An Extensive Performance Analysis of MIMO OFDM System: A Survey

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Abstract: Now a day major challenge in wireless communication especially beyond 3G is to provide high speed data communication with the presence of small and large scale fading. To combat different types of fading of wireless link, space diversity is applied at transmitting end and difference types of combining schemes are incorporated at receiving end. The objective of the research work is to use MIMO (Multiple Input Multiple Output) based orthogonal space type block code (OSTBC) based OFDMA (Orthogonal Frequency Division Multiple Access) on transmitting side. The OFDM technology is widely used in two types of working environments, i.e., a wired environment and a wireless environment. When used to transmit signals through wires like twisted wire pairs and coaxial cables, it is usually called as DMT (digital multi-tone). For instance, DMT is the core technology for all the xDSL (digital subscriber lines) systems which provide high-speed data service via existing telephone networks. However, in a wireless environment such as radio broadcasting system and WLAN (wireless local area network), it is referred to as OFDM. In this review paper we aim at performance enhancement for wireless communication systems, we study the term OFDM throughout this research. Furthermore, we only use the term MIMO-OFDM while explicitly addressing the OFDM systems combined with multiple antennas at both ends of a wireless link.

Keywords- Keywords— MIMO-OFDM, Channel Equalization, MMSE, ZF, FRLS, BER.

I. INTRODUCTION

Wireless mobile communication has witnessed a tremendous growth in the number of users, data rate requirements and coverage over the last several years. As the demand for data rate and system throughput increases, researchers and system designers need to develop efficient methods to meet the demand at reasonable complexity and cost. A common approach is to increase the bandwidth and improve the system’s bandwidth utilization giving rise to a wideband frequency selective channel. Multipath propagation, however, limits the gains that can be obtained from increased bandwidth. The need to utilize the spatial dimension of the propagation environment has resulted in systems deploying multiple antennas at both the transmitter and receiver, providing multiplexing and diversity gains. These are generally referred to as MIMO systems and have been shown to theoretically exhibit a linear relationship between channel capacity and number of antennas. The combination of MIMO communication with Orthogonal Frequency Division Multiplexing (OFDM) digital modulation is a technique for achieving high spectral efficiency and high data-rate transmission over mobile frequency selective channels. It is being deployed in current and future wireless standards such as 3GPP LTE and LTE Advanced, IEEE 802.16e (WiMAX) [5] and B3G. Recent capacity achieving MIMO-OFDM based transmission schemes such as adaptive MIMO precoding, adaptive coding and modulation, adaptive multiuser resource allocation and scheduling and various forms of codebook and non-codebook based limited feedback MIMO schemes can achieve high QoS and throughput for mobile wireless systems. An illustration of a feedback based linear precoded MIMO system is shown in Fig. 1, where the receiver estimates the CSI, quantizes it and sends the quantized channel back to the transmitter. These schemes alter the modulation scheme, subcarrier power allocation, eigen mode, and selected antenna(s) based on the CSI and as such require both the transmitter and receiver to have accurate knowledge of the channel state information. In TDD systems, channel reciprocity is used to obtain CSI at the receiver. In FDD systems, however, CSI is estimated at the receiver and some quantized form of the CSI is fed back to the transmitter via a low rate feedback link. In practical MIMO systems, feedback delay is inevitable due to delays in estimation, processing and feedback. The CSI may become outdated before its actual usage at the transmitter, resulting in high performance degradation especially in high mobility environments. The effects of using imperfect CSI in adaptive and limited feedback MIMO systems have been studied extensively In , the effects of channel aging on massive MIMO systems was studied. The authors showed that outdated CSI degrades the performance of massive MIMO systems. Prediction of the CSI into the future has therefore, been recognized has an effective technique of mitigating the performance degradation due to feedback delays.

Although several studies have been reported on the prediction of narrowband and frequency selective MIMO channels, the majority have been based on classical Single-

Input Single-Ouput (SISO) methods which treat the MIMO channel as a number of parallel links. These approaches are sufficient when there is no correlation between antennas in MIMO systems since the knowledge about an independent signal cannot be used to improve the extrapolation of a signal. However, as a result of spacing constraints in practical MIMO systems, spatial correlation is an inevitable phenomenon. Moreover, the performance of these methods are bounded by those of the SISO schemes upon which they are based. Analytical and simulation results on SISO prediction have proven that with dense scattering, SISO channels can only be predicted over a very short distance. In the order of tenths of a wavelength depending on the environment and propagation scenarios. The bound on SISO channel prediction error indicates that channel prediction schemes require CSI over several wavelengths in order to accurately predict the channel and that prediction beyond a wavelength is not realistic, particularly in practical cases where the stationarity assumption does not hold long enough relative to the length of observation.

