MIMO-OFDM WIRELESS COMMUNICATION SYSTEM PERFORMANCE ANALYSIS FOR CHANNEL ESTIMATION

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Abstract - *This study proposes a hybrid Wiener filter-based pilot-based low-complexity channel estimator for use in the LTE-A downlink using cell-specific reference signals (C-RS) and user equipment reference signals (UE-RS). Sub-optimally, the suggested system only needs 8.8 and 74.5 percent as many calculations as the optimum system and other sub-optimum systems, respectively. In addition, a Fast Fourier Transform (FFT)-based CE technique is developed, which requires less computing power. End-to-end LTE-A system throughput validation of the reported pilot-based system demonstrates the feasibility of the proposed system. Next, we provide a novel blind CE method for SIMO and MIMO systems that makes use of a hybrid OFDM symbol structure. It is shown that the created system achieves comparable performance to a pilot-based system with an equivalent level of complexity and improved spectrum efficiency, provided that a sufficient number of receive antennas are used. Last but not least, we offer alternative Resource Grid (RG) configurations that support the blind-based CE method designed for MIMO-OFDM systems, with the goal of enhancing MSE performance while reducing the number of necessary receive antennas. From the standpoint of the investigated blind-based CE scheme, the results reveal that the suggested RG configurations give better MSE performance than the LTE-A RG configuration.*

Key Words: MIMO-OFDM, wireless communication, channel estimation, performance analysis, least squares estimation, linear minimum mean square error (LMMSE), zero-forcing (ZF).

1. INTRODUCTION

A MIMO-OFDM wireless communication system is a type of wireless communication system that utilizes multiple-input-multiple-output (MIMO) technology and orthogonal frequency-division multiplexing (OFDM) modulation. MIMO technology uses multiple antennas at both the transmitter and receiver to increase the system's capacity and improve its performance by reducing interference and improving signal quality.

OFDM modulation, on the other hand, divides the data stream into multiple subcarriers and modulates them separately. This helps to mitigate the effects of channel fading and improves the system's spectral efficiency. MIMO-OFDM systems combine these two technologies to provide high-speed, reliable wireless communication over a wide range of distances.

MIMO-OFDM wireless communication systems are commonly used in many applications such as wireless LANs, cellular networks, and digital broadcasting. They offer several advantages over traditional wireless communication systems, including higher data rates, better coverage, and improved resistance to interference and fading.

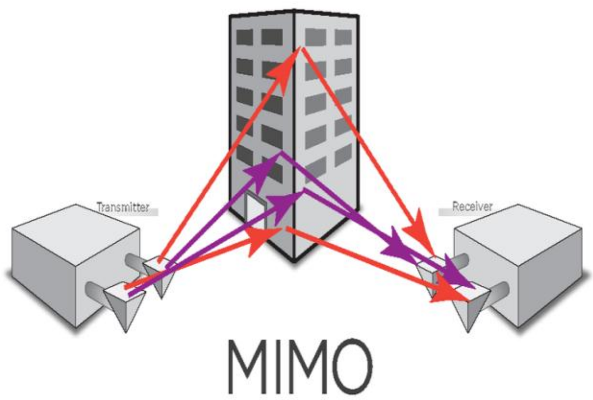

Figure-1: MIMO

The basic principle of a MIMO-OFDM wireless communication system is to divide the available frequency band into multiple subcarriers and use OFDM modulation to transmit data over these subcarriers. Each subcarrier carries a small portion of the data, and the data is distributed across all the subcarriers in a way that maximizes the spectral efficiency of the system.

In a MIMO-OFDM system, multiple antennas are used at both the transmitter and receiver end to exploit the spatial diversity of the wireless channel. The signals transmitted from each antenna are combined at the receiver, which improves the quality of the received signal and increases the data rate.

The MIMO-OFDM system uses advanced signal processing techniques to mitigate the effects of multipath fading and interference. The system uses different algorithms to process the received signals, such as Space-Time Block Coding (STBC), Spatial Multiplexing (SM), and Beamforming. These techniques improve the signal quality, reduce the error rate, and increase the overall performance of the wireless communication system.

The purpose of a Multiple-Input Multiple-Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM) wireless communication system is to provide a high-speed and reliable wireless communication link between two or more devices. The system is designed to achieve the following objectives:

1. Increase the data rate: A MIMO-OFDM system can provide high data rates by using multiple antennas at both the transmitter and receiver ends. The system exploits the spatial diversity of the wireless channel to transmit and receive multiple streams of data simultaneously.

2. Improve spectral efficiency: By dividing the available frequency band into multiple subcarriers, the MIMO-OFDM system can transmit data over multiple channels simultaneously. This maximizes the use of the available spectrum and improves the spectral efficiency of the system.

3. Enhance the quality of the wireless link: The MIMO-OFDM system uses advanced signal processing techniques to mitigate the effects of multipath fading and interference. These techniques improve the signal quality, reduce the error rate, and increase the overall performance of the wireless communication system.

