Investigation of Channel Estimation Techniques for MIMO-OFDM Systems

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Abstract— Use of multiple antennas at the transmitter and receiver ends called as MIMO has become a very popular technique for improvement of data rates required by the current and future wireless networks. OFDM combined with MIMO is very attractive air interface in mobile and wireless communication scenario. Less complex and reliable channel estimation and detection techniques are required to take advantages offered by MIMO. In this thesis, channel estimation and detection techniques for MIMO and MIMO-OFDM system are studied. In MIMO-OFDM system, the received OFDM symbols can be processed in time domain or frequency domain. The numbers of channel estimation methods for OFDM and MIMO-OFDM system are studied. This research work has implemented a combined time and frequency domain approach to channel estimation for MIMO-OFDM.

Keywords— MIMO-OFDM System, Channel Estimation Technique, Bit Error Rate, Mean Square Error

I. INTRODUCTION

The anytime, anywhere connectivity with fast transfer of data has become an essential feature of the state of the art communication system. Higher data rates are possible with the help of multiple antennas at the transmitter and receiver ends. Simple transmit diversity technique and Space-Time Block Codes (STBC) for Multiple Input Multiple Output (MIMO) systems was proposed by Alamouti [1]. Since then MIMO has been an active area of research. The number of transmitter-receiver concepts has been introduced in literature, an excellent overview of which can be found in [2]. The MIMO technology is now being part of next generation communication networks. Orthogonal Frequency Division Multiplexing (OFDM) is used to combat multipath fading in wireless transmission. Hence, MIMO-OFDM technology is employed in Wireless LAN (IEEE 802.11n). MIMO techniques introduced in WiMAX networks based on IEEE 802.16e [3] and Long Term Evolution (LTE) [4] are essential components for supporting higher data rates with reliability on wireless links. In LTE, there were four transmit antennas in downlink. LTE-Advanced have eight transmit antennas in downlink and four in the uplink, providing spectral efficiencies of 30 b/s/Hz in uplink and 15 b/s/Hz in downlink. WiMAX standard also uses MIMO both in uplink and downlink. The previous generation of Wi-Fi (IEEE WLAN Standard 802.11n) was designed for peak data rates of 600 Mbps with 4X4 MIMO-OFDM. The latest generation Wi-Fi ((IEEE WLAN Standard 802.11ac) can deliver data rates in Gbps. Thus, MIMO along with OFDM will remain the most popular air interface for wireless communication in near future. MIMO systems can be categorized as spatial diversity, spatial multiplexing and beamforming systems [5]. A combinations of these techniques have also emerged which are called as hybrid systems [6]. In spatial multiplexing techniques, information is de-multiplexed and independently transmitted over multiple antennas. Transmission of multiple information simultaneously results in an increase in the data rate, i.e. multiplexing gain is achieved, but the diversity gain is reduced because of higher error rate. Spatial decent variety strategies transmit a similar data over various reception apparatuses enhancing the mistake rate, however the information rate is influenced. In beamforming system, the radio wire bar is guided the specific wanted way with the goal that the flag to-commotion proportion (SNR) is enhanced at the recipient. The decent variety multiplexing tradeoff is examined in [7]. This exploration work is kept to spatial decent variety and spatial multiplexing MIMO and MIMO-OFDM frameworks.

The system's ability to achieve MIMO capacity depends on channel state information. Accurately estimating MIMO channel is much more challenging than SISO channel [8]. There is a number of channel estimation schemes suggested in the literature. Reference gives a detailed survey of the channel estimation schemes. These schemes can be categorized as Training based (TBCE), Blind (BCE) and Semi-Blind (SBCE). Training based schemes are capable of accurately estimating a MIMO channel, provided a large training overhead is made available. Hence, there is considerable reduction in system throughput. The least-square (LS) and minimum-mean-square-error (MMSE) techniques are widely used for channel estimation when training symbols are available. The LS method is simpler than the MMSE, but the performance of MMSE scheme is better. MMSE method, however, requires knowledge of second order channel statistics. Blind methods do not require the training overhead. However, these methods not only impose high complexity and slow convergence, but also suffer from unavoidable estimation and decision ambiguities. Semi-blind methods offer attractive, practical means of implementing MIMO systems. Semi-blind channel estimation schemes, use a very few training symbols to provide the initial MIMO channel estimation and make use of blind information to improve further the estimation. Some SBCE schemes also exchange the information between the channel estimator and the data detector iteratively, which are termed as joint channel estimation and data detection [9]. This research work has proposed a new approach to semi-blind channel estimation which is an improvement over the SBCE of [10].

