A Review on Alamouti Space-Time Block Codes in MIMO System

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Abstract: Wireless designers constantly seek to improve the spectrum efficiency/capacity, coverage of wireless networks, and link reliability. Space-time wireless technology that uses multiple antennas along with appropriate signalling and receiver techniques offers a powerful tool for improving wireless performance. Some aspects of this technology have already been incorporated into various wireless network and cellular mobile standards. More advanced MIMO techniques are planned for future mobile networks, wireless local area network (LANs) and wide area network (WANs). Multiple antennas when used with appropriate space-time coding (STC) techniques can achieve huge performance gains in multipath fading wireless links.

Keywords: MIMO, LAN, STC, Wireless

1. Introduction:

Wireless is the fastest growing segment of the communications market in the world. It has a wide range of services from satellites that provide low bit rates but global coverage and cellular systems with continental coverage to high bit rate local area networks and personal area networks with a maximum range of a few to a hundred meters. Using a cellular system is by far the most common wireless method to access data or perform voice dialing. In the near future, we will expect seamless global roaming across different wireless networks and ubiquitous access to personalized applications and rich content via a universal and user-friendly interface. Yet, in this climate, researchers still struggle with the fundamental questions about the physical limitations of communicating over wireless channel. These include multipath fading, limited spectrum resources, multiple-access interference, and limited battery life of mobile devices.

In this paper we consider the use of multiple antenna elements at both the transmitter and the receiver ends to improve a wireless connection. BER for MIMO STBC can be calculated in many ways but in this paper we aiming to calculate the BER of MIMO STBC system in BPSK and QPSK modulation by using detection techniques in Rayleigh fading channel. We used here 2Tx, 2Rx and 4Tx, 4Rx MIMO STBC system.

2. Related Work:

In 1998 Mr. Siavash M. Alamouti suggested, "A Simple Transmit Diversity Technique for Wireless Communications". He Proposed a simple two-branch transmit diversity scheme. Using two transmit antennas and one receive antenna the scheme provides the same diversity order as maximal-ratio receiver combining (MRRC) with one transmit antenna, and two receive antennas. It is also shown that the scheme may easily be generalized to two transmit antennas and M receive antennas to provide a diversity order of 2M. The new scheme does not require any bandwidth expansion any feedback from the receiver to the transmitter and its computation complexity is similar to MRRC [1].

In 1999 Mr. Vahid Tarokh, Hamid Jafarkhani and A.R. Calderbank suggested, "Space-Time Block Codes from Orthogonal Designs". They Proposed Space–time block coding, a new paradigm for communication over Rayleigh fading channels using multiple transmit antennas. Data is encoded using a space–time block code and the encoded data is split into n streams which are simultaneously transmitted using n transmit antennas. The received signal at each receive antenna is a linear superposition of the n transmitted signals perturbed by noise. Maximum likelihood decoding is achieved in a simple way through decoupling of the signals transmitted from different antennas rather than joint detection. This uses the orthogonal structure of the space–time block code and gives a maximum-likelihood decoding algorithm which is based only on linear processing at the receiver. Space–time block codes are designed to achieve the maximum diversity order for a given number of transmit and receive antennas subject to the constraint of having a simple decoding algorithm. The classical mathematical framework of orthogonal designs is applied to construct space–time block codes. It is shown that space–time block codes constructed in this way only exist for few sporadic values of n. Subsequently, a generalization of orthogonal designs is shown to provide space–time block codes for both real and complex constellations for any number of transmit antennas. These codes achieve the maximum possible transmission rate for any number of transmit antennas using any arbitrary real constellation such as PAM. For an arbitrary complex constellation such as PSK and QAM, space–time block codes are designed that achieve 1/2 of the maximum possible transmission rate for any number of transmit antennas. For the specific cases of two, three, and four transmit antennas, space–time block codes are designed that achieve, respectively, all, 3/4, and 3/4 of maximum possible transmission rate using arbitrary complex constellations. The best trade-off between the decoding delay and the number of transmit antennas is also computed and it is shown that many of the codes presented here are optimal in this sense as well [2].

In 2002 Mr. Yi Gong and Khaled Ben Letaief Suggested, "Concatenated Space-Time Block Coded Modulation in Fading Channels". They Proposed Trellis coded modulation (TCM) is a bandwidth efficient transmission scheme that can achieve high coding gain by integrating coding and modulation. This paper presents an analytical expression for the error event probability of concatenated space–time block coding with TCM which reveals some dominant factors affecting the system performance over slow fading channels when perfect interleavers are used. This leads to establishing the design criteria for constructing optimal trellis codes of such concatenated system over slow flat fading channels. Through simulation, significant performance improvement is shown to be obtained by concatenating the interleaved streams of these codes with space–time block codes over fading channels. Simulation results also demonstrate that these trellis codes have better error performance than traditional codes designed for single-antenna Gaussian or fading channels. Performance results over quasi-static fading channels without interleaving are also compared in this paper. Furthermore, it is shown that concatenated space–time block coding with TCM (with/without interleaving) outperforms space–time trellis codes under the same spectral efficiency, trellis complexity, and signal constellation [3].