II. MIMO CHANNEL

The problem of channel prediction for flat-fading SISO channels has been studied extensively in the past. The narrowband SISO channel is modeled as an autoregressive (AR) process of a particular order and a linear predictor that minimizes the mean squared error (MSE) is used to predict future channel states using past estimates. These schemes consider the time-varying channel as a stochastic wide sense stationary (WSS) process and use the knowledge of the temporal autocorrelation function for prediction without explicitly modeling the physical scattering phenomenon causing the fading. Since the temporal autocorrelation function may be time-varying in practical scenarios, adaptive filtering methods such as recursive least squares (RLS), QR-decomposition based RLS, least mean squares (LMS) [8] and Kalman filtering have been proposed to track the temporal evolution of the AR parameters. The AR prediction methods have also been applied to frequency-selective SISO channels.

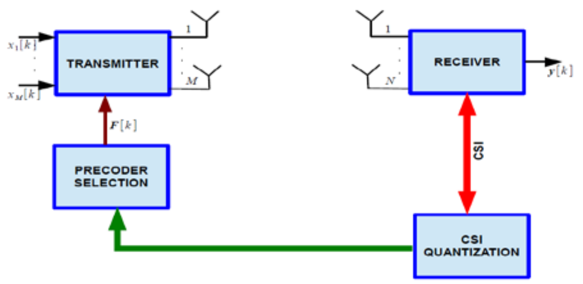

Fig. 1: Block diagram of a N × M limited feedback linear precoded

MIMO System

Orthogonal frequency division multiple accessing (OFDMA) is expected to be the enabling technology for the fourth generation (4G) wireless communication systems. One of the features that make OFDMA the primary choice for 4G is its compatibility with the multiple input multiple output (MIMO) technology [1], [2], because MIMO has a very significant potential for enhancing wireless systems in capacity, data rate, and coverage aspects.

In the 4G generation mobile communication system, for satisfying rapid demand of the subscriber needs to access high speed wireless Internet anytime and anywhere. For satisfying this demand, IEEE 802.16e standard is proposed as a standard of wireless interface for broadband wireless access (BWA) [11]. In IEEE 802.16e standard, an orthogonal frequency division multiple access (OFDMA) technique is used for multiple access scheme and multiple-input multiple-output (MIMO) system is applied to increase data rate. MIMO systems have been researched to increase data rate and reliability, recently. To achieve these advantages, various multiple antenna techniques have been proposed. Especially, spatial multiplexing (SM) can provide optimal capacity by simultaneously transmitting different data stream for each transmit antenna. The substreams can be separated at receiver by various detection techniques including zeroforcing (ZF), minimum mean square error (MMSE), ordered successive interference cancellation (OSIC), and ML detections. In the view point of the bit error rate (BER) performance, the ML detector guarantees optimal performance, because it searches for the transmit vector symbol over the set of all candidates. However, extremely high complexity required in implementing it precludes its use in practical MIMO systems. To make its use possible, I will try to propose an efficient decoding algorithm although different algorithms have been proposed [16]. In this research, I will deal with the DSP algorithm in IEEE 802.16e MIMO-OFDMA systems for showing the system performance of the algorithm in comparison with different receiver under fading channel. In IEEE 802.16e OFDMA system, a frame consists of downlink (DL) sub frame and uplink (UL) sub frame because the duplexing mode is time division duplex (TDD). The IEEE 802.16e standard includes various MIMO techniques, such as SM, transmit diversity, antenna selection, antenna grouping, and precoding.

III. LETERATURE SURVEY

T. Padhi, M. Chandra and A. Kar, [1] Wireless communication technologies have evolved by leaps and bounds in modern times. The ease of communication at the user end and the growth of feature rich mobile systems over the years has added to the ever increasing demand of higher data rates in a communication system. MIMO-OFDM systems have been a breakthrough in achieving appreciable data rates while keeping the issues faced in communication systems at bay. Channel Equalization in MIMO-OFDM systems is an area that has been extensively researched upon with the passage of time, to boost the data rates for high speed communication. In this article, performance analysis of a Fast Recursive Least Squares (FRLS) based adaptive channel equalizer for MIMO-OFDM systems employed in signal transmission using Binary Phase Shift Keying (BPSK) modulation was done and compared with the much popular Zero-forcing equalizer (ZF) and Minimum Mean Square Error (MMSE) equalizer. A qualitative analysis of the robustness of channel equalizers in a MIMO-OFDM systems with two transmit and two receiving antennae, was carried out. Simulations over a wide range of SNRs was done and Bit Error Rate (BER) was determined.