II. LITERATURE REVIEW

Akhilesh Venkatasubramanian et al. [1], the information rates of remote correspondence frameworks working in a recurrence specific foundation can be enhanced by utilizing Multiple-Input Multiple-Output (MIMO) in relationship with Orthogonal Frequency Division Multiplexing (OFDM). The inadequacies of Code Division Multiple Access (CDMA) can be overwhelmed by utilizing Interleave Division Multiple Access (IDMA) which is effectively incorporated into MIMO frameworks. IDMA joined with OFDM can be utilized to execute recurrence particular channels. In this paper we diagram the fundamental standards of an OFDM-IDMA transmitter and collector took after by reenactment results to think about the productivity of actualizing OFDM-IDMA. The execution of our collector is characterized by the reproduction aftereffects of the vitality per bit to clamor control ghostly thickness proportion (Eb/N0) and Bit Error Rate (BER). An emotional diminishing in BER is accomplished by utilizing the channel translating and channel estimation strategies proposed. It is discovered that the OFDM-IDMA framework is more compelling than simply utilizing IDMA or OFDM-CDMA. Along these lines the entire research is to attempt and actualize a system that ends up being to a great degree successful over the effectively existing strategies.

R. Prasad et al. [2], the motivation reaction of remote channels between the Nt transmit and Nr get recieving wires of a MIMO-OFDM framework are gather roughly inadequate (ga-meager), i.e., the NtNr channels have few huge ways in respect to the channel postpone spread and the time-slacks of the huge ways amongst transmit and get reception apparatus sets concur. Regularly, remote channels are likewise aggregate roughly bunch scanty (gac-meager), i.e., each ga-inadequate channel comprises of groups, where a couple of bunches have every single solid segment while most bunches have every single powerless segment. In this paper, we cast the issue of assessing the ga-meager and gac-scanty square blurring and time-differing diverts in the inadequate Bayesian learning (SBL) structure and propose a bundle of novel calculations for pilot-based channel estimation, and joint channel estimation and information discovery, in MIMO-OFDM frameworks. The proposed calculations are fit for assessing the meager remote channels notwithstanding when the estimation network is just halfway known. Further, we utilize a first-arrange autoregressive displaying of the worldly variety of the ga-scanty and gac-inadequate channels and propose a recursive Kalman separating and smoothing (KFS) system for joint channel estimation, following, and information recognition. We likewise propose novel, parallel-usage based, low-intricacy strategies for assessing gac-inadequate channels. Monte Carlo reenactments represent the advantage of abusing the gac-scanty structure in the remote divert regarding the mean square mistake (MSE) and coded bit blunder rate (BER) execution.

R. Prasad et al. [3], It is notable that the motivation reaction of a wideband remote channel is roughly scanty, as in it has few huge parts in respect to the channel postpone spread. In this paper, we think about the estimation of the obscure channel coefficients and its help in OFDM frameworks utilizing a meager Bayesian learning (SBL) structure for correct deduction. In a semi static, square blurring situation, we utilize the SBL calculation for channel estimation and propose a joint SBL (J-SBL) and a low-many-sided quality recursive J-SBL calculation for joint channel estimation and information location. In a period changing situation, we utilize a first-arrange autoregressive model for the remote channel and propose a novel, recursive, low-multifaceted nature Kalman sifting based SBL (KSBL) calculation for channel estimation. We sum up the KSBL calculation to acquire the recursive joint KSBL calculation that performs joint channel estimation and information location. Our calculations can productively recuperate a gathering of around inadequate vectors notwithstanding when the estimation framework is incompletely obscure because of the nearness of obscure information images. Additionally, the calculations can completely abuse the relationship structure in the numerous estimations. Monte Carlo reproductions represent the viability of the proposed methods regarding the mean-square blunder and bit mistake rate execution.