In 2002 Mr. Dhananjay A. Gore and Arogyaswami J. Paulraj Suggested, "MIMO Antenna Subset Selection With Space-Time Coding". They Proposed Multiple-input multiple-output (MIMO) antenna subset selection employing space-time coding. We consider two cases differentiated based on the type of channel knowledge used in the selection process. We address both the selection algorithms and the performance analysis. We first consider the case when the antenna subsets are selected based on exact channel knowledge (ECK). Our results assume the transmission of orthogonal space-time block codes (with emphasis on the Alamouti code). Next, we treat the case of antenna subset selection when statistical channel knowledge (SCK) is employed by the selection algorithm. This analysis is applicable to general space-time coding schemes. When ECK is available, we show that the selection algorithm chooses the antenna set that maximizes the channel Frobenius norm leading to both coding and diversity gain. When SCK is available, the selection algorithm chooses the antenna set that maximizes the determinant of the covariance of the vectorized channel leading mostly to a coding gain. In case of ECK-based selection, we provide analytical expressions for average SNR and outage probability improvement. For the case when SCK-based selection is used, we derive expressions for coding gain. We also present extensive simulation studies, validating our results [4].

In 2002 Mr. David Gesbert, Helmut Bolcskei, Dhananjay A. Gore and Arogyaswami J. Paulraj Suggested, "Outdoor MIMO Wireless Channel: Models and Performance Prediction". They Proposed a new model for multiple-input–multiple-output (MIMO) outdoor wireless fading channels and their capacity performance. The proposed model is more general and realistic than the usual independent and identically distributed (i.i.d.) model, and allows us to investigate the behaviour of channel capacity as a function of the scattering radii at transmitter and receiver, distance between the transmit and receive arrays, and antenna beam widths and spacing. We show how MIMO capacity is governed by spatial fading correlation and the condition number of the channel matrix through specific sets of propagation parameters. The proposed model explains the existence of "pinhole" channels which exhibit low spatial fading correlation at both ends of the link but still have poor rank properties, and hence, low ergodic capacity. In fact, the model suggests the existence of a more general family of channels spanning continuously from full rank i.i.d. to low-rank pinhole cases. We suggest guidelines for predicting high rank (and hence, high ergodic capacity) in MIMO channels, and show that even at long ranges, high channel rank can easily be sustained under mild scattering conditions. Finally, we validate our results by simulations using ray tracing techniques. Connections with basic antenna theory are made [5].

In 2003 Mr. Macro Chiani, Moe Z. Win and Alberto Zanella Suggested, "On the Capacity of Spatially Correlated MIMO Rayleigh-Fading Channels". They proposed the capacity distribution of spatially correlated, multiple-input–multiple-output (MIMO) channels. In particular, we derive a concise closed-form expression for the characteristic function (c.f.) of MIMO system capacity with arbitrary correlation among the transmitting antennas or among the receiving antennas in frequency-flat Rayleigh-fading environments. Using the exact expression of the c.f., the probability density function (pdf) and the cumulative distribution function (CDF) can be easily obtained, thus enabling the exact evaluation of the outage and mean capacity of spatially correlated MIMO channels. Our results are valid for scenarios with the number of transmitting antennas greater than or equal to that of receiving antennas with arbitrary correlation among them. Moreover, the results are valid for an arbitrary number of transmitting and receiving antennas in uncorrelated MIMO channels. It is shown that the capacity loss is negligible even with a correlation coefficient between two adjacent antennas as large as 0.5 for exponential correlation model. Finally, we derive an exact expression for the mean value of the capacity for arbitrary correlation matrices [6].

In 2003 Mr. Naofal Al-dhahir Suggested, "A New High-Rate Differential Space-Time Block Coding Scheme". He Proposed a new high-rate differential space-time transmission scheme based on spatial multiplexing of Alamouti-encoded information streams is developed in this letter. At the receiver, joint space-time differential interference cancellation and decoding is performed, realizing diversity and rate gains, without requiring channel knowledge or bandwidth expansion. Our focus is on the case of two information streams with two transmit antennas per stream on flat-fading channels for simplicity. However, the development readily extends to more than two information streams, to more than two transmit antennas per stream, and to frequency-selective channels using previously published techniques [7].

