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INTRODUCTION

1.1 INTRODUCTION

In next generation for wireless communication, mobile terminals will face mass data service. Thus signal process in mobile terminal is needed to economize power, while high spectrum efficiency and wireless data networks reliability should be guaranteed at the same time. When perfect knowledge of the wireless channel conditions is available at the receiver, the capacity has been shown to grow linearly with the number of antennas.

Several techniques are under consideration for the next generation of digital phone systems, with the aim of improving cell capacity, multi-path immunity, and flexibility. These include Code Division Multiple Access (CDMA) and Coded Orthogonal Frequency Division Multiplexing (COFDM). Both these techniques could be applied to providing a fixed wireless system for rural areas. However, each technique has different properties, making it more suited for specific applications.

OFDM is currently being used in several new radio broadcast systems including the proposal for high definition digital television, Digital Video Broadcasting (DVB) and Digital Audio Broadcasting (DAB). However, little research has been done into the use of OFDM as a transmission method for mobile telecommunications systems.

Orthogonal Frequency Division Multiplexing (OFDM) is a special form of multi-carrier transmission where all the sub carriers are orthogonal to each other. OFDM promises a higher user data rate and great resilience to severe signal fading effects of the wireless channel at a reasonable level of implementation complexity.

OFDM/COFDM allows many users to transmit in an allocated band, by subdividing the available bandwidth into many narrow bandwidth carriers. Each user is allocated several carriers in which to transmit their data. The transmission is generated in such a way that the carriers used are orthogonal to one another, thus allowing them to be packed together much closer than standard frequency division multiplexing (FDM) leads to OFDM/COFDM providing a high spectral efficiency. MIMO (multiple-input multiple-

output) systems that operate at high rates require simple yet effective space-time transmission schemes to increase capacity and performance with acceptable BER (Bit Error Rate) proportionally with the number of antennas that can handle the large traffic volume in real time.

MIMO - OFDM has become an important combination that seems to play an important role in the emergent and future wireless communications systems as well as in the so called 4G concept. These systems offer significant diversity advantages over traditional wireless communication systems by exploiting both transmit and receive diversity by employing the V - BLAST schemes. These have led to MIMO - OFDM being regarded as one of the most promising emerging wireless technologies.

With CDMA systems, all users transmit in the same frequency band using specialized codes as a basis of channelization. The transmitted information is spread in bandwidth by multiplying it by a wide bandwidth pseudo random sequence. Both the base station and the mobile station know these random codes that are used to modulate the data sent, allowing it to de-scramble the received signal. In this thesis we have also study performance CDMA combined with MIMO and V-BLAST detection at receiver.

In this thesis, efforts have been made to study transmit signal processing for the downlink of multi-user systems Using MIMO (Multiple-Input Multiple-Output) systems.

We presented here how the V-BLAST algorithm implements a non-linear detection technique based on spatial nulling process; we will use nulling process ZF (Zero Forcing) and MMSE (Minimum mean square error) individual and compare both techniques for OFDM Multi-user and CDMA multi-user detection. Emphasis is placed on implementing channel estimation strategies for an iterative Vertical Bell-Labs Layered Space Time (V-BLAST) architecture. The channel estimate can be sequentially improved between successive iterations of the iterative V-BLAST algorithm.

We have implemented and analyzed the performance of V-BLAST algorithm for ZF and MMSE nulling using modulation QPSK, 16 - QAM and

64 - QAM with fixed number of transmitting antennas and receive antennas (i.e. 4 transmit antennas and 8 receive antennas) in MATLAB.

The communication system has challenge of accommodating many users in a small area. Multi-user detection (MUD) is the intelligent estimation/demodulation of

transmitted bits in the presence of Multiple Access Interference (MAI). MAI occurs in multi-access communication systems (CDMA/ TDMA/ FDMA) where simultaneously occurring digital streams of information interfere with each other.

CDMA is a popular multiple access technology for wireless communication however its performance is limited by multiple access interference and multi-path distortion. Conventional detectors based on the matched filter just treat the MAI as additive white Gaussian noise (AWGN). With the advent of spread spectrum and hence CDMA, fixed bandwidth was used to accommodate many users by making use of certain coding properties over the bandwidth. Multi-user detection is a concept to make improvements over conventional CDMA receiver.

Multi-user detection technique employed to improve the performance of CDMA. MUD is basically the design of signal processing algorithms that algorithms take into account the correlative structure of the MAI.

