Review on BER ANALYSIS OF MIMO-OFDM SYSTEM

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ABSTRACT: With the evolution of the wireless system, the demand for high speed data services have been increasing day by day, which is impossible to be achieved by the conventional serial data transmission system, without trade-off between high speed data services and increasing the bandwidth of the system. Here, both the options are inconvenient, as one never demands the degradation of the service quality (because if we increase data rate in serial data transmission ISI will gradually increase which make the extraction of actual information at receiver nearly impossible) and secondly the need for extra spectrum in a limited spectrum scenario. In order to overcome this problem new parallel data transmission system was proposed, which is known as OFDM system. The performance of OFDM system can further be improved by using multiple antennas at transmitting and receiving side to provide spatial diversity. Multiple antennas can be used at the transmitter and receiver, an arrangement called a MIMO system. A MIMO system takes advantage of the spatial diversity that is obtained by spatially separated antennas in a dense multipath scattering environment.
This paper presents an brief review of the basics of MIMO-OFDM technology and focuses on the BER Analysis of MIMO-OFDM systems

I-INTRODUCTION

1.1 General

Wireless communication is one of the most vivacious areas in the communication field now a day. Although the development in this area was started way back in 1960s, but a lot of research is done in this area in last decade. The reason for this is due to a variety of factors discussed below:

- The demand for seem-less connectivity has risen manifolds, mainly due to cellular telephony but expected to be soon eclipsed by wireless data applications.
- The sophisticated signal processing algorithms can be implemented with the advent of VLSI technology. Due to the success of 2G wireless standards especially CDMA it has been shown that communication ideas can be implemented in practice. The research push in the past decade has led to a much better-off set of perspectives and tools on how to communicate over wireless channels, and the scenario is still very much in the emerging stages.

There are two fundamental aspects of wireless communication that make the problem demanding and motivating as compared to wire line communication.

- First is the phenomenon of fading: the time variation of the channel strengths due to the small-scale effect of multipath fading, as well as larger-scale effects such as path loss via distance attenuation and shadowing by obstacles.
- Second, unlike in the wired world where each transmitter–receiver pair can often be thought of as an isolated point-to-point link, wireless users communicate over the air and there is significant interference between them. The interference can be between transmitters communicating with a common receiver (e.g., uplink of a cellular system), between signals from a single transmitter to multiple receivers (e.g., downlink of a cellular system), or between different transmitter–receiver pairs (e.g., interference between users in different cells).

1.2 OFDM

OFDM has become a popular technique for transmission of signals over wireless channels [1]. OFDM has been adopted in several wireless standards such as digital audio broadcasting (DAB), digital video broadcasting (DVB-T), the IEEE 802.11a [2] LAN standard and the IEEE 802.16a MAN standard. OFDM is also being pursued for dedicated short-range communications (DSRC) for road side to vehicle communications and as a potential candidate for fourth-generation (4G) mobile wireless systems.
OFDM converts a frequency-selective channel into a parallel collection of frequency flat sub-channels. The subcarriers have the minimum frequency separation required to maintain orthogonality of their corresponding time domain waveforms, yet the signal spectra corresponding to the different subcarriers overlap in frequency. Hence, the available bandwidth is used very efficiently. If knowledge of the channel is available at the transmitter, then the OFDM transmitter can adapt its signaling strategy to match the channel. Due to the fact that OFDM uses a large collection of narrowly spaced sub-channels, these adaptive strategies can approach the ideal water pouring capacity of a frequency-selective channel. In practice this is achieved by using adaptive bit loading techniques, where different sized signal constellations are transmitted on the subcarriers.
OFDM is a block modulation scheme where a block of N information symbols is transmitted in parallel on N subcarriers. The time duration of an OFDM symbol is N times larger than that of a single-carrier system. An OFDM modulator can be implemented as an IDFT on a block of N information symbols followed by an ADC. To mitigate the effects of ISI caused by channel time spread, each block of IDFT coefficients is typically preceded by a CP or a guard interval consisting of G samples, such that the length of the CP is at least equal to the channel length. Under this condition, a linear convolution of the transmitted sequence and the channel is converted to a circular convolution. As a result, the effects of the ISI are easily and completely eliminated. Moreover, the approach enables the receiver to use fast signal processing transforms such as a fast FFT for OFDM implementation [1]. Similar techniques