Mel Li et al. [4], in this paper, we will examine the Least Mean Square (LMS) and Recursive Least Square (RLS) calculations. At that point, we apply these two calculations to a Multiple-input Multiple-output (MIMO-OFDM) framework in light of Space-Time Block Coding (STBC), and do a few reproductions on these two calculations. From the reproduction, it is discovered that the merging pace of the RLS calculation is quicker than LMS calculation, i.e., the execution of RLS is superior to LMS calculation.

III. MIMO SYSTEM

In wireless communication environment, the main challenge is to combat multipath fading. Multipath is a phenomenon that occurs due to the arrival of the transmitted signal through different paths. The signal arrives at the receiver through different angles, with different time delays and different frequency shifts. As a result, the signal power at the receiver fluctuate giving rise to fading [6]. Apart from fading, constraints such as low power and limited bandwidth make the communication system designer's task of increasing data rate and reliability more challenging. MIMO technology can be used effectively to meet these requirements by taking advantage of multipath.

The Single Input Single Output (SISO) communication system consists of a single transmits and receive antenna. The capacity of a SISO system is given by Shannon's capacity equation [7] as,

$$C = \log_2(1 + SNR)\, bits/\sec/Hz \qquad (1)$$

The multi-antenna systems can offer an advantage in terms of array gain, diversity gain, and multiplexing gain.

Array Gain

The coherent combining of wireless signals at the receiver end results in increase in SNR. This increase in SNR is called array gain. The coherent combining can be achieved through spatial processing at transmitter or receiver or both the locations.

Diversity Gain

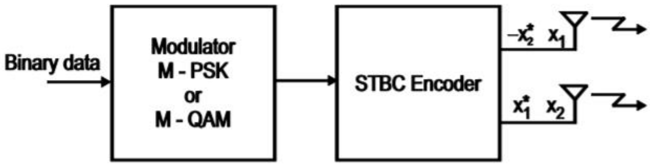
Diversity gain can be achieved by providing multiple independent copies of the signal in space, time or frequency. When multiple copies of the signal are available at the receiver, the probability of receiving at least one copy correctly increases. Thus, the diversity gain is an improvement in link reliability.

Multiplexing Gain

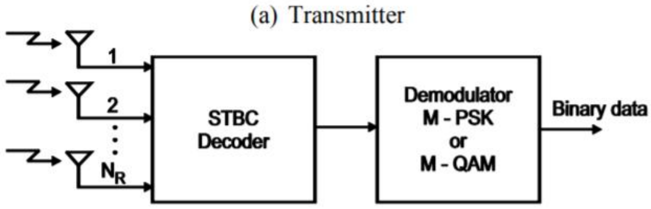
The multiplexing gain is an increase in data rate without any additional power or bandwidth. This gain can be achieved by transmitting multiple independent data streams.

IV. SPACE TIME BLOCK CODE

The space-time block codes have become popular because of their simplicity. These codes started appearing in literature after the revolutionary work by Alamouti [1] who designed the code for two transmit antennas. These codes were extended for more than two transmit antennas using orthogonal design [2] [3] and are known as space-time block codes (STBC). However, Alamouti codes are the only known full diversity and full data rate codes for two transmit antennas whereas for more than two transmit antennas the codes are either full diversity or full data rate codes.



