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A Review Implementation of a MIMO QAM- OFDM-Based Wireless LAN System

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ABSTRACT: This paper provides a comprehensive overview of critical developments in the field of multiple-input multi-pleoutput (MIMO) wireless communication systems. The state of the art in single-user MIMO (SU-MIMO) and multiuser MIMO (MU-MIMO) communications is presented, highlighting the key aspects of these technologies. Both open-loop and closed-loop SU-MIMO systems are discussed in this paper with particular emphasis on the data rate maximization aspect of MIMO. A detailed review of various MU-MIMO uplink and downlink techniques then follows, clarifying the underlying concepts and emphasizing the importance of MU-MIMO in cellular communication systems. This paper also touches upon the topic of MU-MIMO capacity as well as the promising convex optimization approaches to MIMO system design.

Keywords: Multiple-Input Multiple-Output (MIMO), Multiuser MIMO, Wireless Communications, Beam-forming, Diversity,

I. INTRODUCTION

Multiple-input multiple-output (MIMO) wireless systems employ multiple transmit and receive antennas to in-crease the transmission data rate through spatial multiplexing or to improve system reliability in terms of bit error rate (BER) performance using space-time codes (STCs) for diversity maximization [1]. MIMO systems exploit multipath propagation to achieve these benefits, without the expense of additional bandwidth. More re-cent MIMO techniques like the geometric mean decomposition (GMD) technique proposed in [2] aim at combining the diversity and data rate maximization aspects of MIMO in an optimal manner. These advantages make MIMO a very attractive and promising option for future mobile communication systems especially when combined with the benefits of orthogonal frequency-division multiplexing (OFDM) [3,4]. performance analysis of various important SU-MIMO and multiuser MIMO (MU-MIMO) techniques respectively that are proposed for the next generation wireless communication systems. In-depth description of several MU-MIMO uplink and downlink schemes is given in Section 4 followed by a brief discussion of the MU-MIMO capacity. Section 5 provides an overview of convex optimization which has become an important tool for designing optimal MIMO beam forming systems.

II. 3GPP LTE

The 3rd generation partnership project's (3GPP) long term evolution (LTE) project is aimed at developing a new mobile communications standard for gradual migration from 3G to 4G. LTE physical layer is almost near completion. It specifies an OFDM based system with support for MIMO. Downlink transmission is based on OFDMA while SC-FDMA is used for the uplink due to its low PAPR characteristics. It supports both TDD and FDD operation. A packet switching architecture is specified for LTE LTE supports scalable bandwidths of 1.25, 2.5, 5, 10 and 20 MHz. Peak data rates of 100 Mb/s and 50 Mb/s are supported in the downlink and the uplink respectively, in 20 MHz channel. The standard specifies full performance within a cell up to 5 km radius and slight degradation from 5–30 km. Operation up to 100 km may be possible. It also supports high-speed mobility with high performance at speeds up to 120 km/h while the E-UTRAN (Evolved Universal Terrestrial Radio Access Network i.e., LTE's RAN) should be able to maintain the connection up to 350 km/h, or even up to 500 km/h.

LTE also specifies very low latency operation with control plane (C-plane) latency of < 50-100ms and user plane (U-plane) latency of < 10 ms The single-user MIMO techniques supported include STBC and SM. Closed-loop multiple codeword (MCW) SM with codebook based precoding and with support for cyclic delay diversity (CDD) is specified. A maximum of two downlink spatial streams are specified. LTE also supports MU-MIMO in the downlink as well as in the uplink. Closed-loop transmit diversity using MIMO beam forming, BLAST) [1] is one of the very first open-loop spatial multiplexing MIMO systems which has been practically demonstrated to achieve much higher spectral efficiencies than SISO systems, in rich scattering environments. In V-BLAST, a single data stream is demultiplexed into multiple substreams which are mapped on to symbols and then transmitted through multiple antennas. Inter- substream coding is not employed in V-BLAST, how-ever channel coding can be applied to the individual sub-streams for reduction of bit error rate (BER). CSI in a V-BLAST system is available at the receiver only by means of channel the simple block diagram of a V-BLAST system. V-BLAST detection can be accomplished by using linear detectors like zero-forcing (ZF) or minimum mean square error (MMSE) detector along with symbol cancellation (also called successive interference cancellation). Symbol cancellation is a nonlinear technique which enhances the detection performance by subtracting the detected components of the transmit vector from the received symbol vector [1]. This technique, however, is prone to error propagation.