can be employed in single-carrier systems as well, by preceding each transmitted data block of length N by a CP of length, while using frequency-domain equalization at the receiver.
OFDM systems are attractive for the way they handle ISI, which is usually introduced by frequency selective multipath fading in a wireless environment. Each sub-carrier is modulated at a very low symbol rate, making the symbols much longer than the channel impulse response. In this way, ISI is diminished. Moreover, if a guard interval between consecutive OFDM symbols is inserted, the effects of ISI can completely vanish. This guard interval must be longer than the multipath delay. Although each sub-carrier operates at a low data rate, a total high data rate can be achieved by using a large number of sub-carriers. ISI has very small or no effect on the OFDM systems hence an equalizer is not needed at the receiver side.
OFDM has many advantages compared with other transmission techniques. One of such advantages is high spectral efficiency (measured in bits/sec/Hz). The orthogonal in OFDM implies a precise mathematical relationship between the frequencies of the subchannels that use in the OFDM system. Each one of the frequencies is an integer multiple of a fundamental frequency. This ensures that a sunchannel does not interfere with other subchannels even though the subchannels overlap. This results in high spectral efficiency.
OFDM has been adopted in the IEEE802.11a LAN and IEEE802.16a LAN/MAN standards. OFDM is also being considered in IEEE802.20a, a standard in the making for maintaining high-bandwidth connections to users moving at speeds up to 60 mph. The IEEE802.11a LAN standard operates at raw data rates up to 54 Mb/s (channel conditions permitting) with a 20-MHz channel spacing, thus yielding a bandwidth efficiency of 2.7 b/s/Hz. The actual throughput is highly dependent on the MAC protocol. Likewise, IEEE802.16a operates in many modes depending on channel conditions with a data rate ranging from 4.20 to 22.91 Mb/s in a typical bandwidth of 6 MHz, translating into a bandwidth efficiency of 0.7 to 3.82 bits/s/Hz.

1.3 MIMO
Multiple antennas can be used at the transmitter and receiver, an arrangement called a MIMO system. A MIMO system takes advantage of the spatial diversity that is obtained by spatially separated antennas in a dense multipath scattering environment. MIMO systems may be implemented in a number of different ways to obtain either a diversity gain to combat signal fading or to obtain a capacity gain. Generally, there are three categories of MIMO techniques. The first aims to improve the power efficiency by maximizing spatial diversity. Such techniques include delay diversity, STBC [4], [5] and STTC [6]. The second class uses a layered approach to increase capacity. One popular example of such a system is V-BLAST suggested by Foschini et al. [7] where full spatial diversity is usually not achieved. Finally, the third type exploits the knowledge of channel at the transmitter. It decomposes the channel coefficient matrix using SVD and uses these decomposed unitary matrices as pre- and post-filters at the transmitter and the receiver to achieve near capacity [8].

1.4 MIMO-OFDM
Spatially multiplexed MIMO is known to boost the throughput, on the other hand, when much higher throughputs are aimed at, the multipath character of the environment causes the MIMO channel to be frequency-selective. OFDM can transform such a frequency-selective MIMO channel into a set of parallel frequency-flat MIMO channels and also increase the frequency efficiency. Therefore, MIMO-OFDM [9] technology has been researched as the infrastructure for next generation wireless networks.
Therefore, MIMO-OFDM, produced by employing multiple transmit and receive antennas in an OFDM system has becoming a practical alternative to single carrier and SISO transmission [10]. However, channel estimation becomes computationally more complex compared to the SISO systems due to the increased number of channels to be estimated. This complexity problem is further compounded when the channel from the i_{th} transmit antenna to the
m_{th} receive antenna is frequency-selective. Using OFDM, information symbols are transmitted over several parallel independent sub-carriers using the computationally efficient IFFT/FFT modulation/demodulation vectors. [11]
These MIMO wireless systems, combined with OFDM, have allowed for the easy transmission of symbols in time, space and frequency. In order to extract diversity from the channel, different coding schemes have been developed. The seminal example is the Alamouti Space Time Block code [4] which could extract spatial and temporal diversity. Many other codes have also been proposed [5] which have been able to achieve some or all of the available diversity in the channel at various transmission rates.
In open-loop schemes, there are generally two approaches to implement MIMO systems. One is to increase the STD by means of space-time coding and space-frequency coding. Another is to raise the channel capacity by employing SDM that simultaneously transmits independent data symbols through multiple transmit antennas. STD mitigates impairments of channel fading and noise, whereas SDM increases the spectral efficiency.

