side. Zero Forcing (ZF) and Minimum Mean Square Error (MMSE) detectors are utilized in this requirement [6]. A communication system containing M transmit (TX) and N receive (RX) antennas is taken. This system, presumed to be working in a Rayleigh flat-fading environment, uses the spatial dimension by utilizing Spatial Multiplexing, where MAPU is Multi Antenna Processing Unit. Assuming that at distinct times, the transmitter transmits a M-dimensional (complex) signal vector $\mathbf{a}$ i.e., it sends M parallel streams of data and the receiver documents a N-dimensional complex vector x.

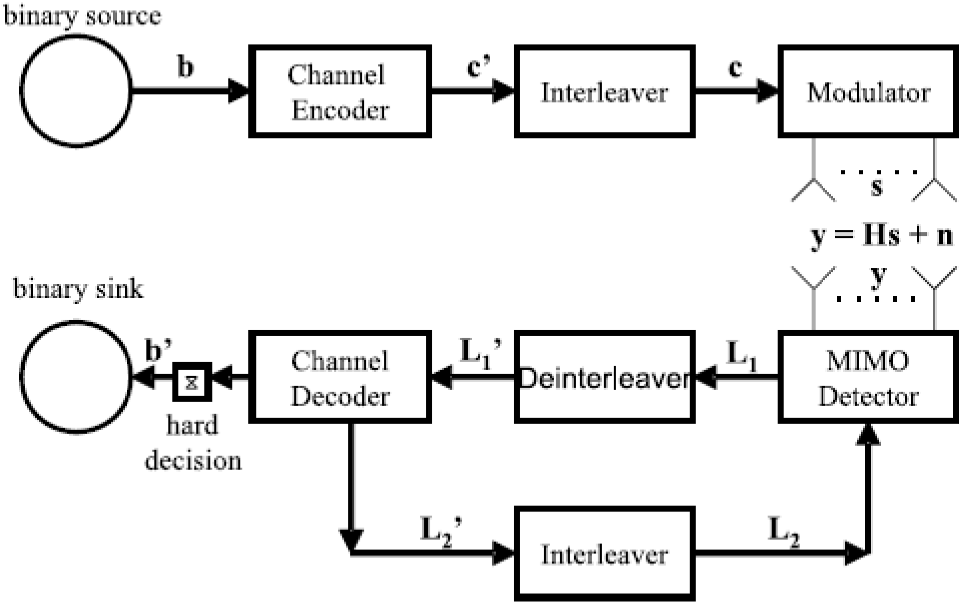

Figure 3.1: General configuration of a iterative decoding and detection [9]

The actual BLAST system uses diagonally-layered space-time architecture known as D-BLAST, and uses multi-element antenna arrays at each of the transmitter and receiver and an effective diagonally-layered coding formation in which code blocks are distributed across diagonals in space-time. In an self-sustaining Rayleigh scattering environment, this processing formation gives theoretical rates which increase linearly as the number of transmit antennas increase, with these rates reaching 90% of Shannon capacity. Anyways, the diagonal method tolerates various implementation complications which make it unsuitable for beginning of the implementation.

Instead, an adjusted version known as Vertical Bell Laboratories Layered Space Time or V-BLAST for short was proposed. V-BLAST upgrades the operation at the price of growth in calculation complicatedness. In V-BLAST, instead of jointly finding all the transmit signals, the find is done iteratively. At every symbol time for every subcarrier it first finds the most powerful layer (relying on the channel matrix) and then cancels the effect of this most powerful layer from every received signal is taken as interference. The finding continues with the remaining powerful layers, and so on [8]. The optimum finding order in such a nulling and cancellation method is from the most powerful to the least powerful signal. Taking the channel H being known to the receiver letting the ordered set

$$S \equiv \{k1, k2, \ldots, kM\} \tag{3.1}$$

be the permutation of the integers $1 , 2 , \ldots , M$ telling the order by which components of the sent symbol vector **a** are separated.

The main steps of the V-BLAST algorithm can be summarized as follows:

Step 1: Nulling: An approximation of the most powerful sent signal is got by nulling out all the weak sent signals. Using nulling vector $\mathbf{w}k1$, form decision statistic $yk1$

Step 2: Slicing: Slice $yk1$ to obtain $\hat{\boldsymbol{a}}$k1:

$$\hat{a}k1 \ = \ \Phi \ (yk1) \tag{3.2}$$

where $\Phi \ (.)$ shows the quantization (slicing) working as per the constellation in utilization, and $\hat{\boldsymbol{a}}i$ can be carved to the closest constellation position.