2. TECHNIQUES FOR CHANNEL ESTIMATION

Channel estimation is crucial in wireless communication systems to estimate the characteristics of the wireless channel and compensate for channel impairments. In MIMO-OFDM wireless communication systems, there are multiple antennas at both the transmitter and receiver ends, which makes channel estimation even more complex. Some common techniques for channel estimation include pilot-based estimation, compressed sensing-based estimation, maximum likelihood estimation, and Kalman filter-based estimation. Pilot-based estimation involves inserting known pilot symbols into the transmitted signal, while compressed sensing-based estimation utilizes the sparse nature of the wireless channel. Maximum likelihood estimation maximizes the likelihood function of the received signal, while Kalman filter-based estimation uses a recursive algorithm to estimate the channel. These techniques are essential for achieving reliable wireless communication and improving the performance of MIMO-OFDM systems.

3.PROBLEM STATEMENT

The ever-increasing demand for high-speed and reliable wireless communication systems has led to the widespread adoption of Multiple-Input Multiple-Output (MIMO) and Orthogonal Frequency Division Multiplexing (OFDM) technologies. In MIMO-OFDM systems, accurate channel estimation plays a crucial role in achieving optimal system performance. However, various factors such as channel fading, noise, and interference pose significant challenges to the accurate estimation of the channel state information. Therefore, there is a need for a comprehensive analysis of MIMO-OFDM wireless communication system performance specifically focusing on channel estimation techniques. This research paper aims to address this gap by investigating and evaluating existing channel estimation techniques in MIMO-OFDM systems to identify their limitations, strengths, and potential areas for improvement. By conducting a detailed performance analysis, this research aims to provide valuable insights and recommendations for enhancing the accuracy and efficiency of channel estimation in MIMO-OFDM wireless communication systems.

4.RESULT AND ANALYSIS

Utilising a hybrid Wiener filter, it is claimed that a pilot-based reduced complexity channel estimator for Cell-Specific Refer ence Signals (C-RS) and User Equipment RS (UE-RS) in LTE-A Downlink (DL) systems may be created. This estimator will be used in the system. The system that has been developed is a sub-optimum scheme that needs between 8.8 and 74.5 percent of the number of calculations that are needed by the optimal system and other sub-optimum systems, respectively. In addition, a CE approach that is based on the Fast Fourier Transform (FFT) and has a lower computational complexity is presented. Because the throughput of the provided pilot-based system has been tested in an end-to-end LTE-A system, this demonstrates that the suggested system is acceptable for practical application. Next, a brand new CE method for SIMO and MIMO systems that is based on a hybrid OFDM symbol structure is described. This method is blind-based and uses CE. It has been shown that the proposed system, when equipped with an adequate number of receive antennas, operates just as well as a pilot-based system, while having a comparable level of complexity and a higher spectral efficiency. Finally, novel Resource Grid (RG) configurations that service the blind-based CE scheme designed for the MIMO-OFDM system are described. These configurations have been developed with the intention of improving the Mean Squared Error (MSE) performance while simultaneously minimising the number of necessary receive antennas. When compared to the LTE-A RG configuration, the results demonstrate that the suggested RG configurations provide improved MSE performance from the point of view of the blind-based CE scheme that is the subject of the inquiry.

5. TIME-FREQUENCY RESOURCE GRID OF LTE

The Long-Term Evolution (LTE) wireless communication standard uses a Time-Frequency Resource Grid to transmit data over the air interface. The Resource Grid is a two-dimensional matrix that represents the time and frequency domains of the signal. The Resource Grid is divided into time slots and subcarriers, which are used to transmit data in the time and frequency domains, respectively. Each subcarrier is modulated using Orthogonal Frequency Division Multiplexing (OFDM) modulation, which enables high data rates and efficient spectrum usage. The Resource Grid is also divided into Physical Resource Blocks (PRBs), which consist of a group of subcarriers and time slots. The size of the PRBs can be adjusted to accommodate different channel conditions and data rates. The Resource Grid is a fundamental component of the LTE standard and plays a crucial role in achieving high-speed wireless communication.

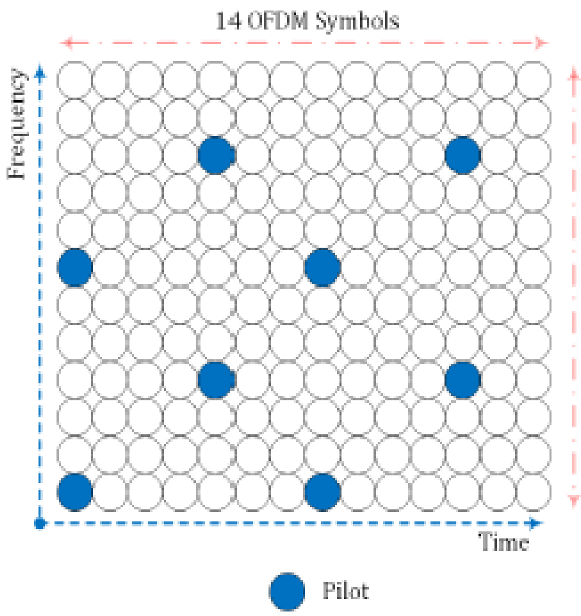

Figure-2: An example of the time-frequency resource grid for LTE-A.