(a) Transmitter



(b) Receiver

Figure 1: A MIMO communication system with STBC Code

V. PROPOSED METHODOLOGY

The MIMO-OFDM device modified into applied with the useful resource of MATLAB/SIMULINK. The execution device is binary facts this is modulated the use of QAM and mapped into the constellation elements. The virtual modulation scheme will transmit the records in parallel by means of manner of assigning symbols to every sub channel and the modulation scheme will determine the phase mapping of sub-channels thru a complex I-Q mapping vector show in figure 2.

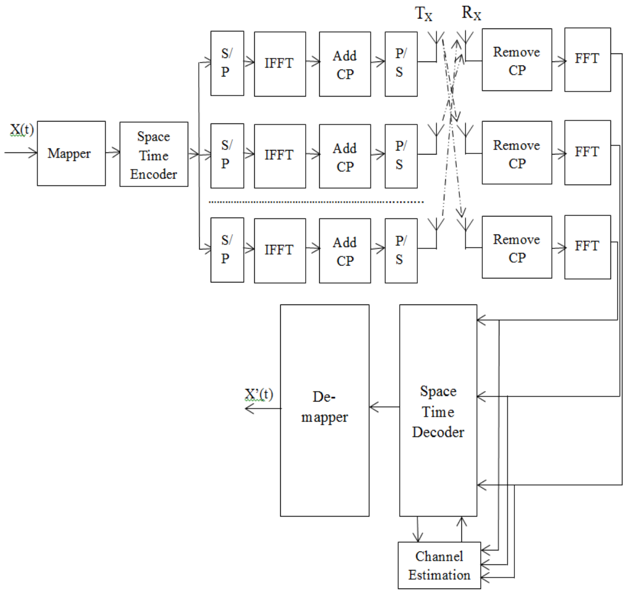


Figure 2: MIMO-OFDM System Models with Channel Estimation Technique

The complicated parallel facts stream must be converted into an analogue signal this is suitable to the transmission channel. The complicated parallel facts stream has to be transformed into an analogue sign that is suitable to the transmission channel. It is performed to the cyclic prefix add to the baseband modulation signal because the baseband signal is not overlap. After than the signal is splitter the two or more part according to the requirement.

VI. SIMULATION RESULT

In simulations it is assumed that the system is perfectly synchronized. Different values of SNR are taken and the performance is checked.