Step 3: Cancellation: Taking $\hat{a}k1 \ = \boldsymbol{a}k1$, remove $\boldsymbol{a}k1$ from the received vector $\boldsymbol{x}1$, giving the changed received vector $\boldsymbol{x}2$:

$$\boldsymbol{x}2 \ = \ \boldsymbol{x}1 \ - \ \hat{a}k1 \ (H)k1 \tag{3.3}$$

3.2.1 V BLAST ZF RECEIVER

The V-BLAST-ZF receiver uses the corresponding linear ZF criteria but the finding is done iteratively. For every symbol time, on every subcarrier, it first finds the most powerful layer then removes the effect of this most powerful layer from all of the received signals which is called as interference. The finding goes on with the remaining most powerful layer and so on. The optimum finding order is given by taking that row of G which has minimum Euclidean norm i.e., to maximize the SNR(Signal To Noise Ratio), where G is a matrix that shows the linear processing in the receiver. G's i-th row is equal to the i-th weight vector's w transpose and I is the identity matrix. If H is not a square value, G is equal to the *pseudo-inverse* of H [7]:

$$G \ = \ H+= \ (\ H'H \ ) - IH' \tag{3.4}$$

The row index is taken as:

$$k \ = \ arg \ \{min_i \ || \ (\boldsymbol{G})i \ || \ 2\} \tag{3.5}$$

3.2.2 V-BLAST RECEIVER

The V-BLAST minimum mean-square error (MMSE) receiver utilizes the Wiener equalization of the channel matrix **H** rather than the ZF equalization [9]. This receiver takes care of the reduction of interference with noise improvement, reducing the total error at the price of a higher complication.

To get the linear MMSE, **G** must be taken such that the Mean Square Error $\varepsilon 2$ is reduced: The MMSE receiver has low sensitivity to noise at the price of decreased signal division quality .In other words they are called as the co-channel signals.

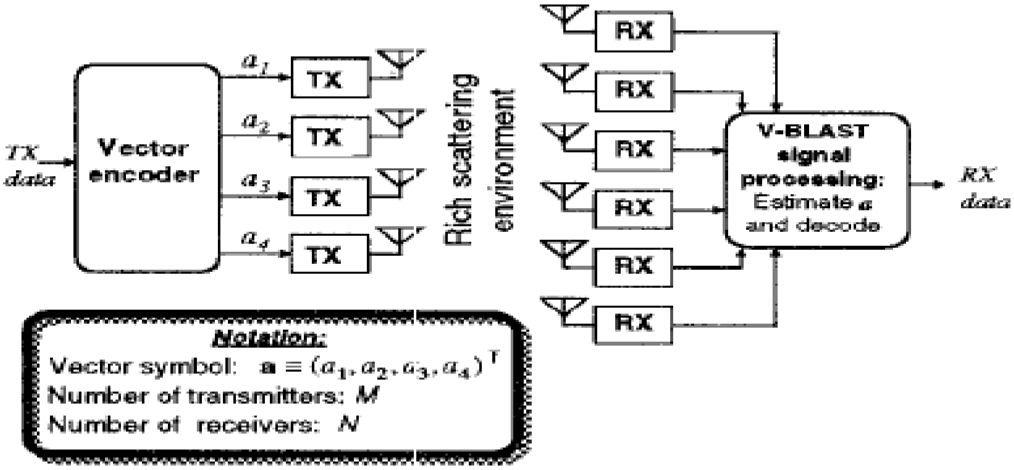

Figure 3.2: Block diagram of V-blast

3.2.3 V-BLAST DETECTION ALGORITHM

Step 1: Initialization

1. $i \leftarrow 1$
2. $G1 = H+$
3. $k1 = argmin_j || (G1)\, j\, ||2$

Step 2: Iteration

1. $wki = (Gi)\; k\; i$
2. $ykI = w\; kix$
3. $\hat{a}k\; i = \Phi(\; y\; k\; i)$
4. $xi + 1 = xi - \hat{a}\; ki(H)\; k\; i$
5. $G\; i + 1 = H + ki$
6. $k\; i + 1 = argminj \notin \{k1, k2, \ldots., ki\} || (G\; i + 1)\; j\; ||2$

7. $i \leftarrow i + 1$

3.2.4 V-BLAST ALGORITHM

The V-BLAST algorithm has been discussed in details elsewhere [5], [9]. Here, we describe its main points for completeness and in order to introduce notations. The main idea of the BLAST architecture is to split the information bit stream into several substreams and transmit them in parallel using a set of Tx antennas (the number of Tx antennas equals the number of substreams) at the same time and frequency. At the Rx side, each Rx antennas “sees” all the transmitted signals, which are mixed due to the nature of the wireless propagation channel. Using appropriate signal processing at the Rx side, these signals can be unmixed so that the matrix wireless channel is transformed into a set of virtual parallel independent channels (provided that mutltipath is rich enough). The following basic assumptions are employed.

- The channel is random, quasi-static (i.e., fixed for every frame of information bits but varying from frame to frame), frequency independent (i.e., negligible delay spread) and with complex additive white Gaussian noise (AWGN).

- The Tx signal vector is comprised of individual symbol substreams. No space-time coding is employed. However, conventional coding can be used for each substream individually (but no inter-substream coding is allowed).

- The noise vector is comprised of independent AWGN components with equal variance.

- The Tx signals, noise and channel gains are independent of each other.

- Perfect channel knowledge is assumed to be available at the receiver.