The performance of linear multi-user detectors has been studied here. The most popular linear detectors include the (GA) Genetic Algorithm, ZF (Zero forcing) and MMSE (Minimum Mean Square Error). Comparing with other algorithms GA provide better response compared to other algorithms and therefore believed to be next generation algorithm for optimization problem. The proof of the statement is explored by analyzing and comparing MATLAB 7.0 simulated results for different number of users, modulation techniques and spreading codes under effect of Rayleigh fading and AWGN channel. The implementations of the Zero Forcing detector and the MMSE linear detector involve matrix inversion operations. If the number of users becomes large the size of the matrix to be inverted grows and hence the computation time of such a matrix inversion becomes unacceptable.

Probabilistic Data Association (PDA) is another such algorithm that employs a soft inter-user interference (IUI) cancellation, where the term "Probability" refers to the fact that the each user signal is iteratively updated. The PDA detector models the undecided user signals as binary random variables and inter-user interference (IUI) as Gaussian noise. Based on this, the probability of each user's has to be updated & converged to make a decision. Thus, the performance of PDA detector provides better response with other by incorporating low SNRs and higher BER.

We have also implemented a Probabilistic Data Association (PDA) algorithm and is explored by comparing and analyzing MATLAB Simulated results with different no. of users, Additive White Gaussian Noise (AWGN) channel and varying the Modulation techniques such as QPSK, GMSK, 16-QAM and 64-QAM.

1.2. V-BLAST IMPLEMENTATION, ANALYSIS AND ARCHITECTURE FOR OFDM AND CDMA BASED MUD

1.2.1 Introduction

Here information about various types of representation of V-BLAST schemes and complete V-BLAST architecture, algorithm which has been implemented in this project is briefly described.

1.2.2 Spatial Multiplexing Schemes

Spatial multiplexing scheme exploits the rich scattering wireless channel allowing the receiver antennas to detect the different signals simultaneously transmitted by the transmit antennas. This method uses multiple antennas at the transmitter and the receiver in conjunction with rich scattering environment within the same frequency band to provide a linearly increasing capacity gain in the number of antennas. Hence, the concept of spatial multiplexing is different from that of space-time coding method, which permits to efficiently introduce a space-time correlation among transmitted signals to improve information protection and increase diversity gain.

1.2.3 Layered Schemes

In V-BLAST systems Layered schemes are use both the side of communication system i.e. at transmission side and reception side.

1.2.4 Comparison of V-Blast with D-Blast

There are two approaches for the transmission over MIMO systems.

(1) V-BLAST,

(2) D-BLAST.

Generally, spatial multiplexing is often referred to as V-BLAST. However, due to its complex coding procedure, Vertical Bell Laboratories Layered Space- Time

architecture (V-BLAST) has been proposed as a simplified version. In V-BLAST, channel coding may be applied to individual antennas (sub-layers), corresponding to the data stream transmitted from each transmit antenna, while in D-BLAST coding processing is applied not only across the time but also to each sub-layer, which implies higher complexity.

1.2.5 General Assumptions for V-Blast Implementation

- M antennas at both the transmitter and N at the receiver
- Transmitter has no knowledge on channel characteristics
- Rich Rayleigh fading scattering environment
- Narrow band (flat fading) channel
- Tx power constrained to P (single antenna power: P/M)
- Noise: complex AWGN with power N at each Rx antenna
- Average SNR equals >= P/N
- Normalized MxN MIMO channel impulse response matrix (H) With average gain of unity for each matrix element (each element is Rayleigh fading)
- Long burst assumption (many symbols) with static channel during burst.

1.2.6 MIMO V-Blast System Model

Although various implementation architectures for Multiple - Input Multiple - Output (MIMO) systems have been introduced since the BLAST (**B**ell **L**aboratories **L**ayered **S**pace-**T**ime) system was proposed, a variation of such system, V-BLAST still emerges as a promising architecture due to lower receiver complexity (V-BLAST receiver algorithm) and higher data rates in the case of large number of antennas. In this project we consider a V-BLAST system with N transmit and M = N receives antennas. At the transmitter, a single bit stream (TDMA frame, for example) is horizontally encoded (HE) and de-multiplexed into N sub streams, and each sub stream is mapped to a symbol by the same constellation and sent to its respective transmit antenna. Since total transmit power E_S is preserved irrespective of the number of transmit antennas, there is no increase in the amount of interference

caused to the other users or sub streams. Thus, at each symbol time t, a transmitted signal vector of size N, $\mathbf{a}^t = [a\,1^t, aNt]^T$, is sent to the receiver over a rich-scattering and quasi-static flat fading wireless channel. Each time sequence $\{a^t\}$ j, (j = 1, 2,..., N) is referred to as a layer. Transmitter needs no information about the channel, which eliminates the need for fast feedback links. At the receiver, the signal ri^t received by antenna i at time t is a noisy superposition of the N transmitted signals respectively corrupted by noise ni^t,

1.2.6.1 Transmitter Model

The transmitter (Figure: 1.1) has an array of N-antennas and performs a MIMO vertical encoding (VE). The first step is the encoding of the bit stream from the information source (TDMA frame for multi-user operation). The coded bits are then mapped to some symbols. It has been established that OFDM is a spectrally efficient modulation technique, thus spectral efficiency depends mainly on the bandwidth of the symbol, B_S. This depends on the modulation technique used to modulate the individual sub-carriers. It is the mapping (over a constellation) that corresponds to the choice of modulation technique, which should minimize B_S.