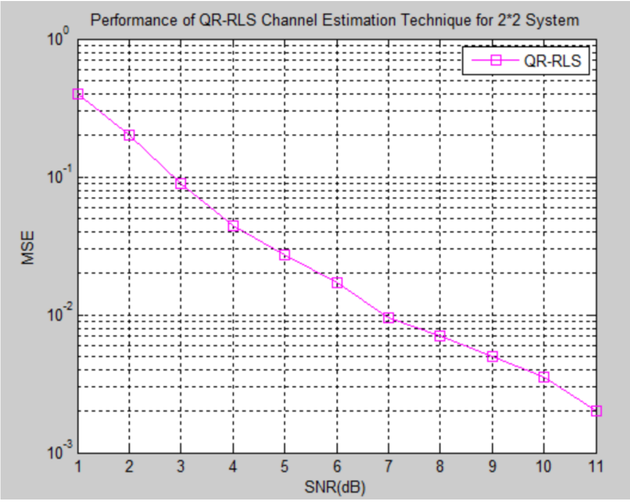


Figure 3: Performance MSE for 2×2 MIMO-OFDM Systems

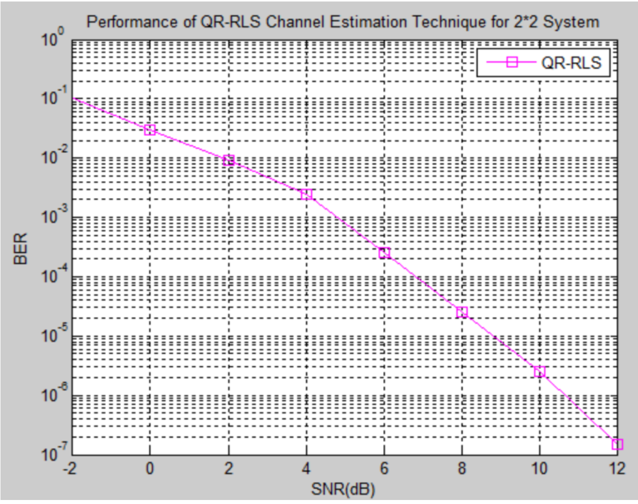


Figure 4: Performance BER for 2×2 MIMO-OFDM Systems

VII. CONCLUSION

In this paper channel estimation techniques for MIMO and MIMO-OFDM based systems are investigated. The channel estimation techniques are studied through simulations using MATLAB. New improved techniques are proposed, and their performance is evaluated and compared with existing techniques. For spatial diversity MIMO systems, detection is simple. The STBC or SFBC MIMO-OFDM systems are most suitable for practical applications where reliability is more important than the data rate.

REFERENCES

[1] Akhilesh Venkatasubramanian, Krithika. V and Partibane. B, "Channel Estimation For A Multi-User MIMOOFDM-IDMA System", International Conference on Communication and Signal Processing, April 6-8, 2017, India.

[2] R. Prasad, C. R. Murthy, B. D. Rao, "Joint channel estimation and data detection in MIMO-OFDM systems: A sparse Bayesian learning approach", IEEE Trans. Signal Process., vol. 63, no. 20, pp. 5369-5382, Oct. 2015.

[3] R. Prasad, C. R. Murthy, B. D. Rao, "Joint approximately sparse channel estimation and data detection in OFDM systems using sparse Bayesian learning", IEEE Trans. Signal Process., vol. 62, no. 14, pp. 3591-3603, Jul. 2014.

[4] Mel Li, Xiang Wang and Kun Zhang, "Comparative Study of Adaptive Filter Channel Estimation Technique in MIMO-OFDM System Based on STBC", Proceedings of the 2014 International Conference on Machine Learning and Cybernetics, Lanzhou, 13-16 July, 2014.

[5] Biswajit Sahoo, Ravi Ranjan Prasad, and P. Samundiswary, "BER Analysis of Mobile WiMAX System using LDPC Coding and MIMO System under Rayleigh Channel", International conference on Communication and Signal Processing, April 3-5, 2013, India.

[6] Mukesh Patidar, Rupesh Dubey, Nitinkumar Jain and Saritakul Pariya, "Performance Analysis of WiMAX 802.16e Physical Layer Model", International Conference on wireless communication, 2012 IEEE.

[7] Chin-Liang Wang and Shun-Sheng Wang and Hsiao-Ling Chang, "A Low-Complexity SLM Based PAPR Reduction Scheme for SFBC MIMO-OFDM Systems", International Conference on Wireless Communication, 2011 IEEE.

[8] Divyang Rawal, Park Youn Ok and C. Vijaykumar, "A Novel training based QR-RLS channel estimator for MIMO OFDM systems", Wireless Advanced (WiAD), 6th Conference on, IEEE 2010.

[9] Ke Chen and Xiaojing Huang, "A Novel Approach for Interference Suppression in Multi-Sub band Convolutional Coded OFDM System", School of Electrical, Computer & Telecommunications University of Wollongong, Australia (2010).

[10] Sen-Hung Wang, and Chih-Peng Li, "A Low-Complexity PAPR Reduction Scheme for SFBC MIMO-OFDM Systems", IEEE Signal Processing Letters, Vol. 16, No. 11, November 2009.

[11] Yang Zhou and Tao Jiang, "A Novel Multi-Points Square Mapping Combined With PTS to Reduce PAPR of OFDM Signals Without Side Information", IEEE Transactions on Broadcasting, Vol. 55, No. 4, December 2009.

[12] Wei Jiang and Daoben Li, "Convolutional Multi-code Multiplexing for OFDM Systems", Beijing University of

Posts and Telecommunications Beijing 100876, China (2007).

[13] B. Sklar, "Digital Communications Fundamentals and Applications," Prentice Hall, Upper Saddle River, NJ, 2000.