- There is no performance degradation due to synchronization and timing errors. The received signal vector can be presented in the following complex baseband vector form [9]:

$$R = Hqv \tag{3.6}$$

where is the transmitted symbol vector, is the channel matrix (i.e., the matrix of complex transfer factors from each Tx to each Rx antenna), and is the noise vector. Presenting the channel matrix in a column-wise way, where is a column vector of transfer factors from the th Tx antenna to all Rx antennas.

The V-BLAST processing begins with the first Tx symbol and proceeds in sequence to the mth symbol. When the optimal ordering procedure is employed, the Tx indexing is changed prior to the processing. The main steps of the V-BLAST processing (detection) algorithm are as follows [5], [9].

a) The interference cancellation step: At the th processing step (i.e., when the signal from the th transmitter is detected) the interference from the first x-i transmitters, can be subtracted based on the estimations of the Tx symbols (which are actually assumed to be error-free) and the knowledge of H.
b) The interference nulling step: Based on the knowledge of the channel matrix, the interference from yet to be detected symbols can be nulled out using the Gram–Schmidt orthogonalization process (applied to the column vectors of H).
c) The optimal ordering procedure: the order of symbol processing is organized according to their after-processing SNR's in the decreasing order (i.e., the symbol with highest SNR is detected first).

3.3 C-BLAST

Originally proposed by Foschini in 1996 [1], this architecture is now considered the reference in performance for MIMO systems, since it can reach capacities near the Shannon limit. However, the complexity is still too high to be practical. C-BLAST is also described in standard textbooks of communications.

3.3.1 Encoder

The encoder uses a space time arrangement that corresponds to a diagonal layering. The information bit stream coming from the source is de-multiplexed into several

Sub-streams (serial to parallel), and each sub-stream is coded separately and mapped to complex symbols. Then the symbols of each sub-stream are dispersed “diagonally” across antennas and time. Note that the layer might have more symbols than the number of transmit antennas, and the frame can be very long. Unfortunately, given the structure of the decoder, the space time wastage is necessary. This ultimately makes C-BLAST unable to reach the capacity limit, since the wastage is repeated every time a new set of layers are to be transmitted. Note that since the symbols are spread across antennas, this scheme captures transmit diversity.

3.3.2 Decoder

The decoder proceeds to decode one layer after another. They first symbol of the layer is guaranteed to be detected without errors, since it is transmitted alone (but the system pays the space-time wastage). After that, the next symbol on the layer is demodulated and detected, facing one interferer. The next will face two interferers, and soon. Once all the symbols of the first layer are demodulated, the sub-stream associated to the layer can be decoded. Decoding should be error free, otherwise the whole process would suffer from error propagation. In order to ensure the absence of errors, the channel code associated to the stream must be powerful and the stream must be long. Once the layer is decoded, it can be subtracted, thus “peeling it” and “exposing” the next one, for which therefore mentioned process is repeated.

