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A Literature Review on STBC MIMO System with Multiple Modulation Techniques for Improving the Performance

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Abstract-Multi-input multi-output (MIMO) technology has been used to improve wireless communications systems over the past several years. The multiple antennas of MIMO systems are used to increase data rates through multiplexing gain and/or increase the reliability of the system through diversity gain. It is known that an optimum tradeoff between diversity gain and multiplexing gain can be achieved by having proper space-time block code (STBC) designs. The current STBC designs minimizing the pair-wise error probability (PEP) of the maximum likelihood (ML) detector are based mainly on the rank and the determinant criteria.

Keywords- STBC, MIMO Modulation Techniques.

I. INTRODUCTION

In wireless communication systems, the use of multiple antennas, also known as Multiple Input Multiple Output (MIMO) communications, is now a widely accepted and important technology for improving their reliability and throughput performance. Following the seminal works of Telatar [1] and Foschini [2], multiple antennas have not only been extensively studied by the academia, but also successfully implemented by the industry. Current day broadband wireless access systems such as IEEE 802.11n, 3GPP-LTE and LTE-advanced support the use of multiple antennas to improve the spectral efficiency and resilience to signal fading conditions. Fig.1 shows a simple block diagram of a MIMO communication system with Nt transmit antennas and Nr receive antennas. One of the key benefits of using multiple antennas is that the capacity of a multiple antenna link is known to increase linearly with the minimum of the number of antennas at the transmitter and receiver [1]. Hence, multiple antennas can be used to increase the number of independent signaling dimensions (also known as the multiplexing gain), and hence, the rate, of the communication link. Another important, and related, feature of MIMO systems is that the use of multiple antennas can provide diversity benefits, thereby improving the resilience to fading, since the signal arrives at the different receive antennas through independent paths. Over the past two decades, an enormous amount of research has gone into the design, analysis and optimization of MIMO communication systems, and it remains an active area of research to this day.

It is known that a significant improvement in the capacity of a MIMO communication link is possible when the Channel State Information (CSI) is available at both the transmitter and receiver [1]. When the channel undergoes frequency non-selective fading, as in, for example, narrow-band communication systems, the CSI consists of a complex-valued matrix $H \in \mathbb{C}^{Nr \times Nt}$,

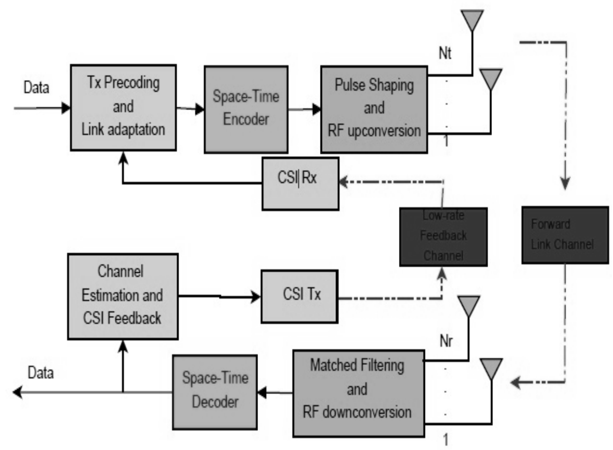

Fig 1: MIMO communication system block diagram.

whose $(i, j)^{th}$ entry contains the channel gain from the j^{th} transmit antenna to the i^{th} receive antenna, and where Nr and Nt represent the number of antennas at the receiver and transmitter, respectively. The CSI can be estimated at the receiver by sending a known training sequence from the transmitter. To acquire CSI at the transmitter, one has to either send a training sequence in the reverse direction, which is possible in Time Division Duplex (TDD) systems, or send quantized CSI on a low-rate feedback channel from the receiver to the transmitter, which is applicable to both TDD and Frequency Division Duplex (FDD) systems. Both reverse channel training and quantized feedback options are supported in many standards, for example, in the IEEE

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802.11n standard [3]. The low-rate reverse-link feedback channel needs to be designed with care, as the performance of the MIMO link depends critically on the accurate and timely availability of the CSI at the transmitter. Consequently, the problem of CSI feedback has been studied