In 2003 Mr. Suhas N. Diggavi, Naofal Al-Dhahir and A.R. Calderbank Suggested, "Algebraic Properties of Space-Time Block Codes in Intersymbol Interference Multiple-Access Channels". They Proposed the multiple-access channel where users employ space–time block codes (STBC). The problem is formulated in the context of an intersymbol interference (ISI) multiple-access channel which occurs for transmission over frequency- selective channels. The algebraic structure of the STBC is utilized to design joint interference suppression, equalization, and decoding schemes. Each of the K users transmits using $M_t = 2$ transmit antennas and a time-reversed STBC suitable for frequency- selective channels. We first show that a diversity order of $2M_t(v+1)$ is achievable at full transmission rate for each user, when we have M_r receive antennas, channel memory of v, and an optimal multiuser maximum-likelihood (ML) decoder is used. Due to the decoding complexity of the ML detector we study the algebraic structure of linear multiuser detectors which utilize the properties of the STBC. We do this both in the transform (D-domain) formulation and when we impose finite block-length constraints (matrix formulation). The receiver is designed to utilize the algebraic structure of the codes in order to preserve the block quaternionic structure of the equivalent channel for each user. We also explore some algebraic properties of D-domain quaternionic matrices and of quaternionic block circulant matrices that arise in this study [8].

In 2003 Mr. Harold Artes, Dominik Seethaler and Franz Hlawatsch Suggested, "Efficient Detection Algorithms For MIMO Channels: A Geometrical Approach to Approximate

ML Detection". They Proposed It is well known that suboptimal detection schemes for multiple-input multiple-output (MIMO) spatial multiplexing systems (equalization-based schemes as well as nulling-and-cancelling schemes) are unable to exploit all of the available diversity, and thus, their performance is inferior to ML detection. Motivated by experimental evidence that this inferior performance is primarily caused by the inability of suboptimal schemes to deal with "bad" (i.e., poorly conditioned) channel realizations, we study the decision regions of suboptimal schemes for bad channels. Based on a simplified model for bad channels, we then develop two computationally efficient detection algorithms that are robust to bad channels. In particular, the novel sphere-projection algorithm (SPA) is a simple add-on to standard suboptimal detectors that is able to achieve near-ML performance and significantly increased diversity gains. The SPA's computational complexity is comparable with that of nulling-and-cancelling detectors and only a fraction of that of the Fincke–Phost sphere-decoding algorithm for ML detection [9].

In 2004 Mr. Ben Lu, Guosen yue and Xiaodong Wang Suggested, "Performance Analysis and Design Optimization of LDPC-Coded MIMO OFDM Systems". They Proposed the performance analysis and design optimization of low-density parity check (LDPC) coded multiple-input multiple-output (MIMO) orthogonal frequency-division multiplexing (OFDM) systems for high data rate wireless transmission. The tools of density evolution with mixture Gaussian approximations are used to optimize irregular LDPC codes and to compute minimum operational signal-to-noise ratios (SNRs) for ergodic MIMO OFDM channels. In particular, the optimization is done for various MIMO OFDM system configurations, which include a different number of antennas, different channel models, and different demodulation schemes; the optimized performances compared with the corresponding channel capacity. It is shown that along with the optimized irregular LDPC codes, a turbo iterative receiver that consists of a soft maximum a posteriori (MAP) demodulator and a belief-propagation LDPC decoder can perform within 1 dB from the ergodic capacity of the MIMO OFDM systems under consideration. It is also shown that compared with the optimal MAP demodulator-based receivers, the receivers employing a low-complexity linear minimum mean-square-error soft-interference-cancellation (LMMSE-SIC) demodulator have a small performance loss (1dB) in spatially uncorrelated MIMO channels but suffer extra performance loss in MIMO channels with spatial correlation. Finally, from the LDPC profiles that already are optimized for ergodic channels, we heuristically construct small block-size irregular LDPC codes for outage MIMO OFDM channels; as shown from simulation results, the irregular LDPC codes constructed here are helpful in expediting the convergence of the iterative receivers [10].

In 2004 Mr. Gordon L. Stuber, John R. Barry, Steve W. Mclaughlin, Ye(Geoffrey) Li, and Thomas G. Pratt and Mrs Mary Ann Ingram Suggested, "Broadband MIMO-OFDM Wireless Communications". They Proposed Orthogonal frequency division multiplexing (OFDM) is a popular method for high data rate wireless transmission. OFDM may be combined with antenna arrays at the transmitter and receiver to increase the diversity gain and/or to enhance the system capacity on stime-variant and frequency-selective channels, resulting in a multiple-input multiple-output (MIMO) configuration. This paper explores various physical layer research challenges in MIMO-OFDM system design, including physical channel measurements and modelling, analog beam forming techniques using adaptive antenna arrays, space–time techniques for MIMO-OFDM, error control coding techniques, OFDM preamble and packet design, and signal processing algorithms used for performing time and frequency synchronization, channel estimation, and channel tracking in MIMO-OFDM systems. Finally, the paper considers a software radio implementation of MIMO-OFDM [11].