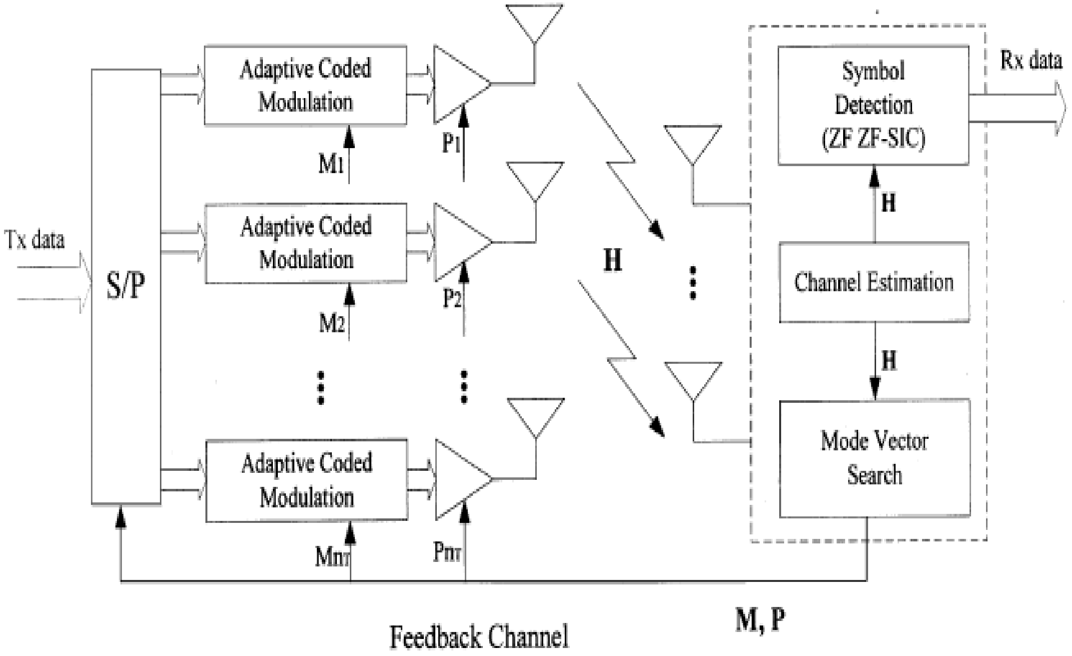

Figure 3.3: Block diagram of C-BLAST

CHAPTER 4: GENETIC ALGORITHM FOR V-BLAST AND C-BLAST

4.1 GENETIC ALGORITHM

A genetic algorithm (GA) is a technique for solving both of the constrained and unconstrained enhancement issues that are constructed on a natural selection process that imitates biological evolution. The algorithm repeatedly alters a population of individual answers. At every stage, the GA randomly chooses individuals from the present population and utilizes them as parents to construct the children for the coming generation. Over consecutive generations, the population advances to an optimum solution. We can use the GA to resolve issues that are not fairly suited for standard optimization algorithms, adding issues in which the objective function is intermittent, non-differentiable, stochastic, or highly non-linear.

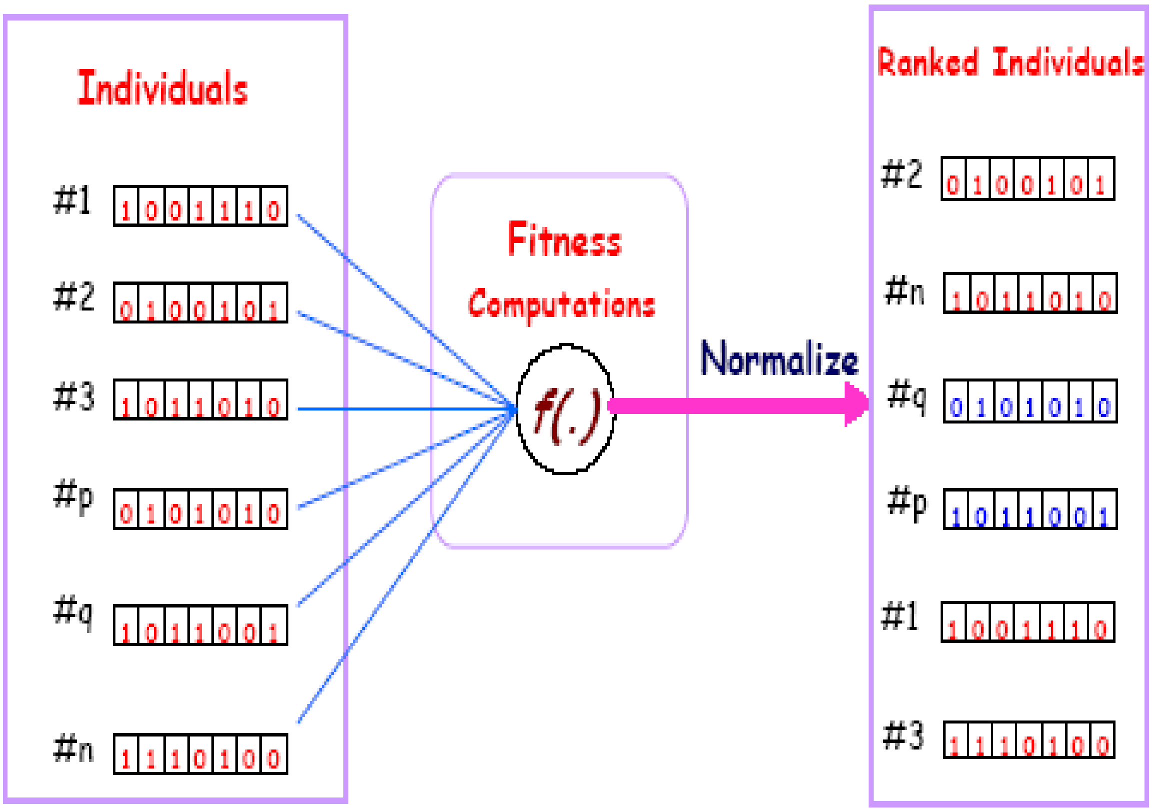

Figure 4.1: Concept of genetic algorithm

The genetic algorithm varies from a classical, derivative-based, enhancement algorithm in two principal methods as given in the following table.

Table 4.1: Comparison between Classical Algorithm and Genetic Algorithm

Classical Algorithm	Genetic Algorithm
Creates a single point at every iteration. The succession of points reaches an optimum solution.	Creates a population of points at every iteration. The top point in the population reaches an optimum solution.
Chooses the next point in the succession by a deterministic calculation.	Takes the next population by caclulation which utilizes random number generators.

In a genetic algorithm, a population of candidate solutions (called individuals, creatures, or phenotypes) to an optimization problem is evolved toward fitter solutions. Every candidate answer has a set of characteristics (its chromosomes or genotype) which can be mutated and changed; traditionally, answers are given in binary as strings of 0s and 1s, but some other types of encodings are also feasible. The evolution generally begins from a population of randomly created individuals, and is an iterative process, with the population in each iteration is called a generation. In each generation, the fitness of every individual in the population is assessed; the fitness is usually the value of the objective function in the optimization issue being solved. The more fit individuals are stochastically selected from the current population, and each individual's genome is changed i.e., recombined and possibly randomly mutated to form a new generation. The new generation of candidate answers is then utilized in the next iteration of the algorithm. Commonly, the algorithm ends when either a maximum number of generations have been constructed, or a satisfactory fitness level has been achieved for the population.