II-LITERATURE REVIEW
MIMO antenna system with OFDMA is the most promising combination of technologies for high data-rate services in next generation wireless networks. Nowadays, different commercial solutions employing the OFDMA technology are under development, such as the IEEE WiMAX and 3GPP. These high data-rate systems are expected to operate in heterogeneous environments. Interference mitigation and channel-aware scheduling algorithms are crucial to maximally exploit their capacity. The work carried out till date on the said field is reported here forth.

2.1 OFDM
P. S. Mundra et.al describes the emerging modulation technologies in the family of linear modulation and constant envelope techniques of digital modulation. Both of these techniques have been used extensively in mobile communication systems. The selection of one over the other depends on the priorities set in the system requirements. If most efficient bandwidth utilization and moderate hardware complexity is the key note – QPSK (π/4 QPSK) will be a better choice. Whereas continuous phase modulation

schemes offer constant envelope, narrow power spectra, good error rate performance, etc. GMSK is the solution when out of band signal power, tolerance against filter parameter and non-linear power amplifiers are important features and compromise in channel separation is permissible and higher circuit complexity is of less consideration. Spectral efficiency can be further improved by using suitable coding techniques.

Higher modulation schemes with COFDM for a Rician fading channel with two frequency bands are considered by W.A.C. Fernando. Rectangular QAM and 8-PSK constellation modulation schemes are considered with convolutional coding and TCM. Coding gain is considered at two different values of BER. It has been shown that there is no significant difference of BER performance between two frequency bands considered. BER slope is high for CC-OFDM for high SNR values whereas, TCM-OFDM performance seems to be better compared to CC-OFDM by considering the fact that TCM code has a lower trellis size.

Exact analytical calculation has been described by A. Maraz et.al, which is appropriate to determine the symbol error probability of MPSK and M-QAM modulation schemes. Results could be utilized in advanced wireless networks (e.g. 3GPP LTE and WiMAX) to predict symbol error rate, or even channel capacity. Transmission happens in the presence of additive white Gaussian noise, different types of fading channels have effect on analyzed signal, and arbitrary number interference sources are modeled. M-QAM and M-PSK symbol error rate results are extended for OFDMA transmission with equally spaced subcarriers of interferers. Proposed method is capable for analyzing a composite OFDMA transmission system model with various fading and interference scenarios, which could be hereby a substantial component of an accurate physical layer scheduling algorithm in mentioned wireless systems.

2.2 MIMO-OFDM

OFDM for MIMO channels (MIMO-OFDM) is considered by Y. Li et.al. for wideband transmission to mitigate intersymbol interference and enhance system capacity. The MIMO-OFDM system uses two independent space-time codes for two sets of two transmit antennas. At the receiver, the independent space-time codes are decoded using pre-whitening followed by ML decoding based on successive interference cancellation. Using these techniques in a 4-input 4-output OFDM system, the net data transmission rate can reach 4 Mbits/sec over a 1.25 MHz wireless channel, with a 10-11 dB SNR required for a 10% SER, depending on the radio environment and signal detection technique for word lengths up to 500 bits.

S. Moghe et.al introduced a new generation of IEEE 802.11n wireless network standard. The objective is to obtain numerical values for various measures of networking performance of IEEE 802.11n. The initial approach was to investigate the abilities of IEEE 802.11n standard to model a transmitter and receiver that communicated over a user defined channel. Simulation of single OFDM symbol SISO system followed by MIMO is presented. Also, the performance of the system using Matlab's built in BER tool in both SISO and MIMO Techniques is tested. Different Variation in BER on varying Parameters like Delay and K factor are carried out in the work.