In 2004 Mr. Narayan Prasad and Mahesh K. Varanasi Suggested, "Analysis of Decision Feedback Detection for MIMO Rayleigh-Fading Channels and the Optimization of Power and Rate Allocations". They Proposed for an uncoded, K-transmit, N-receive antenna coherent narrow-band communication system employing a decorrelating decision feedback detector (D-DFD), the exact average (over channel realizations) joint error probability (JEP) as well as the average per-symbol error probabilities (SEPs) are derived without making any simplifying assumptions on error propagation. It is proved that the diversity orders of the JEP and the SEP (of every symbol) is limited by error propagation to N-K+1. Based on our exact error probability analysis, however, we suggest an optimization of JEP over nonnegative quadrature amplitude modulation (QAM) constellation sizes (rates) and average powers across transmitters which yield significant improvements over the usual equal power and equal rate assignment. In fact, the JEP of such an optimized design has the much improved diversity order of N (which is also the diversity order obtained through the optimum maximum-likelihood (ML) detector). Moreover, it is seen that these simple optimized designs can achieve a significant fraction of the ϵ-outage capacity even without outer codes. It is also known but only through simulations that when the symbols are detected in certain channel realization-dependent orders it is possible to improve substantially over fixed-order detection in the case of the equal rate and equal power assignment. We provide an analysis for a recently proposed channel-dependent ordering rule and show that it does not provide an improvement of the diversity order of the JEP beyond N-K+1. Another ordering rule that was proposed earlier to maximize the worst case post-detection signal-tonoise ratio (SNR) under the perfect feedback assumption is shown to be optimal under a more compelling criterion that does not involve that simplifying assumption. While efficiently computable, this ordering rule is seen to perform almost as well as the optimal channel-dependent ordering rule that minimizes the conditional JEP (and hence the JEP). Nevertheless, a multiple-input multiple output (MIMO) system with an optimized rate and power allocation and a fixed order of detection is not only less complex but also has a significantly lower JEP than that of the equal-power, equal-rate system, where transmitters are detected in a channel-dependent order, optimal or otherwise [12].

In 2004 Mr. Michael A. Jensen and Jon W. Wallance suggested, "A Review of Antenna and Propagation for MIMO Wireless Communications". They Proposed Multiple-input–multiple-output (MIMO) wireless systems use multiple antenna elements at transmit and receive to offer improved capacity over single antenna topologies in multipath channels. In such systems, the antenna properties as well as the multipath channel characteristics play a key role in determining communication performance. This paper reviews recent research findings concerning antennas and propagation in MIMO systems. Issues considered include channel capacity computation, channel measurement and modelling approaches, and the impact of antenna element properties and array configuration on system performance. Throughout the discussion, outstanding research questions in these areas are highlighted [13].

In 2004 Mr. Molisch A. and Win M. Suggested, "MIMO System with Antenna Selection- An Overview". They Proposed Multiple-input multiple-output (MIMO) systems with reduced complexity. Either one, or both, link ends choose the best L out of N available antennas. This implies that only L instead of N transceiver chains have to be built, and also the signal processing can be simplified. We show that in ideal channels, full diversity order can be achieved, and also the number of independent data streams for spatial multiplexing can be maintained if certain conditions on L are fulfilled. We then discuss the impact of system non idealities such as noisy channel estimation, correlations of the received signals, etc [14].

In 2004 Mr. Markus Rupp, Gerhard Gritsch and Hans Weinrichter Suggested, "Approximate ML Detection for MIMO Systems with very Low Complexity". They Proposed recently many Space-Time Coding schemes for multiple antenna systems (MIMO) have been proposed in order to achieve high data rate when transmitting over wireless channels. However, most of such schemes rely on Maximum Likelihood (ML) detection which can become quite complex when many antennas are involved and higher modulation schemes are utilized. On the other hand, the high diversity gains of MIMO channels are easily lost when low complexity receivers like ZF or MMSE are applied. It is thus of utmost importance to look for low-complexity receivers which achieve almost ML performance. In this paper, a new scheme for approximate ML detection for typical flat Rayleigh fading channels is proposed achieving ML performance in the area of Bit Error Ratio between 〖10〗^(-4) and 0.1 as it is of interest in wireless communications. The proposed scheme allows to transmit 64QAM schemes on 4×4 antenna schemes with a detection complexity of only 1% of a brute force ML receiver [15].