A model genetic algorithm needs:

1. A genetic representation of the solution domain,
2. A fitness function to evaluate the solution domain.

4.2 GENETIC ALGORITHM STEPS

4.2.1 Selection

During each successive generation, a proportion of the existing population is selected to breed a new generation. Individual solutions are selected through a fitness-based process, where fitter solutions (as measured by a fitness function) are typically more likely to be selected. Certain selection methods rate the fitness of each solution and preferentially select the best solutions. Other methods rate only a random sample of the population, as the former process may be very time-consuming. The fitness function is defined over the genetic representation and measures the *quality* of the represented solution. The fitness function is always problem dependent. For instance, in the knapsack problem one wants to maximize the total value of objects that can be put in a knapsack of some fixed capacity. A representation of a solution might be an array of bits, where each bit represents a different object, and the value of the bit (0 or 1) represents whether or not the object is in the knapsack. Not every such representation is valid, as the size of objects may exceed the capacity of the knapsack. The *fitness* of the solution is the sum of values of all objects in the knapsack if the representation is valid, or 0 otherwise. In some problems, it is hard or even impossible to define the fitness expression; in these cases, a simulation may be used to determine the fitness function value of a phenotype (e.g. computational fluid dynamics is used to determine the air resistance of a vehicle whose shape is encoded as the phenotype), or even interactive genetic algorithms are used.

4.2.2 Genetic Operators

The next step is to generate a second generation population of solutions from those selected through a combination of genetic operators known as crossover (also called recombination), and mutation.

For each new solution to be produced, a pair of "parent" solutions is selected for breeding from the pool selected previously. By producing a "child" solution using the above methods of crossover and mutation, a new solution is created which typically shares many of the characteristics of its "parents". New parents are selected for each new child, and the process continues until a new population of solutions of appropriate size is generated. Although reproduction methods that are based on the use of two parents are more "biology inspired", some research suggests that more than two "parents" generate higher quality chromosomes.

These processes ultimately result in the next generation population of chromosomes that is different from the initial generation. Generally the average fitness will have increased by this procedure for the population, since only the best organisms from the first generation are selected for breeding, along with a small proportion of less fit solutions. These less fit solutions ensure genetic diversity within the genetic pool of the parents and therefore ensure the genetic diversity of the subsequent generation of children. Opinion is divided over the importance of crossover versus mutation. There are many references in Fogel (2006) that support the importance of mutation-based search. Although crossover and mutation are known as the main genetic operators, it is possible to use other operators such as regrouping, colonization-extinction, or migration in genetic algorithms.

It is worth tuning parameters such as the mutation probability, crossover probability and population size to find reasonable settings for the problem class being worked on. A very small mutation rate may lead to genetic drift (which is non-ergodic in nature). A recombination rate that is too high may lead to premature convergence of the genetic algorithm. A mutation rate that is too high may lead to loss of good solutions unless there is elitist selection.

4.2.3 Termination

This generational process is repeated until a termination condition has been reached. Common terminating conditions are:

- A solution is found that satisfies minimum criteria
- Fixed number of generations reached
- Allocated budget (computation time/money) reached
- The highest ranking solution's fitness is reaching or has reached a plateau such that successive iterations no longer produce better results
- Manual inspection
- Combinations of the above

4.3 METHODOLOGY

STEP 1: Implement V BLAST and C BLAST algorithm in combination.

STEP 2: Implement V-BLAST and C-BLAST algorithm with Genetic Algorithm in order to optimize V-BLAST and C-BLAST results.

STEP 3: Compare the results a) when only V-BLAST and C-BLAST are applied.

b) when V-BLAST and C-BLAST with GA are applied.

STEP 4: Evaluate the throughput and bit error rate.

CHAPTER 5: RESULTS AND ANALYSIS

5.1 SIMULATION RESULTS

This chapter shows simulation results, that have been obtained using MATLAB, are shown below:

5.1.1 BER versus SNR graph for comparison of V-BLAST and C-BLAST at receiver

The below figures report the modification of the c blast and v blast algorithm on the basis of Genetic Algorithm and it shows that the algorithm implemented on v blast shows a rapid decrease in terms of bit error rate. Genetic Algorithm fits the value on the basis of iteration and the mutation values. The genetic algorithm uses its fitness function to reduce the value of the error and increases the SNR. The fitness value optimizes the input vector at the receiver end found at the segmented section. The percentage decrease in bit error rate can be termed to 10-12 %.