F. Jiang and C. Li, [2] In this paper, a turbo equalization scheme for MIMO-OFDM systems under imperfect channel estimation based on soft-input soft-output (SISO) minimum mean-square error (MMSE) sorted QR decomposition (SQRD) is proposed. A turbo structure consists of a SISO detector and a SISO decoder where extrinsic information is exchanged between the two SISO modules. Turbo equalization schemes are preferable in practical communication systems due to their good performance and acceptable computational complexity. MMSE-SQRD based SISO detection derives from SISO MMSE detection, and successive interference cancellation (SIC) is performed using a posteriori information obtained from previous detected symbols. Compared to SISO MMSE detection, MMSE-SQRD based SISO detection is of low complexity but has significant bit error rate (BER) performance enhancement. However, the derivation of the MMSE-SQRD based SISO detection scheme is under perfect knowledge of channel information at receivers. When channel estimation errors are presented, it has been pointed out that the system performance will degrade. In this paper, we studied this practical issue, and proposed the SISO MMSE-SQRD based turbo equalization under imperfect channel estimation. Authors first model the channel estimation error as added random Gaussian noise over the channel estimation matrix; based on that, author rederive the SISO MMSE detection for the data, and then redefine the extended channel matrix and receive vector by taking into account of channel estimation errors; after that, the SQRD algorithm is adjusted in accordance; MMSE-SQRD based data detection algorithm is finally performed. Numerical simulation results show that the proposed SISO MMSE-SQRD based turbo equalization for MIMO-OFDM systems under imperfect channel estimation outperforms the traditional MMSE based SISO detection with imperfect channel estimation in terms of BER performance and computational complexity.

H. Besbes, S. Ben Rayana and G. R. B. Othman, [3] In the case of memoryless MIMO channel and when the channel matrix is ill-conditioned, it is well known that performances of the Maximum Likelihood (ML) equalizer are well pronounced, compared to MMSE and ZF equalizers. In dispersive channels the conventional equalizer intends to cancel the inter-symbol interference, and did not take into the account the conditioning of the channel matrix. It intends to inverse the channel matrix somehow, which may cause noise enhancement and performances degradation. Using this fact and in order to overcome this issue, author propose in this research a joint partial equalization and ML detection approach, where the equalizer is built based on a novel non-quadratic criterion. The proposed criterion ensures that the equalized channel matrix conserves its conditioning; which will be handled by the ML detector. Simulation results show that the improvement is well pronounced in cases where the channel matrix is ill-conditioned.

Y. S. Chen, [4] Authors propose a semiblind channel-estimation method for multiple-input multiple-output (MIMO) single carrier with frequency-domain equalization systems. By taking advantage of periodic precoding and the block circulant channel model after cyclic prefix removal, author obtain the channel-product matrices by solving a series of decoupled linear systems, which is gained from the covariance matrix of the received data. Then, the channel-impulse-response matrix is obtained by computing the positive eigenvalues and eigenvectors of a Hermitian matrix formed from the channel-product matrices. Authors also propose an optimal design of the precoding sequence, which minimizes the noise effect and numerical error in covariance matrix estimation, and discuss the impact of the optimal sequence on channel equalization. With the proposed framework, the method is shown to be robust with respect to channel-order overestimation, and the identifiability condition is simply that the channel-impulse-response matrix has full column rank. Due to the identifiability condition, the method is applicable to MIMO channels with more transmitters or more receivers. Simulations are used to demonstrate the performance of the proposed method.

IV. PROBLEM IDENTIFICATION

The BER performance analysis of the much popular ZF and MMSE equalizer with a new adaptive FRLS equalizer in the MIMO-OFDM system where data transmission took place using BPSK digital modulation technique was done. SNRs has been analyzed in a Rayleigh fading environment

.Authors found that the FRLS equalizer showed much better BER performance than the ZF equalizer but was at par with the MMSE equalizer. There was a significant difference between the BER performance of FRLS and ZF equalizer and an overall gain of 4db was achieved at BER 10-3. This work can be improved to explore the use of even complex adaptive filters in channel equalization in MIMO-OFDM systems with robustness with low computational complexity.

V. CONCLUSION

A MIMO system contains multiple antennas at the transmitter and receiver end, and most of the techniques like space and time diversity exploit this feature of having multiple antennas at both ends for signal transmission and reception, respectively. The advent of feature rich and powerful devices for mobile telephony, have raised the demands for a communication system with higher throughput, data rate and Quality of Service (QoS). These devices are multimedia driven, and for a seamless user experience, high speed data communications form the core of the idea. This can be realized with traditional systems in place but it almost becomes impractical if the cost of implementation is taken into consideration, which is one of the most important constraint that need to be taken care of in communication system design. To solve the problem of high speed data and speech communications along with appreciable spectral efficiency and improved link reliability, Multiple Input Multiple Output (MIMO) systems were introduced.

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