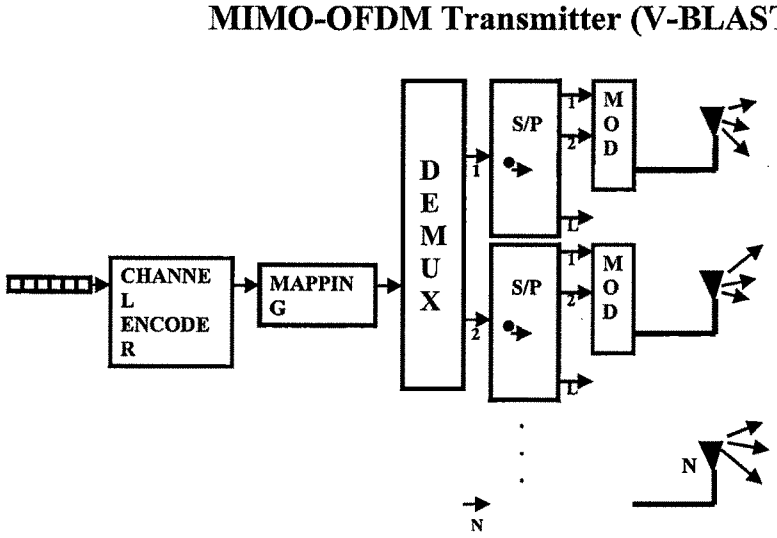

Figure 1.1 OFDM MIMO V-BLAST Transmitter model

1.2.6.2 Receiver model

After the channel, the cyclic extension is removed as it just contains the channel spread (assumed negligible in the simulation). Then the FFT is taken in each of the M receive antennas (V-BLAST requires $M \geq N$). Each antenna m receives a different noisy superimposition of the faded versions of the N transmitted signals (Figure: 1.2a). If the transmit and receive antennas are sufficiently spatially separated, more than $\lambda/2$ (at 17 GHz it is about 0.9 cm) and there is a sufficiently rich scattering propagation environment, the transmitted signals arriving at different receive antennas undergo uncorrelated fading. Moreover, if the channel state is perfectly known at the receiver, V-BLAST receiver is able to detect the N transmitted Sub-system.

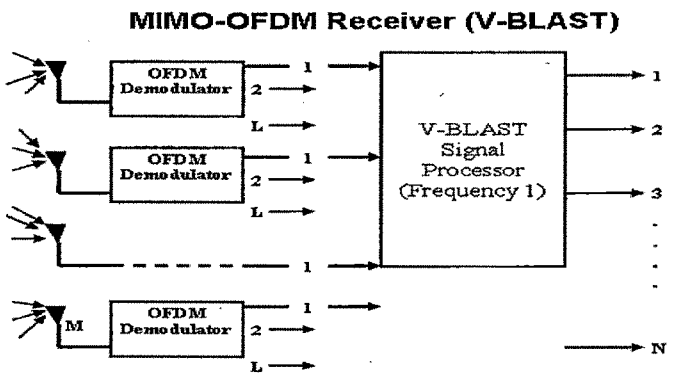

Figure: 1.2.(a) OFDM MIMO V-BLAST Receiver model (Front part)

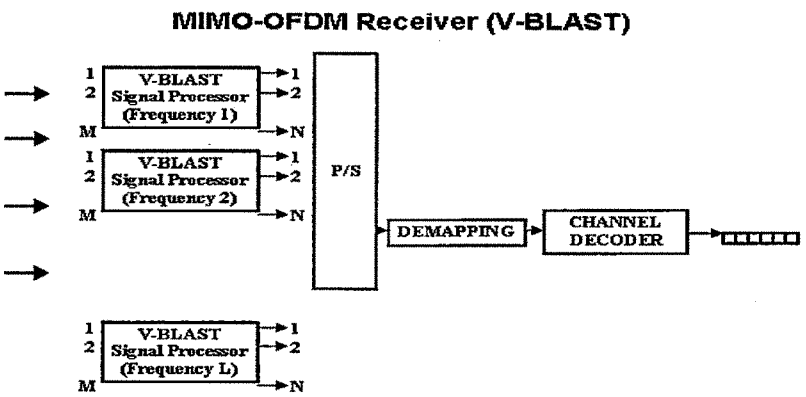

Figure: 1.2(b) MIMO OFDM V-BLAST Receiver model (Back part)

1.2.7 CDMA MIMO V-Blast Models

1.2.7.1 Transmitter Model

The figure 1.3(a) shown below is Model of Simple CDMA MIMO Transmitters. Here Data Bits from individual's users are first spreaded using their spreading code. After that each user's spreaded data is modulated using any convention modulation techniques. Vertical encoding is part of MIMO techniques here modulated signal is divided into a number of transmit antennas.