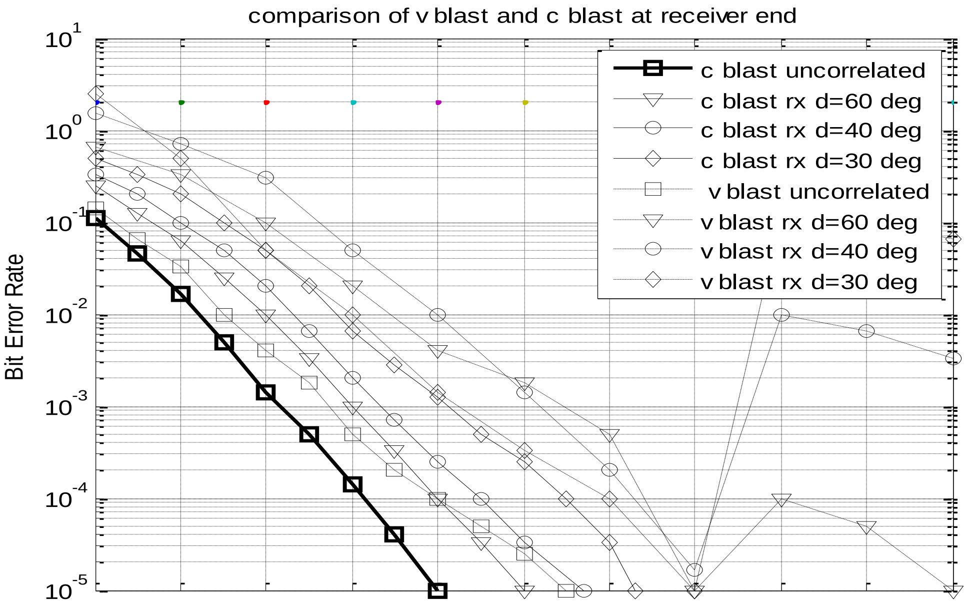

Figure 5.1: BER versus SNR, Rayleigh Fading, for different modulation schemes, using antennas and comparison is shown between VBLAST-CBLAST at receiver end

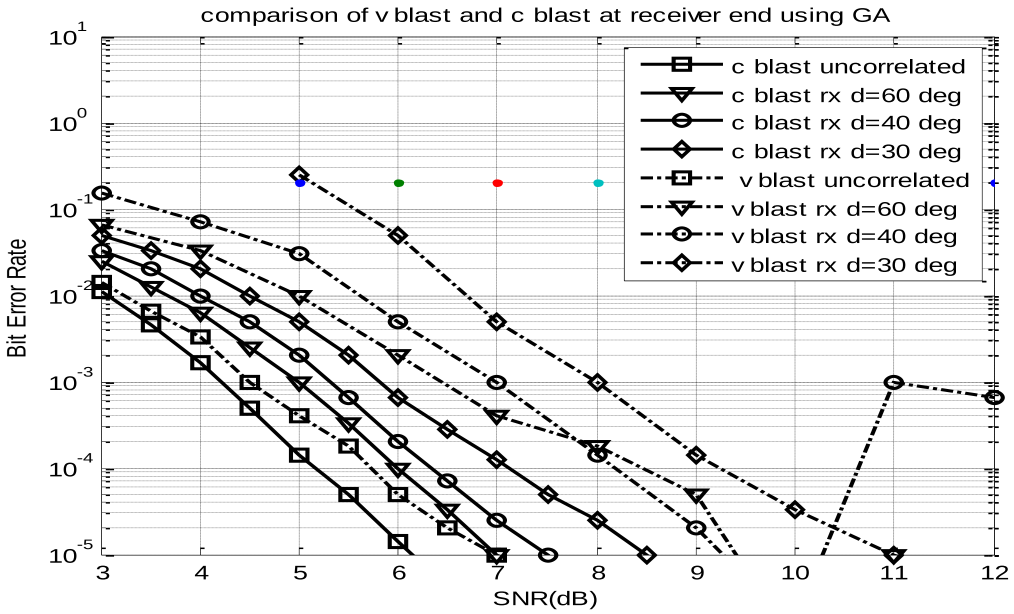

Figure 5.2: BER versus SNR, Rayleigh Fading, for different modulation schemes, using antennas and comparison is shown between VBLAST-CBL*AST* at receiver end using GA

5.1.2 BER versus SNR graph for comparison of V-BLAST and C-BLAST at transmitter

The below figure reports the modification of the c blast and v blast algorithm at rayleigh fading on the basis of Genetic Algorithm and it shows that the algorithm implemented on v blast shows a rapid decrease in terms of bit error rate. Genetic Algorithm fits the value on the basis of iteration and the mutation values. The genetic algorithm uses its fitness function to reduce the value of the error. The fitness value optimizes the input vector at the receiver end found at the segmented section. The percentage decrease in bit error rate can be termed to 10-12%.

There is decrease at the transmitter in the bit error rate and at the receiver as was shown in the above results and also improvement in SNR at both the transmitter and the receiver. This is the effect of genetic algorithm on the SNR and bit error rate of the transimitted and received signal.