In 2005 Mr. Xiaohua(Edward) Li, Mo Chen and Wenyu Liu Suggested, "Application of STBC-Encoded Cooperative Transmissions in Wireless Sensor Networks". They Proposed the efficiency of space-time block code-encoded (STBC) cooperative transmission is studied within low-energy adaptive clustering hierarchy (LEACH), which is a typical networking communication protocol for wireless sensor networks. Cooperation protocol with low overhead is proposed, and synchronization requirements among cooperating sensors are discussed. Energy efficiency is analyzed as a tradeoff between the reduced transmission energy consumption and the increased electronic and overhead energy consumption. Simulations show that with proper design, cooperative transmission can enhance energy efficiency and prolong sensor network lifetime [16].

In 2006 Mr. Georgios K. Psaltopoulos, Michael Joham and Wolfgang Utschick Suggested, "Generalized MMSE Detection Techniques for Multipoint-to-Point Systems". They Proposed we propose a receiver for multipoint-to-point systems based on the minimum mean square error (MMSE) criterion, where the symbols are detected in groups and already detected symbols are fed back for interference subtraction, as known for decision feedback equalization (DFE). The proposed scaled DFE (SDFE) has two special cases: 1) DFE for a group size of one, i.e., for symbol-by-symbol detection. 2) Maximum likelihood detection (MLD), if the group comprises all transmitted symbols. The diversity order of SDFE lies between the poor diversity order of DFE and the full diversity order of MLD. Therefore, SDFE offers a trade-off between complexity due to the group-wise symbol detection and the increased diversity order compared to DFE. We also present an algorithm to compute the SDFE filters with an order of complexity which is the same as that to compute linear equalization filters. Motivated by the promising results of detectors based on lattice reduction (LR), we combine SDFE with LR. The resulting detector exhibits full diversity order and improved performance compared to LR-DFE. The simulations show that SDFE is an interesting generalization of DFE for detectors with zero-forcing constraint, since SDFE even outperforms LR-DFE for realistic signal-to-noise ratio (SNR). However, LR-DFE exhibits the best results for an affordable complexity, when dropping the zero-forcing constraint [17].

In 2007 Mr. Fan Wang, Yong Xiong and Ziumei Yang Suggested, "Approximate ML Detection Based on MMSE for MIMO Systems". They Proposed we derive two types of approximate maximum likelihood (ML) detection based on minimum mean squared error (MMSE), MMSE-CML (conditional ML) detection and MMSE-CLML (conditional local ML) detection, for MIMO communication system. A simple reliability judge rule to judge the estimate of the transmit symbols is also given. For the proposed MMSE-CML detection, received signals are first sent into MMSE detector to do linear equalization, then the estimate of transmit signals is judged in reliability judge module; If the estimate is judged to be reliable, we take the estimate as the final result; if not, the received signals are then sent into conditional ML (CML) detector to get the final result; Unlike conventional ML detector, the CML detector performs a tree search till the estimate satisfies the reliability judge rule or an entire tree search has been done. For the proposed MMSE-CLML detection, we use CLML search instead of CML search in MMSE-CML, which searches in the neighbourhood of the output provided by the MMSE detector. Simulation results show that the MMSE-CML detector achieves near the same performance as optimal CML detector at reduced complexity, and MMSE-CLML detector achieves suboptimal performance at remarkably reduced complexity [18].

In 2007 Mr. Anastasios G. Gravalos, Marios G. Handjinicolaou and Qiang Ni Suggested, "Performance analysis of IEEE 802.11n under different STBC rates using 64-QAM". They Proposed the main focus of current research and development for the next-generation wireless local area network (WLAN) communication systems is to enhance the link throughput and channel capacity. In this paper, the performance analysis of the ongoing next-generation WLAN standard, IEEE 802.11n high throughput WLAN PHY layer is presented. The design criteria is based on a 4x4 MIMO-OFDM scheme using 64-QAM (Quadrature Amplitude Modulation) technique under Rayleigh frequency-selective fading and flat fading channels. Simulation results show that a significant performance gain, 4~7 dB, depending on the channel selection, can be achieved when 1/2 space-time block code (STBC) rate is applied with respect to bit-error-rate (BER). Furthermore, performance gain of 7 dB is achieved when the 4x4 system using 1/2 STBC is compared with a 2x2 system using STBC code rate [19].

In 2008 Mr. Tianogao Gou and Syed A. Jafar Suggested, "Degree of Freedom of the K user M×N MIMO Interference Channel". They Proposed we provide inner bound and outer bound for the total number of degrees of freedom of the K user multiple input multiple output (MIMO) Gaussian interference channel with M antennas at each transmitter and N antennas at each receiver if the channel coefficients are time-varying and drawn from a continuous distribution. The bounds are tight when the ratio $(\max(M,N))/(\min(M,N))=R$ is equal to an integer. For this case, we show that the total number of degrees of freedom is equal to $\min(M,N)$ if $K \leq R$ and $\min(M,N) \; R/(R+1)$ if $K>R$. Achievability is based on interference alignment. We also provide examples where using interference alignment combined with zero forcing can achieve more degrees of freedom than merely zero forcing for some MIMO interference channels with constant channel coefficients [20].