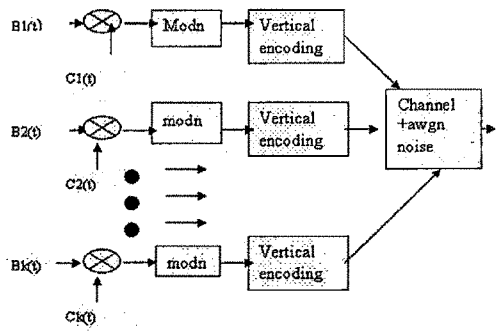

Figure 1.3(a) CDMA MIMO Transmitters

After vertical encoding signals of all users is sent into channel.

1.2.7.2 Receiver Model

The figure 1.3(b) is a Model of Simple CDMA MIMO Receiver. Each receive antennas receives data from every transmit antennas. The correlator is optional. It is used for correlation for individual users. Then the signal is passed form any operator ZF or MMSE in Figure 1.3(b). we have indicated ZF. After Transformation of ZF signal is processed by V-BLAST decoding algorithms, it operates on channel matrix and all the steps of V-BLAST processing are performed to detect individual user signal.

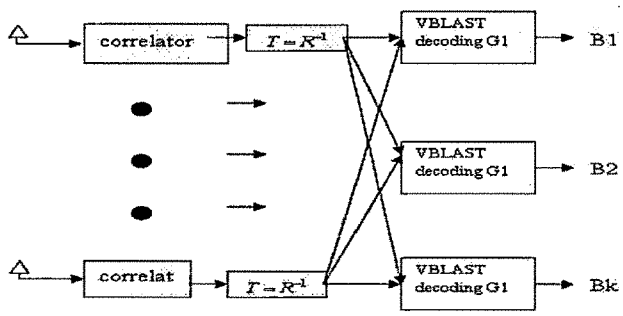

Figure 1.3(b) CDMA MIMO Receivers

1.3. GENETIC ALGORITHM IMPLEMENTATION, ANALYSIS AND ARCHITECTURE FOR CDMA BASED MUD.

1.3.1 Genetic Algorithm Assisted M.U.D. for S-CDMA

Here, we have provided a simple model for investigating the feasibility of applying GA's in CDMA multi-user detection (MUD) as well as for determining the GA's configuration, in order to obtain a satisfactory performance. GA assisted scheme have been applied in this project as a suboptimal multi-user detection technique in CDMA system over single Path Rayleigh fading channels.