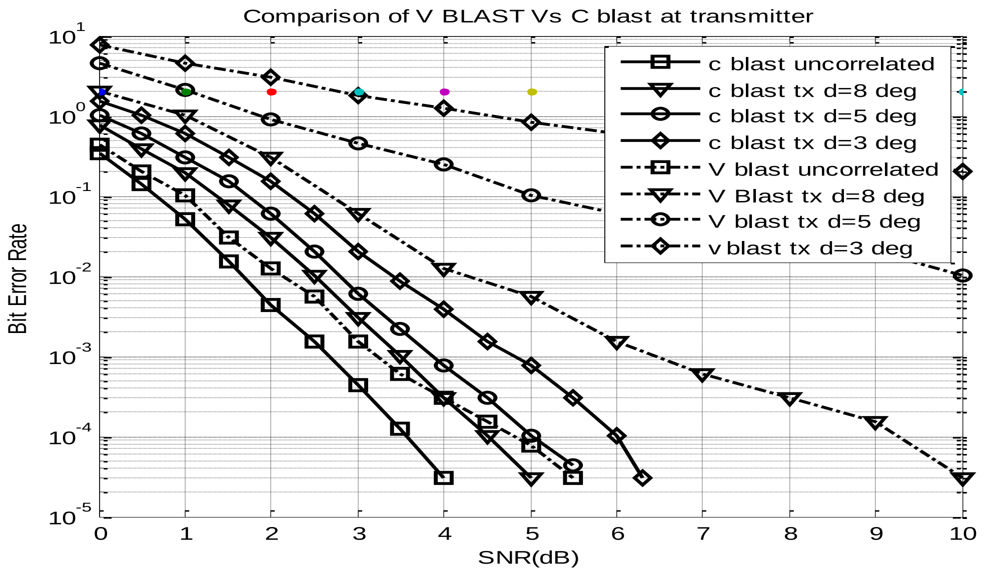

Figure 5.3: BER versus SNR, Rayleigh Fading, for different modulation schemes, using antennas and comparison is shown between VBLAST-CBLAST at transmitter end

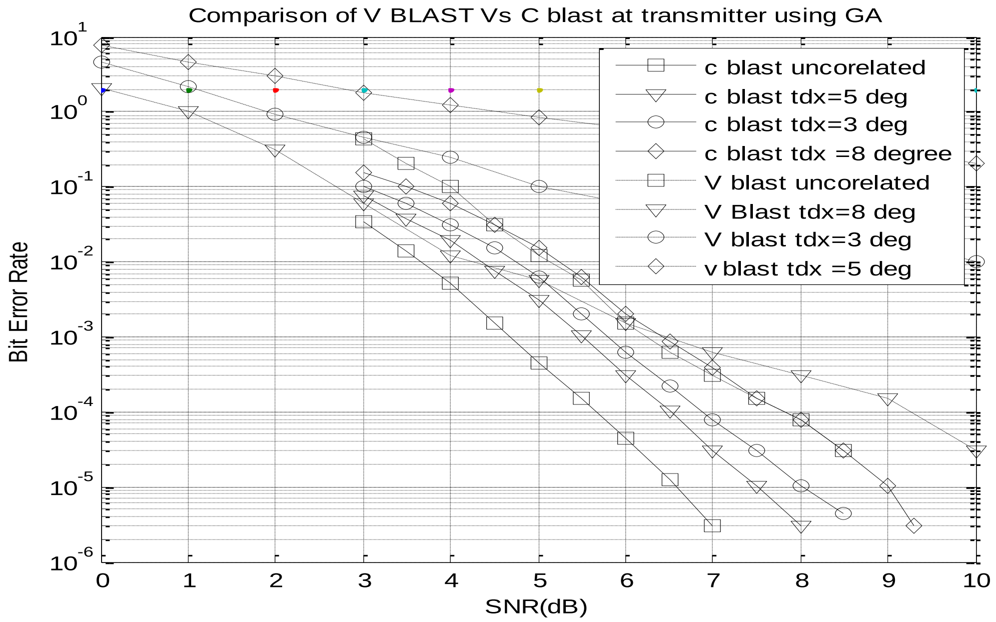

Figure 5.4: BER versus SNR, Rayleigh Fading, for different modulation schemes, using antennas and comparison is shown between VBLAST-CBLAST at transmitter end using GA

5.1.3 BER versus SNR graph for comparison of feedback and semiblind power allocation

The below figure describes the feedback and semiblind power allocation problem. The optimization of the allocation has been done using genetic algorithm. The same procedure of the genetic algorithm is followed as described above and results have been found to improve by 12-15%.