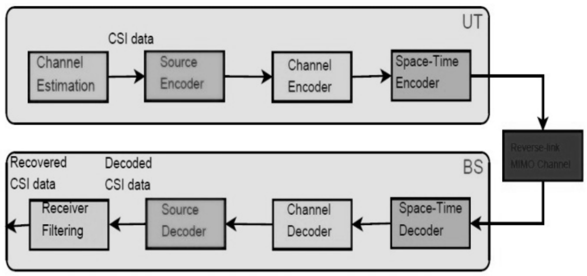

Fig. 2: Block diagram of the low-rate CSI feedback channel.

in detail in recent years (see, for example, [4] for an excellent survey of related literature). The design of the low-rate feedback channel and proposing schemes for improving its reliability and resilience to noise and fading impairments is the focus of this research. Fig. 2 shows a block diagram of the feedback channel for conveying the CSI from the receiver to the transmitter. Designing the feedback channel involves specifying each of the operations in the diagram to obtain as high a quality of received CSI at the base station transmitter as possible. Start with a brief overview of the existing MIMO CSI feedback schemes, and discuss their relative merits and shortcomings.

II. SPACE-TIME BLOCK CODES

Fundamentals of Space-Time Block Coding

Transmission schemes which do not require downlink channel estimation are usually called as open loop transmit diversity techniques. In these schemes, all antennas transmit simultaneously. As downlink channel information is not available, usually the total transmit power is distributed equally among all the antennas. Open loop schemes have less complex signaling formats and are easier to analysis in practical systems.

Space-Time Coding (STC) is an open loop transmission scheme that was introduced. In STC, joint design of channel coding and modulation is done to create efficient transmission techniques which improve system performance by providing both the diversity advantage of multiple transmit antennas and coding gain. In, space-time codes based on trellis-coded modulation (TCM) are presented. These codes are called Space-Time Trellis Codes (STTC) and their performance was shown to be very good in slow Rayleigh fading environments. The receiver for these STTC schemes uses Maximum Likelihood Sequence Estimation (MLSE) and the decoding complexity for these schemes (measured in terms of number of trellis states) increases exponentially with transmission rate for a fixed number of transmit antennas.

Introduced a simple open loop scheme which provides a transmit diversity gain similar to that obtained by using Maximal Ratio Combining (MRC) in receive diversity systems. This scheme was proposed for two transmit antennas. Symbols transmitted from these antennas are encoded in space and time in a simple manner to ensure that transmissions from both the antennas are orthogonal to each other. This would allow the receiver to decode the transmitted information with very little additional computational complexity even if it has a single antenna element. Using the theory of orthogonal designs, the simple scheme in was generalized to systems with more than two transmit antennas. These generalized schemes were called Space-Time Block Codes (STBC).

III. LITERATURE REVIEW

Anitha, M.; Siva Priya, R.; Raja Lakshmi, M.; Vijayalakshmi, S., [1] in commercial wireless communication systems, higher data rates and reliable communication is required. The challenge in system design is the multipath fading which results in weak signal strength at the receiver, this increases the Bit Error Rate (BER) of Communication Systems. Employing multiple antennas is used to get reliable performance through diversity and achievable higher data rate through spatial multiplexing. Multiple Input Multiple Output (MIMO) systems are wireless Technology with multiple antenna elements at both ends of the link to transfer more data at the same time since fading for each link is considered to be independent and have the ability to deal with multipath propagation. This research deals with BER analysis of MIMO Systems under different communication channels Additive White Gaussian Noise (AWGN) and Fading channel (Rayleigh and Rician). MIMO system uses Zero Forcing (ZF) decoder and Maximal Ratio Combining (MRC) at the receiver and encoded Alamouti STBC is used as transmit diversity. System performance in diverse modulation techniques such as BPSK, QAM and PAM is examined using MATLAB. The simulated result shows that comparing the three different channel conditions, Rician fading channel has better performance.