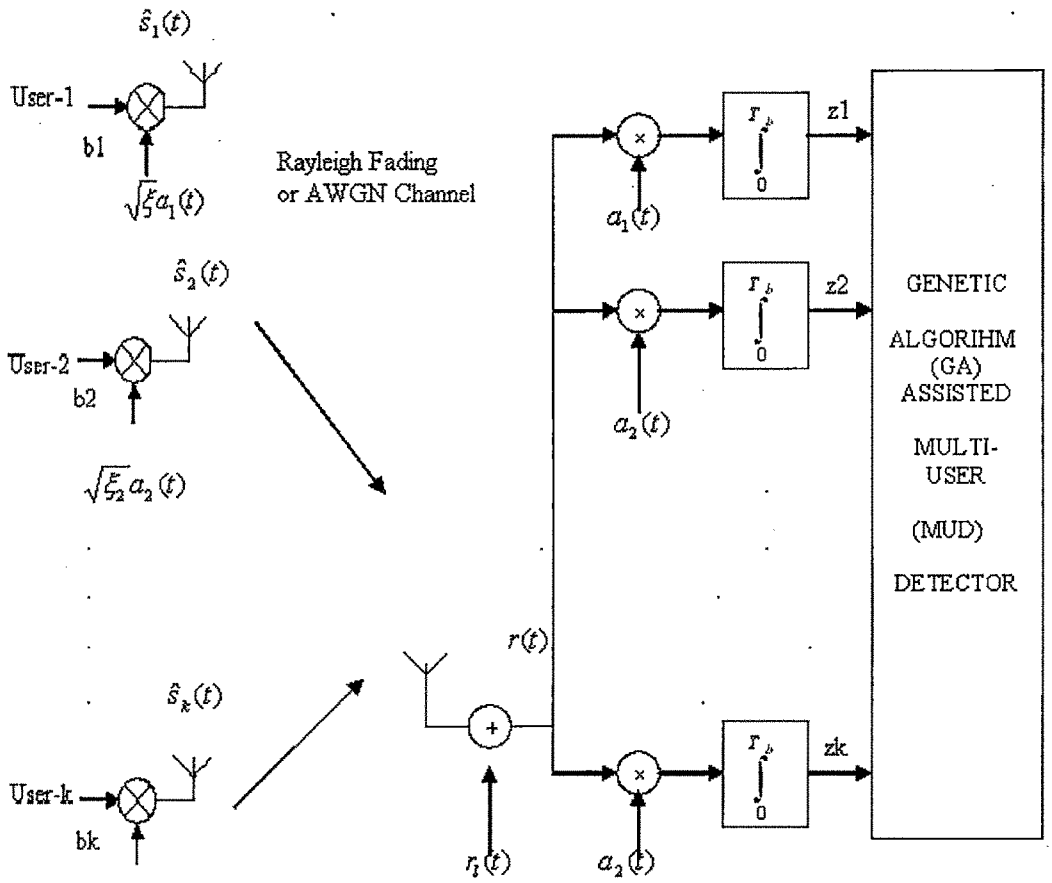

Figure 1.4 Block diagram of the k-user synchronous CDMA system model in a flat Rayleigh fading channel.

1.4. PDA ALGORITHM IMPLEMENTATION, ANALYSIS AND ARCHITECTURE FOR CDMA BASED MUD.

We are here concerned with the family of PDA's and their application as an optimization tool to the problem of multi-user detection in CDMA based wireless communication systems.

1.4.1 System Model

This CDMA system model shows that the number of users transmitting their signal data simultaneously, passed from the channel having multi-path environment. These faded signals are applied in to the receiver, which have been processed by the PDA method, shown in Fig1.5.

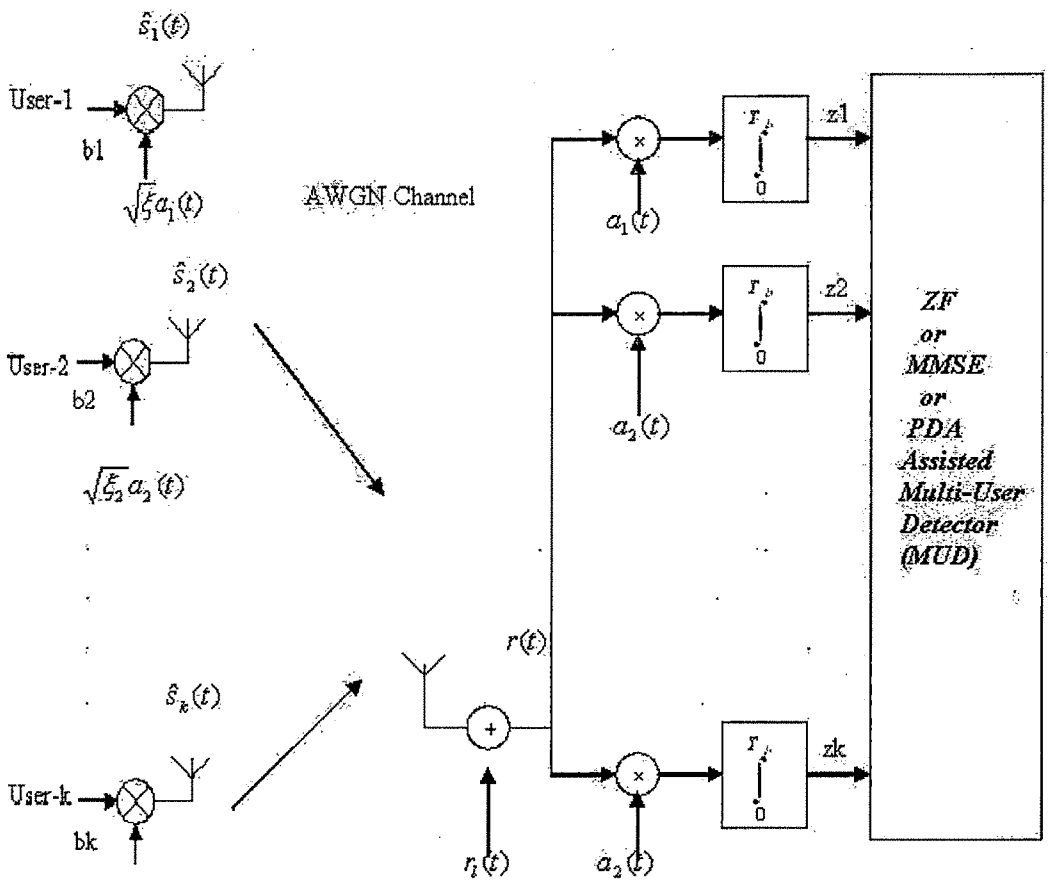

Figure 1.5 CDMA system model with PDA algorithm

1.5 COMPARISON BETWEEN VARIOUS METHODS IMPLEMENTED

1.5.1 V-BLAST Performance

In this project, V-BLAST applied to CDMA and OFDM based Multi-user detection technique in wireless communication system with MIMO environments has been implemented MATLAB 7.0.