In 2008 Mr. Charlotte Dumard and Thomas Zemen Suggested, "Low-Complexity MIMO Multiuser Receiver: A Joint Antenna detection Scheme for Time-Varying Channels". They Proposed this paper deals with the uplink of a wireless multiple- input multiple-output (MIMO) communication system based on multicarrier (MC) code division multiple access (CDMA). We focus on time-varying channels for users moving at vehicular speeds. The optimal maximum a posteriori (MAP) receiver for such a system is prohibitively complex and can be approximated using iterative linear minimum mean-square error (LMMSE) multiuser detection and parallel interference cancellation (PIC). For time-varying channels, two LMMSE filters for channel estimation and multiuser detection need to be computed at every time instant, making implementation in a real-time system difficult. We develop a novel low-complexity receiver that exploits the multiple antenna structure of the system and performs joint iterative multiuser detection and channel estimation. Our receiver algorithms are based on the Krylov subspace method, which solves a linear system with low complexity, trading accuracy for efficiency. The computational complexity of the channel estimator can be reduced by one order of magnitude. For multiuser detection, a PIC scheme in the user space, i.e., after the matched filter, allows simultaneous detection of all users as well as drastic computational complexity reduction by more than one order of magnitude [21].

In 2008 Mr. T.Y. Al-Naffouri and A.A. Quadder Suggested, "A Forward-Backward Kalman Filter-based STBC MIMO OFDM Receiver". They Proposed Orthogonal frequency division multiplexing (OFDM) has emerged as a modulation scheme that can achieve high data rates over frequency selective fading channel by efficiently handling multipath effects. This paper proposes receiver design for spacetime block coded MIMO OFDM transmission over frequency selective time-variant channels. Joint channel and data recovery are performed at the receiver by utilizing the expectation-maximization (EM) algorithm. It makes collective use of the data constraints (pilots, cyclic prefix, the finite alphabet constraint, and space-time block coding) and channel constraints (finite delay spread, frequency and time correlation, and transmit and receive correlation) to implement an effective receiver. The channel estimation part of the receiver boils down to an EM-based forward-backward Kalman filter. A forward-only Kalman filter is also proposed to avoid the latency involved in estimation. Simulation results show that the proposed receiver outperforms other least-squares-based iterative receivers [22].

In 2009 Mr Luis Miguel Cortes-Pena Suggested, "MIMO Space-Time Block Coding (STBC) Simulations and Results". He Proposed Wireless networks have quickly become part of everyday life. Wireless LANs, cell phone networks, and personal area networks are just a few examples of widely used wireless networks. However, wireless devices are range and data rate limited. The research community has spent a great deal of effort on finding ways to overcome these limitations. One method is to use Multiple-Input Multiple-Output (MIMO) links. The multiple antennas allow MIMO systems to perform precoding (multi-layer beam forming), diversity coding (space-time coding), and spatial multiplexing. Beam forming consists of transmitting the same signal with different gain and phase (called wights) over all transmit antennas such that the receiver signal is maximized. Diversity consists of transmitting a single space-time coded stream through all antennas. Spatial multiplexing increases network capacity by splitting a high rate signal into multiple lower rate streams and transmitting them through the different antennas. In spatial multiplexing, the receiver can successfully decode each stream given that the received signals have sufficient spatial signatures and that the receiver has enough antennas to separate the streams. The result of using these MIMO techniques is higher data rate or longer transmit range without requiring additional bandwidth or transmit power. This paper presents a detailed study of diversity coding for MIMO systems. Different space-time block coding (STBC) schemes including Alamouti's STBC for 2 transmit antennas as well as orthogonal STBC for 3 and 4 transmit antennas are explored. Finally, these STBC techniques are implemented in MATLAB and analyzed for performance according to their bit-error rates using BPSK, QPSK, 16-QAM, and 64-QAM modulation schemes [23].