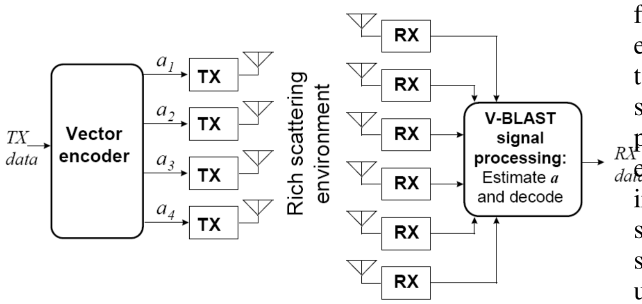

Fig. 1. V-BLAST system block diagram.

Singular Value Decomposition Based MIMO Precoding.

Singular value decomposition (SVD) based MIMO pre-coding is a closed-loop MIMO scheme where the pre-coding filter at the transmitter is designed by taking the SVD of the MIMO channel matrix H. [6] provides an analysis of the classical SVD based MIMO precoding scheme, SVD based precoding with ZF equalization, SVD based precoding with MMSE equalization and also an improved SVD based precoding technique. All of these schemes are analyzed with realis-tic channel knowledge at the transmitter. Figure shows the block diagram of the SVD based MIMO-OFDM transmitter and receive Beyond third generation (3G) and fourth generation (4G) wireless communication systems are targeting far higher data rates, spectral efficiency and mobility requirements than existing 3G networks. By using multiple antennas at the transmitter and the receiver, multiple-input multiple-output (MIMO) technology allows improving both the spectral efficiency (bits/s/Hz), the coverage, and link reliability of the system. Multicarrier modulation such as orthogonal frequency division multiplexing (OFDM) is a powerful technique to handle impairments specific to the wireless radio channel. The combination of multicarrier modulation together with MIMO signaling provides a feasible physical layer technology for future beyond 3G and fourth generation communication systems. The theoretical benefits of MIMO and multicarrier modulation may not be fully achieved because the wireless transmission channels are time and frequency selective. Also, high data rates call for a large bandwidth and high carrier frequencies. As a result, an important Doppler spread is likely to be experienced, leading to variations of the channel over very short period of time. At the same time, transceiver front-end imperfections, mobility and rich scattering environments cause frequency synchronization errors. Unlike their single-carrier counterparts, multi-carrier transmissions are extremely sensitive to carrier frequency offsets (CFO). Therefore, reliable channel estimation and frequency synchronization are necessary to obtain the benefits of MIMO OFDM in mobile systems. These two topics are the main research problems in this thesis. An algorithm for the joint estimation and tracking of channel and CFO parameters in MIMO OFDM is developed in this thesis. A specific state-space model is introduced for MIMO OFDM systems impaired by multiple carrier frequency offsets under time frequency selective fading. In MIMO systems, multiple frequency offsets are justified by mobility, rich scattering environment and large angle spread, as well as potentially separate radio frequency - intermediate frequency chains. An extended Kalman filter stage tracks channel and CFO parameters. Tracking takes place in time domain, which ensures reduced computational complexity, robustness to estimation errors as well as low estimation variance in comparison to frequency domain processing.

The thesis also addresses the problem of blind carrier frequency synchronization in OFDM. Blind techniques exploit statistical or structural properties of the OFDM modulation. Two novel approaches are proposed for blind fine CFO estimation. The first one aims at restoring the orthogonality of the OFDM transmission by exploiting the properties of the received signal covariance matrix. The second approach is a subspace algorithm exploiting the correlation of the channel frequency response among the subcarriers. Both methods achieve reliable estimation of the CFO regardless of multipath fading. The subspace algorithm needs extremely small sample support, which is a key feature in the face of time-selective channels. Finally, the Cram´er-Rao (CRB) bound is established.