From the simulation results for different users (2, 4, 8, and 16) for various modulation techniques like QPSK, 16-QAM, and 64-QAM in AWGN and MIMO Rayleigh fading channel, here we compare the performance of V-BLAST Algorithm with nulling techniques, Zero Forcing and MMSE, we found that result of MMSE nulling is comparatively better than ZF in some cases.

1.5.2 GA Performance

From the simulation results of BER V/S Eb/No for different users(2,4,8,16,64) we have seen that the Performance of the Genetic Algorithm is considerably better than counter algorithms discussed (Zero Forcing, MMSE) because of its powerful principle of estimating the best solution to given problem.

As seen from BER v/s Eb/No results obtained for different algorithms we observe that,

- BER for ZF = 0.6 for 16-users at 0 dB Eb/No value.
- BER for MMSE = 0.2 for 16-users at 0 dB Eb/No value
- BER for GA = 0.04 for 16-users at 0 dB Eb/No value using 16-QAM modulation technique and under influence of AWGN channel using Walsh code.
- BER for GA = 0.65 for 16-users at 0 dB Eb/No value using 16-QAM modulation technique and under influence of Rayleigh fading channel using Walsh code.
- We also observe that BER performance of the GA for 16-user is comparatively better at higher values of Eb/No then ZF and MMSE algorithms.

From the timing diagram performance of the system model introduced here for different parameters is better compared to ZF and MMSE algorithms. So we can say that Genetic Algorithms converges easily and is less complex.

So we can say that the Performance of the Genetic Algorithm is considerably better than other currently available algorithms such as Zero Forcing, MMSE for MUD in CDMA based wireless communication systems.

1.5.3 PDA Performance

Based on the above simulation results of BER V/S Eb/No for different number of users (2,4,8,16, and 64 users), we have seen that the Performance of the Probability Data Association Algorithm is considerably better than counter algorithms discussed (Zero Forcing, MMSE) because of its powerful principle of estimating the best solution to given problem.

As seen from BER v/s Eb/No results obtained for different algorithms we have observe that,

- BER for ZF = 0.6 for 16-users at 0 dB Eb/No value.
- BER for MMSE = 0.2 for 16-users at 0 dB Eb/No value.
- BER for PDA = 0.145 for 16-users at 0 dB Eb/No value using 16-QAM modulation technique and under influence of AWGN channel using Walsh code.
- BER for PDA = 0.146 for 16-users at 0 dB Eb/No value using 16-QAM modulation technique and under influence of Rayleigh fading channel using Walsh code.
- We also observe that BER performance of the PDA algorithm for 16-user is comparatively better at higher values of Eb/No then ZF and MMSE algorithms.

From the timing diagram performance of the system model introduced for different parameters is better compared to ZF and MMSE algorithms.

1. 6. THE VOLUME AND CONTENT OF WORK

The authors have taken up the research work related to study of Multi User detection technique for OFDM and CDMA based Wireless communication systems and implemented various algorithms like V-BLAST technique, Genetic algorithm, PDA. These all techniques have been implemented on MATLAB 7.0 platform with PC

configuration of 512 MB RAM and 1.86 GHZ speed. The algorithms are implemented for BER performance with different no. of users considering various modulation schemes, spreading codes, channels etc. mentioned below.

Modulation schemes:-

I. QPSK
II. 16-QAM
III. 64-QAM
IV. GMSK

Spreading codes:-

I. WALSH CODE
II. GOLD CODE
III. PN CODE

Channels:-

I. AWGN
II. RAYLEIGH FADED

We have simulated various MUD Algorithms for OFDM and CDMA based wireless communication system considering above parameters as mentioned below:

1. Implementation of ZF Algorithm for CDMA based MUD techniques.
2. Implementation of MMSE Algorithm for CDMA based MUD techniques.
3. Implementation of V-BLAST Technique for OFDM based MUD techniques in MIMO environment.
4. Implementation of V-BLAST Technique for CDMA based MUD techniques in MIMO environment.
5. Implementation of Genetic Algorithm for CDMA based MUD techniques.
6. Implementation of PDA Algorithm for CDMA based MUD techniques.
7. Comparison based on results obtained by implementation of these algorithms considering various parameters for best BER and optimum no. of users of OFDM, CDMA based WCS (i.e 3G & 4G Systems, Wireless Adhoc Networks).