Singh, K.; Trivedi, A., [2] Orthogonal Frequency Division Multiplexing (OFDM) is recognized as high data rate transmission technique. Further, application of space-time block coding (STBC) to the OFDM system may help in combating severe affects of fading. In this research, space time block encoded time frequency training OFDM (TFT-OFDM) system is proposed. The TFT-OFDM signal is trained in both time and frequency domain by appending the training sequence and by inserting the grouped pilots, respectively. Such structure of signal helps in providing better spectral efficiency and reliability. The performance of proposed system is analyzed over fast fading channel and compared with various STBC based OFDM transmission schemes. These various STBC-based OFDM transmission techniques are STBC-based cyclic prefix OFDM (CP-OFDM), STBC-based zero padding OFDM (ZP-OFDM), and STBC-based time domain synchronous OFDM (TDS-OFDM). Simulation results indicate that the STBC-based TFT-OFDM is better than other STBC-based OFDM transmission techniques in BER performance.

Kitakatay, M.; Chang-Jun Ahn; Omori, T.; Hashimoto, K.-Y., [3] STBC is a technique to achieve transmit diversity. QO-STBC is full rate STBC constructed from relaxing orthogonality, and requires a decoder to search symbol pairs with ML decoding. Motivated by this, authors have proposed single symbol decodable QO-STBC with full diversity. This code achieves full transmit rate and low system complexity. However, the proposed QO-STBC can achieve a throughput performance like SISO. In order to exploit the advantages of single symbol decodable QO-STBC, the combination of the proposed QO-STBC and an adaptive modulation has been considered. The system performances of non-adaptive QO-STBC, adaptive single symbol decodable QO-STBC are evaluated and compared. It is shown that the proposed scheme can greatly improve the performance of non-adaptive QO-STBC system.

Juinn-Horng Deng; Shiang-Chyun Jhan; Sheng-Yang Huang, [4] A precoding design for double space-time block coding (STBC) system is investigated in this research, i.e., the joint processing of STBC and dirty research coding (DPC) techniques. These techniques are used for avoiding dual spatial streams interference and improving the transmitter diversity. The transceiver design involves the following procedures. First, the ordering QR decomposition of channel matrix and the maximum likelihood (ML) one-dimensional searching algorithm are proposed to acquire a reliable performance. Next, the channel on/off assignment using water filling algorithm is proposed to overcome the deep fading channel problem. Finally, the STBC-DPC system with the modulus operation to limit the transmit signal level, i.e., Tomlinson-Harashima precoding (THP) scheme, is proposed to retain low peak-to-average power ratio (PAPR) performance. Simulation results confirm that the proposed STBC-DPC/THP with water filling ML algorithm can provide the low PAPR and excellent bit error rate (BER) performances.

Jamjareegulgarn, P.,[5] The main objective of this research is to evaluate the network performance of a cooperative diversity-based wireless body area network (WBAN) by using (2,2) Alamouti's space-time block code (STBC) with pre-coding scheme (STBC-PC) and a relay selection procedure (RSP). The considered WBAN model is served for healthcare service in order to mitigate the undesired effects of WBAN due to high path loss and fading as well as to keep a low transmit power while meeting to the desired WBAN quality of services. In this research, the pre-coding scheme is taken to be employed in conjunction with the STBC; since a single antenna of each wireless sensor node in healthcare service can be exploited possibly as well as the high gain can still be achieved without loss of transmission rate. A channel model CM3 B is considered for computing the actual path loss of each WBAN link and the network performance is evaluated in terms of bit error rate (BER). The simulation results confirm that at each BER value, SNRs of STBC-PC without direct link (line-of-sight or LOS) scheme are the lowest which is compared with direct link, receive diversity and MRC, and (2,2) Alamouti's STBC. BER values of DQPSK-based STBC-PC are higher than those of DBPSK-based STBC-PC. Moreover, although any WBAN sensor nodes are chosen as a relay or any type of modulations are employed in STBC-PC with LOS, all of BER values have surprisingly the same trend.