In 2009 Mr. Jan Mietzer, Robert Schober, Lutz Lampe, Wolfgang H. Gerstacker and Peter A. Hoeher Suggested, "Multiple-Anenna Techniques for Wireless Communications-A Comprehensive Literature Survey". They Proposed the use of multiple antennas for wireless communication systems has gained overwhelming interest during the last decade - both in academia and industry. Multiple antennas can be utilized in order to accomplish a multiplexing gain, a diversity gain, or an antenna gain, thus enhancing the bit rate, the error performance, or the signal-to-noise-plus-interference ratio of wireless systems, respectively. With an enormous amount of yearly publications, the field of multiple-antenna systems, often called multiple-input multiple-output (MIMO) systems, has evolved rapidly. To date, there are numerous papers on the performance limits of MIMO systems, and an abundance of transmitter and receiver concepts has been proposed. The objective of this literature survey is to provide non-specialists working in the general area of digital communications with a comprehensive overview of this exciting research field. To this end, the last ten years of research efforts are recapitulated, with focus on spatial multiplexing and spatial diversity techniques. In particular, topics such as transmitter and receiver structures, channel coding, MIMO techniques for frequency-selective fading channels, diversity reception and space-time coding techniques, differential and non-coherent schemes, beam forming techniques and closed loop MIMO techniques, cooperative diversity schemes, as well as practical aspects influencing the performance of multiple-antenna systems are addressed. Although the list of references is certainly not intended to be exhaustive, the publications cited will serve as a good starting point for further reading [24].

In 2010 Mr. M. Raja and Dr. P. Muthuchidambaranathan Suggested, "Performance Analysis of Closed-Loop MIMO System". They Proposed in this paper, it investigate the bit error rate (BER) performance of transmit beamforming using singular value decomposition (SVD) for closed loop multiple-input multiple-output (MIMO) wireless systems with various modulation techniques such as binary phase shift keying (BPSK), quadrature phase-shift keying (QPSK and 16-quadrature amplitude modulation (16-QAM) along with convolution encoder and viterbi decoder. Beam forming separates the MIMO channel into parallel sub channels. The beam forming vectors used at the transmitter and the receiver can be obtained by the singular value decomposition (SVD) of the MIMO channel. Signals are transmitting in the direction of the eigenvector corresponding to the largest Eigen value of the channel. The transmit beam forming is performed by multiplying the input symbols with beam forming vector (i.e.) unitary matrix and the precoded symbols are transmitted over Rayleigh fading channel. At the receiving end the transmitted signals are obtained by performing the receiver shaping by multiplying the received signal with conjugate transpose of the unitary matrix. Furthermore, derive an expression for a capacity of MIMO system and derive expressions for average BER for BPSK and average symbol error rate (SER) for M-QAM. Simulation results displays the diversity performance of the single beam forming when the three modulations are used separately and it shows the proposed SVD-based beam forming with convolution encoder yield the better performance when compare to the other beam forming method [25].

In 2010 Mr. Nirmalendu Bikas Sinha, S. Chakraborty, P.K. Sutrabhar, R.Bera and M.Mitra Suggested, "Optimization of MIMO Detectors: Unleashing the Multiplexing Gain". They Proposed Multiple Input Multiple Output (MIMO) systems have recently emerged as a key technology in wireless communication systems for increasing both data rates and system performance. There are many schemes that can be applied to MIMO systems such as space time block codes, space time trellis codes, and the Vertical Bell Labs Space-Time Architecture (V-BLAST). This paper proposes a novel signal detector scheme called MIMO detectors to enhance the performance in MIMO channels. , we study the general MIMO system, the general V-BLAST architecture with Maximum Likelihood (ML), Zero- Forcing (ZF), Minimum Mean- Square Error (MMSE), and Ordered Successive Interference Cancellation (SIC) detectors and simulate this structure in Rayleigh fading channel. Also compares the performances of MIMO system with different modulation techniques in Fading and AWGN channels. Base on frame error rates and bit error rates, we compare the performance and the computational complexity of these schemes with other existence model. Simulations shown that V-BLAST implements a detection technique, i.e. SIC receiver, based on ZF or MMSE combined with symbol cancellation and optimal ordering to improve the performance with lower complexity, although ML receiver appears to have the best SER performance-BLAST achieves symbol error rates close to the ML scheme while retaining the low-complexity nature of the V-BLAST [26].

In 2010 Mr. Nirmalendu Bikas Sinha, R. Bera and M. Mitra Suggested, "MIMO Detection Algorithms for High Data Rate Wireless Transmission". They Proposed motivated by MIMO broad-band fading channel model, in this section a comparative study is presented regarding various uncoded adaptive and non-adaptive MIMO detection algorithms with respect to BER/PER performance, and hardware complexity. All the simulations are conducted within MIMO-OFDM framework and with a packet structure similar to that of IEEE 802.11a/g standard. As the comparison results show, the RLS algorithm appears to be an affordable solution for wideband MIMO system targeting at Giga-bit wireless transmission. So MIMO can overcome huge processing power required for MIMO detection by using optimizing channel coding and MIMO detection [27].

In 2010 Mr. Ancuta Moldovan, Tudor Palade, Emanuel Puschita, Inna Vermesan and Rebeca Colda Suggested, "Performance Evalution of STBC MIMO Systems with Linear Precoding". They Proposed it is known that transmit channel side information (CSIT) is used to enhance the performance of space-time block codes based multi-antenna communication links. In this paper, we analyze how transmission algorithms can be adapted to the channel condition based on the degree of the available CSIT and the system diversity order. The precoding design criterion considered is minimizing the average pairwise error probability. The analyzed parameters are the bit error rate (BER) and the link throughput [28].