1.7 PREVIOUS WORK AND MOTIVATION

Future mobile and wireless applications will require significantly higher data rates and reduced costs per transmitted bit as compared to third generation systems[1],[2],[47]. These requirements on data rate, link quality, spectral efficiency, mobility, low transmit power BER, SNR as well as intra and inter-cell interference mitigation cannot be met with single antenna systems. Therefore, multiple antenna techniques have been identified as a solution for future mobile and wireless systems[7],[9],[10],[13],[19],[22]. This is also the ultimate goal of wireless system design. The employment of an OFDM communication system in MIMO system has been actively researched[11][22][24][25], which is called MIMO - OFDM system, V-BLAST OFDM system has been proposed to achieve higher capacity and spectral efficiency[8][15][16]. Further, MIMO system is a stronger candidate for 4G along with OFDM.

In wireless communication, the multiple access techniques are being used to expand the capacity and range of existing systems. Basically, these requirements are on higher data rates, mobility, SNR, and low Bit Error Rates. Further, a multi-user detection technique has been identified to mitigate the multiple access interference (MAI), multi-path propagation and fading problems in CDMA system [1][45][47][50][52][61]. MUD is basically a signal processing algorithms to take care of this inter-user interference problem. [3][47][48][49][51][56][60]. Genetic algorithm is also studied by people for various other purposes [32][33][34][35][36][37][38][40].We thought why not to explore the ability of GA for CDMA based MUD here.

Lot of research work is being done in the following areas.

- Multi user detection techniques for wireless communication
- MAI
- CDMA systems and performance
- MIMO systems
- OFDM based wireless communication systems
- Different types of Performance of the above systems based on various algorithms etc.

Based on study of research work already done in above mentioned areas, authors were motivated to take up research work in the area of "***Analysis and implementation of Multi user detection techniques for wireless communication systems***" for comparing the performance of various algorithms used for this purpose and their relative merits and demerits. Where the BER, No. of Users, Modulation Techniques were of prime importance so as to integrate them with coming wireless communication systems.

1.8 CONTRIBUTIONS OF THE THESIS

Major contributions of this thesis are:

- Comprehensive study of 3G/4G OFDM and CDMA based wireless Communication systems.
- Comprehensive study of Multi User detection techniques, multiple access techniques, modulation schemes and MIMO environment for WCS.
- Review of MUD Techniques, Algorithms for OFDM and CDMA based WCS.
- Implementation considerations for MUD Techniques, Algorithms for OFDM and CDMA based WCS.
- Comparative analysis of results obtained by various implementations.
- Development of GUI for implemented Algorithms for academic use.

1.9 ORGANIZATION OF THE THESIS

The thesis is organized in the form of 14 chapters as follows:

Chapter: 1	It reviews the literature on current research, motivation for research work, major contributions of the thesis and organization of the thesis.
Chapter: 2	It gives an introduction to "Analysis and implementation of various Multi-User detection techniques and multiple access techniques in Wireless Communication Systems".
Chapter: 3	It discusses Principles and generation/reception of OFDM along with its applications and advantages.
Chapter: 4	It describes Multiple inputs Multiple outputs systems. i.e. MIMO environment for wireless communication system. It also gives details of mathematical model of MIMO as well as its advantages and disadvantages.
Chapter: 5	It discusses detail architecture of V-BLAST Algorithm implemented for OFDM and CDMA based wireless communication system using MIMO environment.

Chapter: 6 It gives detail about MATLAB implemented OFDM MIMO V-BLAST transmitter and receiver system models and CDMA MIMO V-BLAST transmitter and receiver system model. It also discusses interference cancellation techniques.

Chapter: 7 It describes various modulation schemes and spreading codes used for MATLAB simulation of OFDM and CDMA based MIMO V-BLAST for Multi-user detection.

Chapter:8 It discusses detail architecture of Genetic Algorithm implemented for CDMA based Multi-user detection techniques.

Chapter:9 It describes GA assisted MUD for CDMA systems. It also gives details about S-CDMA system model implemented and its performance. It also mentions various modulation scheme and spreading codes used for MATLAB simulation.

Chapter: 10 It compares genetic Algorithm with ZF and MMSE implemented earlier for multi user detection techniques in CDMA based wireless communication systems and proves the superiority of GA over ZF and MMSE for the same.

Chapter: 11 It describes compete architecture of PDA Algorithm implemented for Multi-user detection techniques for CDMA based systems.

Chapter: 12 It compares PDA Algorithm with ZF and MMSE implemented earlier for multi user detection techniques in CDMA based wireless communication systems and analyze performance of the same.