Y. Wu et.al gives an idea about the theoretical framework for the analysis of code diversity. It can be applied to an arbitrary space–time code, but the value of code diversity will depend on the particular choice of code. It is also shown that it not only improves the diversity and coding advantages for general space time codes but also enables optimal decoding performance with low complexity decoding and only a small number of feedback bits. The method of code diversity also reduces the capacity loss associated with some forms of space–time coding. The code diversity scheme presented here is more robust than other low-rate feedback schemes such as transmit antenna selection and its variations. A new family of full-rate circulant codes are introduced and the advantage of suboptimal linear decoding in combination with code diversity is also demonstrated.

A bit and power allocation strategy for AMC based spatial multiplexing MIMO-OFDMA systems is studied by M. S. Al-Janabi et.al. This strategy aims to maximize the average system throughput by allocating the available resources optimally among the utilized bands depending on the corresponding channel conditions and the total transmission power constraints. The average system throughput is represented as a trade-off criterion between the spectral efficiency and BER. The considered AMC technique utilizes distinct modulation and coding scheme (MCS) options rather than adopting fixed or uncoded approaches. The transmitter divides the OFDMA frame at each transmit antenna into bands depending on the number of active users in an assigned base station (BS). The simulation results show superior performance of the MIMO-AMC-OFDMA system, which adopts the proposed strategy, over other conventional schemes.

A channel estimation method for STBC - OFDM is investigated by F. Delestre et.al for Mobile WiMax systems. A new channel estimation approach is proposed using the dedicated pilot subcarriers defined at constant intervals by the WiMax standard. The estimation method has low computation as only linear operations are needed due to orthogonal pilot coding. The performances of the proposed method have been demonstrated by extensive computer simulations. For the OFDM system with two transmit antennas and one to four receive antennas and using QPSK modulation, the simulated results under different Stanford University Interim (SUI) channels show that the proposed method has only a 4dB loss compared to the ideal case where the channel is known at the receiver.

. Ajey et.al focuses on the performance of a LTE system with two transmit antennas and two receive antennas in a frequency selective fading environment. 4G wireless systems predominately employ MIMO with an OFDM system. Like other 4G systems LTE also employs MIMO-OFDM physical layer. MIMO helps in increasing the throughput whereas OFDM converts a frequency selective fading channel to multiple flat fading sub-channels facilitating easy equalization. It is proposed that LTE system should mandatorily support 2x2 MIMO setup. The performance of the MIMO system is better than that of a single antenna based system either in terms of performance (diversity) or throughput as in the case of transmit diversity or spatial multiplexing respectively.

A novel analytical method for BER and FER estimation of bit-loaded coded MIMO-OFDM systems operating over frequency-selective quasi-static channels with nonideal interleaving is developed by M. M. Avval et.al. The presented numerical results illustrate that the proposed analysis technique provides an accurate estimation of the BER of loaded BICM-MIMO-OFDM systems. This allows the system performance analysis without resorting to lengthy simulations. In the case of bit loading, the relative performance of bit-loading algorithms for coded OFDM is system dependent, and thus, some care should be given to the selection of loading algorithms for coded OFDM systems. The proposed SL (Selected Loading) algorithm guarantees the best performance, at a cost of somewhat higher complexity, when performing loading. Adaptive interleaving has been confirmed to be an interesting alternative and addition to bit loading in coded OFDM.

An analytical framework for the performance assessment of bit-interleaved coded multi-antenna OFDMA systems over space-frequency selective fading channels with application to practical 4G broadband wireless standards is given by D. Molteni et.al. A multicell scenario has been considered for inter-cell interference based on either coordinated or randomized multi-user access. The analytical formulation accounts for the spatial-frequency selectivity of the fading channel and possible non-stationary interference due to subcarrier randomization. Both beamforming and diversity schemes have been considered as multi-antenna systems. The analysis has been carried out for convolutionally coded BICM systems with BPSK modulation, then extended to higher order modulations. Two practical standards have been used as benchmark for the analytical analysis, 3GPP LTE and WiMAX IEEE 802.16d-e.