Jun Chen; Pratt, T.G.,[6] The transmit energy efficiency (EE) of space- polarization multiple-input multiple-output (SpPol-MIMO) architectures, dual-polarized MIMO architectures (DP-MIMO), and conventional co-polarized MIMO (CP-MIMO) schemes are compared for packet-based communication systems using full multiplexing without channel state information at the transmitter. Authors develop a closed-form approximation for assessing the EE of single-input single-output (SISO) and MIMO systems and show tradeoffs that exist between EE, spectral efficiency, modulation schemes, and packet designs. Using a hardware/software testbed, authors also compare the EE among SISO, 2 × 2 CP-MIMO, 2 × 2 DP-MIMO, and 4 × 4 SpPol-MIMO architectures in frequency-selective MIMO channels. Emulation results from the test bed indicate that in the high SNR-regime, SpPol-MIMO provides the best EE performance in spatially uncorrelated channels, with EEs approximately four and two times better than SISO and 2 × 2 MIMO architectures, respectively. At low SNR, SISO systems offer the best energy efficiency but also exhibit the lowest data rates. For all of the architectures, operating points are identified that provide near achievable data rates while operating at a local minimum in energy consumption.

Brookner, E., [7] Contrary to claims made Multiple Input and Multiple Output (MIMO) radars do not provide an order of magnitude better angle resolution, accuracy and identifiability over conventional radars. What is claimed: MIMO array radar system consisting of a full transmit array and thinned receive array (or vice versa; called here a full/thin array) provides an order of magnitude or more of accuracy, resolution and identifiability, the ability to resolve and identify targets than a conventional array. This claim for MIMO results from making the wrong comparison to a full conventional array rather than to a conventional full/thin array. It is shown here that a conventional full/thin array radar can have the same angle accuracy, resolution as a MIMO full/thin array. When searching a small scan angle, the subarrays should be sized so that the volume of space illuminated by the subarrays of the SA-MIMO array matches, or is smaller than, the volume of space to be searched. Using SA-MIMO reduces the processing throughput requirements. MIMO radar in the near term will be useful for coherent and incoherent combining of existing radars to achieve about a 9 dB better power-aperture-gain (PAG).

Jun Chen; Pratt, T.,[8] Space-polarization multiple input multiple output (SP-MIMO) communication systems can provide improved reliability, increased data rates, and higher energy efficiency as compared to conventional co-polarized MIMO (CP-MIMO) systems. To achieve these gains relative to CP-MIMO arrays, SP-MIMO architectures employ a dual-polarized (DP) antenna at each of the antenna locations, effectively doubling the number of ports without substantially increasing the footprint of antenna arrays. CP-MIMO schemes have been explored rigorously in literature, however very few results are available for DP-MIMO and SP-MIMO systems, particularly over realistic and imperfect channels. In this paper, authors present the design of a state-of-the-art 4×4 SP-MIMO wireless communications system testbed to enable comparative performance studies. Examples show that SP-MIMO architectures achieve performance shifts in capacity (bit/s/Hz), bit-error-rate (BER), packet-error-rate (PER) and energy efficiencies (Joule/bit) relative to CP-MIMO systems.

IV. PROBLEM IDENTIFICATION

MIMO system Performance can analyzed using different Modulation schemes in different channel conditions with STBC encoder, ZF and MRC receivers only used and it can be improved by using other different technics. The BER performance of Rician channel in MIMO system is not much better than that of A WGN and Rayleigh channel using BPSK Modulation. Comparing the Equalization technique, MRC is the Equalization technique for MIMO systems. According to the simulation parameters, comparing BPSK modulation, 4- QAM, 16-QAM and 4-PAM, it is observed that BER is low for BPSK, so BPSK Modulation scheme not performed best modulation technique for data transmission that is not suitable for the Rician channel and also for MRC equalizers.

V. CONCULSION

In commercial wireless communication systems, higher data rates and reliable communication is required. The challenge in system design is the multipath fading which results in weak signal strength at the receiver, this increases the Bit Error Rate (BER) of Communication Systems. Employing multiple antennas is used to get reliable performance through diversity and achievable higher data rate through spatial multiplexing. Multiple Input Multiple Output (MIMO) systems are wireless Technology with multiple antenna elements at both ends of the link to transfer more data at the same time since fading for each link is considered to be independent and have the ability to deal with multipath propagation. This synopsis relates with BER analysis of MIMO Systems under different communication channels which can be further more improved in Additive White Gaussian Noise (A WGN) and Fading channel (Rayleigh and Rician). MIMO system uses Zero Forcing (ZF) decoder and Maximal Ratio Combining (MRC) at the receiver and encoded Alamouti STBC can be used as transmit diversity..

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