In 2011 Mr. Hyoung-Muk Lim, Won-Jun Choi, Jae-Seon Yoon and Hyoung-Kyu Song Suggested, "An Improved STBC Structure and Transmission Scheme for High Rate and Reliability in OFDMA Cooperative Communication". They Proposed Space-time block code(STBC) has been studied to get full diversity and full rate in multiple input multiple output(MIMO) system. Achieving full rate is difficult in cooperative communications due to the each user consumes the time slots for transmitting information in cooperation phase. So combining MIMO systems with cooperative communications has been researched for full diversity and full rate. In orthogonal frequency division multiple access (OFDMA) system, it is an alternative way that each user shares their allocated sub channels instead of using the MIMO system to improve the transmission rate. In this paper, a Decode-and-forward (DF) based cooperative communication scheme is proposed. The proposed scheme has improved transmission rate and reliability in multi-path fading channel of the OFDMA up-link condition by modified STBC structure and sub channel sharing [29].

In 2011 Mr. P. Sreesudha and M. Vijaya Lakshmi Suggested, "BER Enhancement of MIMO-CDMA Based on Space-Time Block Codes". They Proposed now a days, the demand for wireless communication systems with high data rates and high capacity has dramatically increased. CDMA (Code Division Multiple access) plays an important role in modern wireless communication systems. MIMO refers to links with multiple antennas at the transmitter and receiver side. CDMA with MIMO is a very promising technique beyond 3G and 4G wireless communications. The BER performance of MIMO-CDMA system depends on its spreading strategy. In this paper MIMO-CDMA system is designed with STBC (Space-Time Block Code) matrices for spreading. The proposed technique outperforms the tdesign permutation spreading method and also the conventional method. Simulation results shows that gain improvement with STBC approach as compared to other existing techniques [30].

In 2011 Mr. Karima El Mouhib, Ahmed Oquour, Ypounes Jabrane, Brahim Ait Es Said and Abdellah Ait Ouahman Suggested, "PAPR Reduction Using BPSO/PTS and STBC in MIMO OFDM System". They Proposed the Multiple Input Multiple Output (MIMO) Orthogonal Frequency Division

Multiplexing (OFDM) system has been receiving a great attention, as one of solutions for achieving high speed, efficient and high-quality service for the wireless communications. However, the transmitted signal still has high PAPR because of OFDM characteristics. Many methods have been proposed to solve this problem, but the most of them decrease high Peak-to-Average Power Ratio (PAPR) as well as the data rate. Approach: This proposal described a new suboptimal technique for reduction of the PAPR by combining two suitable methods for MIMO OFDM systems. The first method was based on Boolean Particle Swarm intelligence Optimization (BPSO) applied to Partial transmit Sequence (PTS) and the second was the Space Time Bloc Coding (STBC). Apply only the PTS technique and independently on each transmitted antenna, was effective to reduce PAPR, but it requires high computation complexity. Therefore, the BPSO/PTS technique provided better performance and it was been promoted as an uncomplicated way for PAPR reduction. Thanks of the BPSO/PTS algorithm; the transmitted sequence was selected with minimizing the maximum PAPR over all transmission antennas. The simulations and the BER performance demonstrated that more inertia weight and phase weighting factor obtained better PAPR reduction performance without bringing much higher complexity. Results show that the added BPSO/PTS method to orthogonal space time bloc coding minimizes computational complexity cost as well as the PAPR and gives best optimal PTS performance in comparison with the conventional methods [31].

In 2011 Mr. Zhongding Lei, Chau Yuen and P.S. Chin Suggested, "Quasi-Orthogonal Space-Time Block Codes for Two Transmit Antennas and Three Time Slots". They Proposed in this paper, a class of quasi-orthogonal space-time block codes (Q-STBC) is proposed for systems with two transmit antennas and three time slots, where the Alamouti code is not applicable due to the odd time slots. The proposed Q-STBC codes achieve rate one and full diversity with low complexity maximum likelihood decoding. The Q-STBC design also shows excellent properties in other practical aspects, such as the compatibility with the single antenna transmission mode, low power fluctuation, and low receiver decoding and transmitter encoding complexity [32].

3. Conclusion:

Space-time block codes and their performance on MIMO fading channels will be presented and evaluated. First, MIMO system for the two-branch n-transmitting antennas and n-receiver antenna will be explained. After that, transmit diversity scheme referred to as Alamouti space-time code will introduce and its key features will be described. After that, space-time block codes with large number of transmit and receive antennas will be explained. This will include the coding and decoding algorithms for space-time block codes with both complex and real signal constellations.

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