2.3 Beamforming in MIMO Systems

A nonlinear interpolation and a modified clustering based transmit beamforming schemes are investigated by J. Huang et.al to reduce the feedback information and improve performance for a MIMO-OFDM system. In the first approach, the indices of both beamforming vectors of the pilot subcarriers and phase parameters are feedback to the transmitter. Then the beamforming vectors for the non-pilot subcarriers in each cluster are constructed via beamforming vectors of the pilot subcarriers using nonlinear interpolation, which fully exploits the correlation between beamforming vectors and outperforms the existing linear interpolation. In the second scheme, only the indice of the beamforming vector in each cluster is conveyed back to the transmitter and the beamforming vector is reused for the whole subcarriers in that cluster.

An exact BER analysis for MIMO-OFDM systems with transmit beamforming and MRC reception in multipath Rayleigh fading channels, under channel prediction and interpolation errors, was presented by F. J. L. Martinez et.al. The resulting exact closed form expression was composed by a finite sum of elementary functions. This expression was used to evaluate the system performance under different channel configurations and number of antennas, with Wiener and sinc filter schemes for both channel prediction and interpolation. Although Wiener filtering outperforms sinc-type filtering, the latter is shown to be a reasonable approach for implementation in a real system, since it offers a good trade-off between performance and complexity.

K. Yi et.al investigated the interference cancellation algorithms for the downlink multi-user MIMO systems. Combined the conventional SLNR (signal-to-leakage and noise ratio) criterion with codebook selection mechanism, a new beamforming algorithm is proposed. Instead of using the channel matrix decomposition as the BD (Block Diagonalization) algorithm, the CSBF (codebook selection for beamforming algorithm) algorithm selects sub codebook from the corresponding codebook for each user and transmits their indices to the users. Consequently, it not only improves the system performance, but also reduces the computational complexity compared with the conventional BD beamforming algorithm. However, the channel state information must be known at transmitter.

A beamforming scheme combined with QOSTBC is demonstrated by Q. Tao et.al. At the transmitter, quasi-orthogonal space-time block coded signals is transmitted by using four independent transmit beams. As the receiver, a pairwise decoding algorithm is employed. A flat Rayleigh fading channel model is used in the simulations to compare performance of the proposed scheme with the traditional quasi-orthogonal space-time block codes approach where four independent transmit antennas are used. It is shown that the best rotation for rotate BPSK-QOSTBC is 2. In spite of the contradictive requirement of antenna element spacing, the results show that the performance of the beams-based transmit diversity is superior to the classic transmit diversity with four independent transmit antennas.

An ICI/ISI-aware beamforming algorithm is devised by X. Sun et.al to cope with large delay spread environments. They constructed an optimization problem and solved it with either an optimal or a suboptimal solution, depending on the antenna configuration. For the optimal solution, the best steering vector achieves the maximum SINR for all subcarriers. For the suboptimal solution, the steering vectors are selected to reduce the ICI/ISI crosstalk among subcarriers. Simulation of the proposed algorithm is also presented and compared it with MRC and beamforming. The results show that, although the ICI/ISI cannot be completely removed, but ICI/ISI aware beamforming can significantly improve the performance of MIMO-OFDM systems in which delay spread is significant.

A new user scheduling strategy is proposed by S. Rahima et.al for multiuser MIMO-OFDM system with a low complexity generalized beamforming (GBF) scheme. In GBF, user antenna outputs are linearly combined with the receive GBF vector to construct an equivalent MISO downlink channel for each subcarrier. The scheduler located at the base station allocates data streams to users based on the subchannel gains of their subcarriers on each spatial channel. The user with maximum variance of subchannel gains is allowed to select his best subcarrier on his best spatial channel in order to maximize the system weighted sum-rate and fairness among users. The system power is simply uniformly allocated to all the subchannels.

2.4 MIMO-OFDM Systems using STBC

V. Tarokh et.al designs a channel codes for improving the data rate and the reliability of communications over fading channels using multiple transmit antennas. The data is encoded by a channel code and the encoded data is split into multiple streams that are simultaneously transmitted using multiple transmit antennas. The received signal at each receive antenna is a linear superposition of the different transmitted signals. The performance criteria for designing channel codes under the assumption that the fading is slow and frequency non-selective is also derived. Performance is shown to be determined by diversity gain quantified by ranks and coding gain quantified by determinants of certain matrices that are constructed from the code sequences.