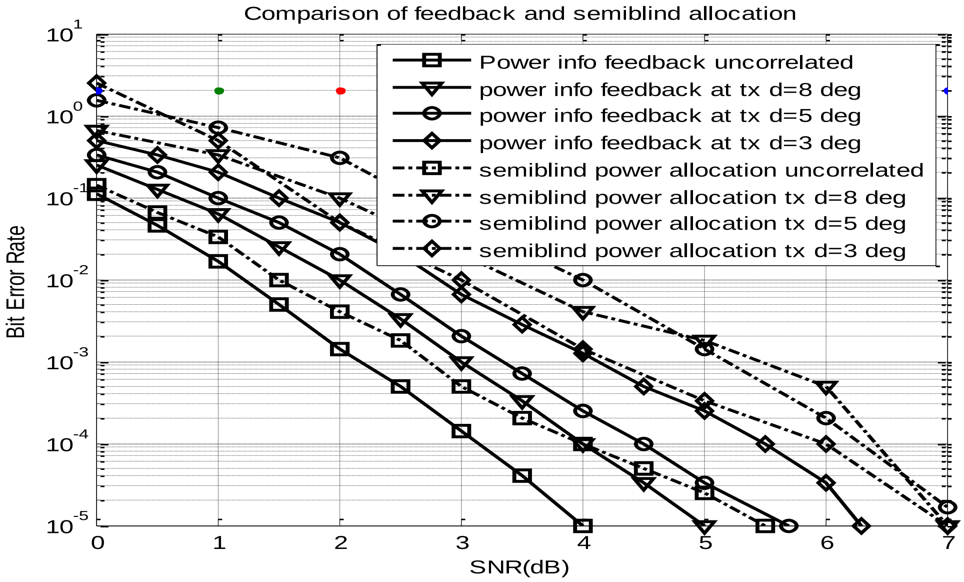

Figure 5.5: BER performance of proposed feedback precoded with V and C-BLAST Scheme.

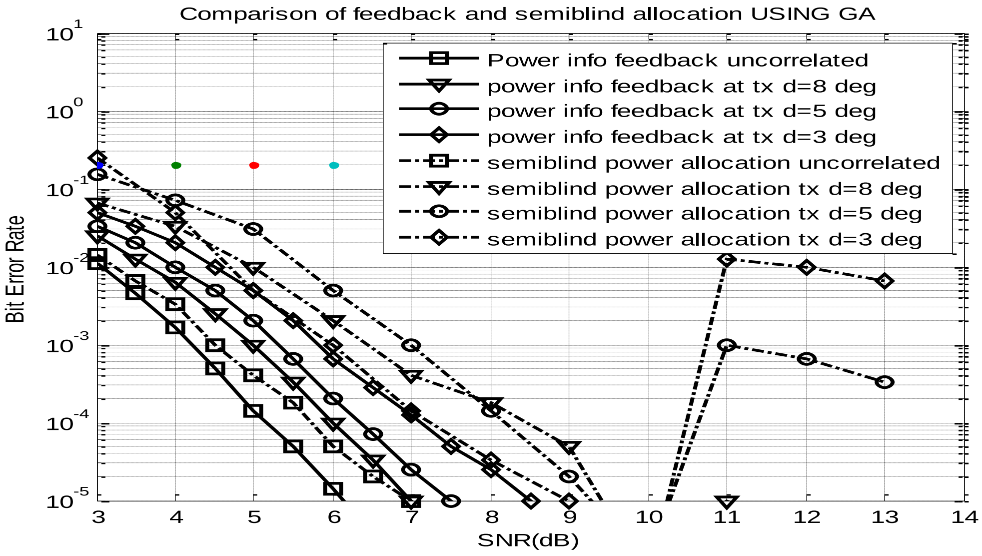

Figure 5.6: BER performance of proposed feedback precoded with V and C-BLAST Scheme using GA

CHAPTER 6: CONCLUSION AND FUTURE SCOPE

6.1 CONCLUSION

The combination of V-BLAST, C-BLAST and Genetic Algorithm is presented in this thesis and it is concluded if only V-BLAST is used then thought is enhanced minutely and also bit error rate but if it is applied using Genetic Algorithm then throughput is enhanced by 10% and also bit error rate decreases. This method known as genetic algorithm improves the performance characteristics of V-BLAST and C-BLAST like SNR, Bit Error Rate and Semiblind Power Allocation which also increase to the range of 10-15 %

The computation values of the genetic algorithm are quite satisfactory with the rayleigh fading channel and AWGN channel. The genetic algorithm optimizes the value on the basis of two function namely objective function and fitness function. The opted values of objective functions are passed to fitness function then it utilizes the best fit value in the process. The current result shows a good decrease in the bit error rate by 10 percent and quality of signal also gets enhanced by 10-12 %.

Optimization of feedback and semiblind power allocation has been done using genetic algorithm. The same procedure of the genetic algorithm is followed as described above and results have been found to improve by 12-15%.

Though the conventional open-loop V-BLAST is severely compromised in practice owing to its poor diversity performance and error propagation, the proposed closed-loop V-BLAST overcomes these difficulties by adaptively assigning transmit powers, rates, and antenna mappings. Based on bit error rate, it shows the performance of these receiver schemes indicates C- BLAST is better than V- BLAST in contrast of performance with lower complexity and compare the computational complexity of these schemes and genetic algorithms improve both the performance characteristics of C-BLAST and V-BLAST.

6.2 FUTURE SCOPE

The future aspects of this work might involve the use of different modulation techniques in both V-BLAST and C-BLAST like QAM 16, QAM 32 and QAM 64 modulation mechanisms and they can be compared to BPSK, QPSK modulation. As the optimization algorithm can be also improved by changing the fitness function or trying other fitness function like Backterial Forging Optimization.

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