Chapter: 13 Analysis of Results which have been obtained by implementing various multi user detection techniques based on V-BLAST, GA, PDA for OFDM and CDMA based systems considering various parameters like modulation scheme, BER, no. of users, spreading codes and channels.

Chapter: 14 It discusses comparison based on implemented algorithms as well as parameters mention in chapter no.13 for CDMA and OFDM based WCS and author proposes probably best techniques based on conclusions derived from various implementations. It also proposes future scopes of this work.

Appendix A Bibliography

1.10. LIST OF PAPERS (BASED ON THE RESEARCH WORK) PRESENTED

Sr. No	Titles	Names of Authors	Journal /Conference	Year of publication
1.	Mobile Communication Networks & Algorithms	K.G.Maradia	CSI journal of Communications. Computer society of India ISSN 0970647X,Redg.No Tech/47489/MBI/2003-05	Aug.-2004 VOL.-28

2.	Opportunities & Threats for implementation of 4G cellular Networks.	K.G.Maradia D.S. Parmar	CSI journal of Communications. Computer society of india ISSN 0970647X,Redg.No Tech/47489/MBI/ 2003-05	Octo.-2005 Vol.-29 Special issue on MEDIA CONVERGENCE
3	Implementation of V_BLAST Algorithm For MIMO-OFDM Based Multi-user Wireless Communication System	K.G.Maradia A.C.Suthar	National Conference on Broadband Communication System-2006 at VIIT,pune on 2-3 Sept.-2006	Sept-01 to Sept-03 2006
4	WI-MAX Technology:A Solution For Morden Day Teleccom	K.G.Maradia	VOX POPULI	Jan-June 2007,Vol.-2
5	Genetic Algorithm For MUD in CDMA Based Wireless Communication	K.G.Maradia Prof S.M.Joshi B.S.Paramar	Smart Computing and Communication SCAC at EE Dept.,FTE. Baroda	Jan-28 2007
6.	Implementation and Comparison of Linear Algorithm For CDMA based Multi-user detection Techniques using MATLAB	K.G.Maradia Prof S.M.Joshi H.L.Jundal	National Conference on Smart Communication Technologies and industrial Informatics (SCTII)-2007 at NIT Rourkela.	Feb-02 t0 Feb-03 2007
7.	Genetic Algorithm For MUD in CDMA Based Wireless Communication	K.G.Maradia Prof S.M.Joshi B.S.Paramar	Zonal Seminar on Wi-Max Tech.,by IETE at Vadodara	Feb-18 2007
8.	Genetic Algorithm for CDMA Based MUD	K.G.Maradia Prof S.M.Joshi B.S.Paramar	International Conference on Emerging Tech. and Appl. In Engg.,Tech. and Science at Computer Science Dept.,S.U. Rajkot	Jan-13,14 2008

9.	Implementation and Analysis of CDMA Based MIMO-V-BLAST For MUD Using ZF and MMSE	K.G.Maradia Prof S.M.Joshi AjayPatil	International Conference on Emerging Tech. and Appl. In Engg.,Tech. and Science at Computer Science Dept.,S.U. Rajkot	Jan-13,14 2008
10.	4G: An Ultimate Mobile Solution	K.G.Maradia Aswar Bhima B.	Electronics For You	Feb-2008 Vol.-40 No.-2 ISSN 0013-516X
11	Implementation & Analysis of PDA algorithm for CDMA Based MUD under AWGN channel.	K.G.Maradia Prof S.M.Joshi Ketan Prajapati	International Journal IJ-CA-ETS, ISSN:0974-3596,Volume-1,Issue-2	Sept.-2009
12	Implementation & Comparison of GA for CDMA Based MUD	K.G.Maradia Prof S.M.Joshi Jayesh Patel	International Journal ICFAI Journal	Oct.-2009
13	Implementation & Analysis of OFDM based MIMO V-BLAST for MUD using ZF & MMSE.	K.G.Maradia Prof S.M.Joshi AjayPatil	International Journal IJ-ETA-ETS,ISSN:0974-3588,Vol.2,Issue-2,	Dec-2009
14	Implementation of ZF linear algorithm for CDMA based MUD Techniques using MATLAB.	K.G.Maradia Prof S.M.Joshi H.L.Jundal	International Journal IJ-ETA-ETS,ISSN:0974-3588,Vol.2,Issue-2,	Dec-2009
15.	Implementation of Genetic algorithm for CDMA Based Multi-User Detection Techniques	K.G. Maradia Prof. S. M. Joshi,B.S. Parmar	Int. Conf. on ICEVD_2008 at Padmshri Dr. Vithalrao Vikhe Patil College of Engg. Ahmednagar,Maharastra	2008