Improved MIMO-OFDM techniques were studied by Y. Li et.al for wireless systems using QPSK modulation for four transmit and four receive antennas (4 X 4). A system employing two 16-states, 2-antenna space–time codes with successive interference cancellation and channel estimation was considered, which was previously proposed to reduce the complexity of a 4-antenna space–

time code system. The results depicts that recently proposed space–time code has a 2-dB improvement over a previously published code at 5-Hz fading. Furthermore, a 4-antenna,

16-state code that achieves an additional 2-dB improvement with lower complexity and a 256-state code that achieves an additional 2-dB gain were also proposed. The 256-state code performed within 3 dB of outage capacity (and within 2 dB with perfect channel estimation).

S. Suthaharan et.al presents a space time block coded multiple-input multiple-output orthogonal frequency division multiplexing (MIMO-OFDM) scheme over frequency selective fading channels. The system provides spectrally efficient transmissions to increase system capacity or system throughput for individual users. The proposed technique utilizes OFDM to transform frequency selective fading channels into multiple flat fading sub channels on which space-time block coding is applied. A multi-user environment with multiple synchronous co-channel users, each equipped with n transmit antennas is considered. The receiver is equipped with multiple receive antennas. At the receiver signals from different users are decoded using minimum mean squared error (MMSE) interference cancellation followed by maximum likelihood (ML) decoding. It is shown that the proposed scheme, with two co-channel terminals, doubles the data rate while maintaining the frame error rate (FER) performance similar to a single user scheme with some additional decoding complexity.
The performance of a wireless communication system is analyzed by A. K. M. N. lslam et.al considering multi-carrier OFDM with MIMO wireless channel and STBC. BER expression for MIMO-OFDM system without and with STBC is presented considering fading and timing jitter with QPSK, DPSK and DQPSK modulation schemes. The performance results are evaluated without and with rate ½ convolution coding with hard decision decoding. The results are presented in terms of BER, power penalty due to fading and coding gain due to error correction coding. It is noticed that there is significant power penalty due to fading and can be reduced by increasing the number of receiving antennas. Among the different modulation schemes QPSK is found to provide the best performance.
Y. Huang et.al gives the system model and the STBC encoding and decoding schemes in MIMO-OFDM system according to STBC coding theories. It focuses on researching and simulating the MIMO-OFDM system's performances, which had added STBC. A detailed analytical behavior and simulated BER performance of the system with different number of transceiver antennas is given. At the same time, BER performance of the system with different modulation modes such as QPSK, 8-PSK, and 16-QAM is also analyzed and simulated. Simulation results show that the system's performance in multipath environment is improved when MIMO-OFDM system has added STBC. Decoding at the receiver is simple linear processing, to keep the decoding complexity as low as possible.