III. OFDM

were reviewed. As blind methods are appealing due to their inherent bandwidth efficiency, they are not likely to be used alone in commercial applications and products. Indeed, they suffer from ambiguities and have high computational complexity. Moreover, some channels not be identifiable. However, they may be used to refine pilot based estimates for each symbol, without requiring any modification of the transmitted signal structure. Blind Semi-blind processing incorporates a little amount of training in order to ensure better performance, improved tracking capabilities and resolve ambiguities. It offers a more feasible implementation of blind criteria to practical systems. Semi-blind methods may find an application in static scenarios (ADSL, DVB-T) as well as in ones with moderate mobility (fixed broadband wireless access, WLAN). Pilot-aided processing is most commonly chosen in real-world systems, especially in fourth generation mobile wireless communications where mobility and high data rates are major requirements. Interleaving sufficient amount of known symbols among the transmitted data allows to track highly time-varying channels. Moreover, the quality of the channel estimates allows often choosing high-order symbol modulations, leading to increased data rates. Complexity issues may also dictate the choice of pilot-aided methods as blind or semi-blind techniques require an increased processing power and better SNR to reach similar performance targets. This issue is critical for battery operated and hence power limited mobile terminals. Finally, pilot symbols are almost always present in practical designs. They are needed for other purposes than channel estimation solely, e.g., for time and semi-blind and pilot-aided channel estimation in OFDM, and allows their comparison.

ML estimation for the multipath Rayleigh fading channel maximum likelihood estimation of the carrier frequency offset for OFDM under multipath Rayleigh fading was investigated in are based on an erroneous likelihood criteria: the received signal in cannot be modeled as jointly Gaussian distributed due to the Rayleigh fading process which multiplies the random data. Hence, while being technically correct for the AWGN case, yield sub-optimal methods under multipath Rayleigh fading. For instance, error floors are observed in A valid approach under multipath Rayleigh fading is given in However, it is still a sub-optimal method. In order to remove the data dependency, the estimator relies on an approximate likelihood function After more than thirty years of research and growth carried out in the field of communication OFDM has been widely implemented in high speed digital communication. OFDM has its major benefits of higher data rates and better performance. The higher data rates are achieved by use of multiple carriers and performance improved by use of guard interval which leads to removal of Inter Symbol Interference (ISI) . OFDM has several features which makes it more advantageous for high speed data transmission. These features include High Spectral competence, Robustness to Channel Fading, and Immunity to Impulse Interference, litheness and Easy Equalization. In spite of these benefits there are some drawbacks such as PAPR, Offset frequency and Inter Carrier Interference (ICI) between sub-carriers. Practical wireless channels typically exhibit frequency selective fading and a low-PAR precoding solution suitable for such channels would be desirable. rather, the solution should be such that the complexity required in each (mobile) terminal is small (due to stringent area and authority constraints), whereas heavier dispensation could be afforded at the BS. Orthogonal frequency-division multiplexing (OFDM) is an efficient and well-established way of commerce with frequency selective channels. In addition to simplify the equalization at the receiver, OFDM also facilitates per-tone influence and bit allocation, scheduling in the frequency domain, and band shaping. However, OFDM is known to suffer from a high PAR [9], which necessitate the use of linear RF components (e.g., power amplifiers) to avoid out-of-band radiation and signal distortions. Unfortunately, linear RF components are, in general, more costly and less power efficient than their nonlinear counterparts, which would eventually result in exorbitant costs for large-scale BS implementations having hundreds of antennas.

Therefore, it is of paramount consequence to reduce the PAR of OFDM-based large-scale MU-MIMO.

IV.CONCLUSIONS

MIMO-OFDM transmission in a quasi-static multipath environment. It consists of adapting the transmit power in the spatial and/or frequency domain using a heuristic expression of the BER for each subcarrier. A review of the different power allocation strategies based on a closed form expression of the optimum power to be allocated for each subcarrier is[18] presented. In the case of the frequency based power allocation, it allows to reduce the computational complexity, by including a subcarrier grouping method with local power adaptation for each subcarrier group. Our subcarrier grouping method minimizes the adverse impact of the local power adaptation by taking into consideration
the channel gains of all the subcarriers. The characteristics allow us to control the trade-off between the transmission performance and the computational complexity Orthogonal frequency-division multiplexing (OFDM) is a type of frequency-division multiplexing (FDM) method which can be used as a digital multi-carrier modulation technique. Usually a large number of closely-spaced orthogonal sub-carriers are used to carry data. The data is splited into various parallel data streams or channels, one for each sub-carrier. In this paper, the basic concepts of Orthogonal Frequency Division Multiplexing (OFDM) systems are discussed. The various channel estimation techniques are described for further research.

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