2.5 MIMO-OFDM Systems using QOSTBC
H. Jafarkhani says that quasi orthogonal codes are designed which provide full transmission rate. The quasi orthogonal codes are those in which transmission metric column are divided into groups the column within each group are not orthogonal instead different groups are orthogonal to each other. As compared to full diversity orthogonal code quasi orthogonal codes have better performance (lower BER) at low SNR's whereas their performance is degrading at higher SNR's.
N. Sharma discuss that a significant improvement in the performance of Quasi orthogonal ST codes is achieved if we phase shift or rotate the constellations of the codes symbols. The basis of constellation rotation is that it increase the minimum distance between the ST code words thus improving performance. Particularly at low BER's performance gain of 6 db and 4 db have been obtained for QPSK & 8PSK respectively as compared to no rotation.
J. Hou et.al analyzed the transmission matrices of QOSTBC's and also proposes some new patterns for the matrices. The main aim of new designs is to reduce the interference of adjacent symbols. The purposed new codes NPI &NP2 performs better as compared to Jafarkhani & TBM codes. The new codes are designed by changing the distribution of conjugates in transmission matrices.
The QOSTBC are designed properly to ensure good performance ever at high SNR. The thing is to choose half of the symbols in quasi orthogonal design from signal constellation set A & other half from rotated constellation C & A. The resulting codes out perform the orthogonal codes in items of diversity decoding & SNR as given by S. Weifeng et.al .
B. Badic et.al studies antenna selection for QOSTBC at the transmitter & receiver. A optimum selection criteria for choosing the best antenna subset is proposed for achieving high diversity & SNR. A simple zero forcing receiver is considered and it is assumed that at the transmitter N≥4 antennas are available and at receiver only n_r=1 antenna is used.
The concept of transmit beam forming is considered & a beam forming matrix is constituted for STBC. The concept of beam forming is extended by L Liu et.al for QSTBC by which has not been implemented yet. The resulting QSTBC beam forming has high rate and degree of spatial diversity.
C. Toker explores 2 feed back methods for QO STBC for achieving full diversity and code rate. The first method purposes rotation of signals by phasors according to feed back from receiver. The second method is based on antenna weighting/selection. The performance gap between the uncoded QO STBC and the four antenna transmit beamformer is reduced to 2.5db using feedback. The proposed scheme is more robust to dynamics in mobile environment & when combined with turbo codes 2.75 db performance gain is obtained.
In the paper given by H. Jafarkhani et.al a family of QOSTBC are considered as building block for QOS ST Trellis codes. The QOSTBC are designed by combining set portioning and a super set of QO STBC & provide full rate diversity & high coding gain.
J. Klutto et al. propose channel orthogonalised space-time block codes (C-STBC) for five & six transmit antennas which are closed loop (feedback) & have rate 3/4 1-5 db gain in obtained as compared to open loop scheme. A closed form expression for evaluating feedback angle is also given.

The scheme of existing complex orthogonal STBC for 7 transmitting antennas is extended for 8 transmitting antennas by X.B. Liang which achieves same rate & decoding delay. This is done by padding a transmission to vector of the 8th transmit antenna to the transmission matrix of the existing complex OSTBC for 7 transmit antennas.

Analyzing the structure and character of several issues of the quasi-orthogonal space–time block code (QOSTBC) X. Wu et.al proposes two novel quasi-orthogonal space–time block codes for four antennas. The novel codes are enriched the family of QOSTBC. Experiment results indicate that these two codes have good performance as Jafarkhani scheme, while the decoding complexity is the same as other quasi-orthogonal codes. The performance of these two schemes is compared when using the ML, MMSE, QR decomposition and ZF algorithm. The decoding algorithm is simplified to decoding of four independent single symbols, so that the complexity of decoding is decreased. By using zero-forcing decoding algorithm for novel codes, simulation results show that zero-forcing algorithm has better bit error rate performance as compared to the existing typical codes and can reduce the computation complexity at receiver.

J. S. Jeong et.al invented a new decoding scheme for reducing complexity at the decoder. By using Quasi-ZF based on the traditional Zero Forcing technique and Quasi-MMSE based on the traditional MMSE technique, we can have channel interference parameter be zero. As a result, only diagonal components remain. Eventually, we can detect the transmitted symbols easily with single ML detector. The proposed schemes can be applied to QOSTBC where channel interference parameters are pure imaginary values. The existing QOSTBC using the pairs of transmitted symbols can be decoded with two parallel ML detectors. Therefore, QOSTBC has higher complexity than OSTBC at the decoder.

S. Cho et.al introduces a new computationally efficient MIMO OFDM transmitter using QO-STBC schemes. Straightforward implementation of these systems requires separate IFFT processing blocks for each of the transmit antennas. In the proposed scheme symmetry properties of Fourier transform are used, which results in good reduction in computational burden. Usually, four transmit antennas need a four IFFT converters. But, using the two kinds of the properties, transmission characteristics of QOSTBC and symmetry of Fourier transform, the Common denominator of signal can be found. As a result, if four antennas have a IFFT converter, calculation of the other values can be done easily. If the number of conversion of IFFT is minimized, computation efficient MIMO OFDM transmitter using QOSTBC schemes can be realized.

2.6 Signal Detection in MIMO-OFDM Systems

M. B. Breinholt et.al developed a equalization techniques that facilitate aggressive frequency reuse in cellular OFDM system. The initial focus is on the case of a single strong interfering base at the mobile. The interfering base is asynchronous, because its cyclic prefix is not time-aligned with the desired base's cyclic prefix. Various methods for combating the asynchronous, interfering base are developed based on channel shortening ideas. The most promising method works to align the cyclic prefix while holding all channel lengths equal to the cyclic prefix length or less. For the case of two receive antennas at the mobile, two sets of space time filters are designed so that the respective channels at either output for either base are time-aligned with length no greater than the cyclic prefix length. As a result, standard frequency-domain equalization/interference suppression techniques (e.g., MMSE combining) can be applied to the outputs of the space-time filters on a per frequency bin basis to obtain symbol estimates for the desired base. Simulations are presented comparing the BER performance of the candidate techniques.

The signal detection technology of MIMO-OFDM system is described by X. Zhang et.al . The signal detection technology of MIMO-OFDM system involves linear detection method of ZF detection and the MMSE detection, as well as the non-linear detection method of V-BLAST detection, those detection algorithms are simulated based on matlab in different modulation for searching which is the optimal detection algorithm for particular channel. Non-linear detection algorithm is superior to the linear detection algorithm in four different modulation modes by the comparison of the simulation results. For non-linear detection algorithm for V-BLAST, the BER between the line ZF and MMSE detection algorithms are relatively low in high SNR conditions. And a further comparison between the two types of non-linear detection algorithms concludes that MMSE-SIC algorithm is better than ZF-SIC.

A new group iterative linear ZF receiver for a MIMO-OFDM system is analyzed by Z. wang et.al . The signals of all layers are firstly grouped and the signals in every group are detected by linear ZF detection method. The successive interference cancellation detection is applied between the different groups. Computer simulation results state the proposed algorithm achieves marked performance improvement compared to standard linear MIMO ZF detection algorithms. When convolutional encoding is applied, the proposed scheme may almost obtain the same performance of conventional ZF-VBLAST while the complexity of proposed algorithm is reduced by about 25%.

Improved Decoder Schemes for QOSTBCs Based on Single-Symbol Decoding are explored by P. V. Bien et.al. The decoder schemes presented in the work can fully eliminate channel interference parameters in detection matrix. As a result, only diagonal components remain and we can detect the transmitted symbols easily with single-symbol ML detector. The proposed schemes can be used for all known QOSTBCs in four transmit antennas systems and can be extended for systems with number of transmit antennas greater than four. The two improved decoder schemes named Modified-ZF and Modified-MMSE are used to reduce decoding complexity of QOSTBCs at the expense of slight SNR lose.

2.7 Tabular Comparison of different MIMO-OFDM systems based on various modulation schemes and BER vs SNR

TABLE 1: COMPARISON OF DIFFERENT MIMO-OFDM SYSTEM PERFORMANCE

S.No	Proposed Works	Modulation Schemes Used	BER vs SNR
1.	MIMO-OFDM for wideband transmission to mitigate intersymbol interference and enhance system capacity.	4-input 4-output OFDM system	10-11 dB SNR required for a 10% BER
2.	Significant improvement in the performance of Quasi orthogonal ST codes	QPSK	BER = 6dB
3.	Significant improvement in the performance of Quasi orthogonal ST codes	8PSK	BER = 4dB
4.	Exploration of 2 feedback methods for QO STBC for achieving full diversity and code rate.	Rotation of signals by phasors according to feedback from receiver and antenna weighting selection.	Performance gap between the two methods = 2.5dB
5.	Exploration of 2 feedback methods for QO STBC for achieving full diversity and code rate.	Turbo codes	Performance increases to a difference of 2.75dB
6.	BER Analysis Of Coded And Uncoded MIMO-OFDM System In Wireless Communication	Alamouti's space-time coding	15dB

III-CONCLUSION

In the present work, an idea about the performance of the MIMO-OFDM systems at higher modulation levels and for different antenna configurations is presented. Performance of MIMO-OFDM system is analyzed under different fading channels. MIMO-OFDM system can be implemented using higher order modulations to achieve large data capacity. But there is a problem of BER (bit error rate) which increases as the order of the modulation increases.

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