6. ACROSS FREQUENCY MIMO 1-D F.OSBCE

The pilots for this version of OSBCE are spread out in one dimension, all while remaining contained within the limits of a single OFDM signal (frequency). The signal is canceled out by Antenna 2, while Antenna 1 is utilized to deliver MASK symbols to the positions of the original pilots. The MASK signal from Antenna 1 would be the only signal that would be received at the exact OFDM symbols on particular subcarriers as a consequence of this, and there would be no interference from any other transmit antennas. This would be the case since there would be no other transmit antennas. In light of this, the phase of the received MASK would serve as a less-than-precise estimate of the channel that would be utilized for equalizing the MPSK symbols, in a manner that is comparable to how the SIMO scenarios would be carried out.

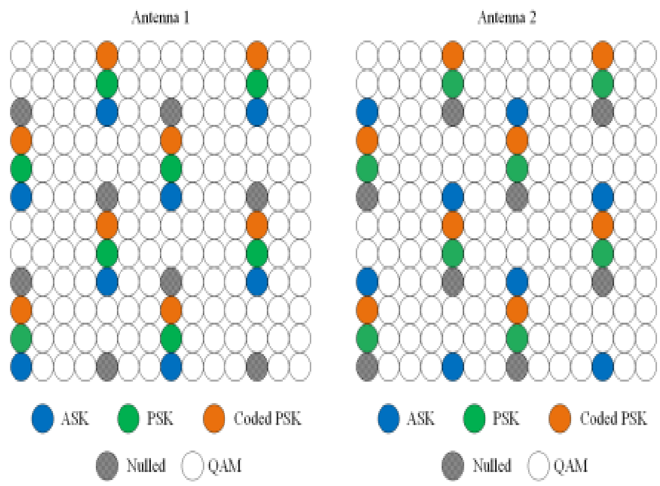

Figure-3: OSBCE Network Relay Exchange (NRx) Mode-01

6.1. Mode-01 M.

In this section of the article, a modified MIMO OSBCE across frequency will be shown as a viable solution to the ongoing problem of distortion. This solution will be discussed in the context of the article. This issue has been lingering for a considerable amount of time. It will be necessary to alter the locations of the MASK and MPSK so that the update can be finished, and it will also be necessary to move them in the other direction.

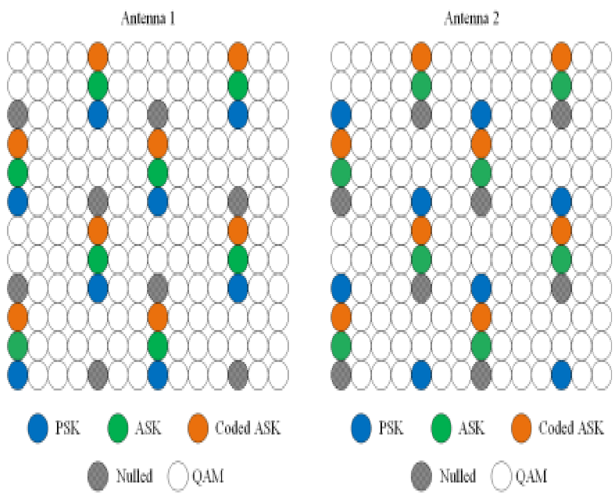

Figure-4: System for NRx Frequency OSBCE in Mode 1 M.

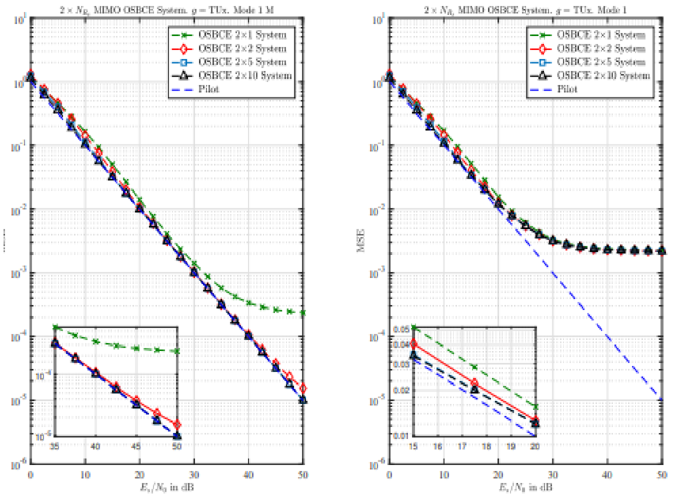

Figure-5: Different NRx (Modes 1 M & 1 F): MSE vs. SNR (2 NRx F. OSBCE).

7. DISTRIBUTION PROPOSAL FOR MIMO 1-D F.OSBCE

We will proceed to the following stage on the assumption that the system model setup and variables are the same and that we have an RG with 12 subcarriers and 14 OFDM symbols. Figure 6 depicts how the MPSK and MASK symbols will be grouped inside the same OFDM signal in the future. These marks are going to be put on the subcarriers that are nearby. As can be seen in Figure 6, the MPSK and MASK symbols are positioned inside the same OFDM signal at neighboring subcarriers.

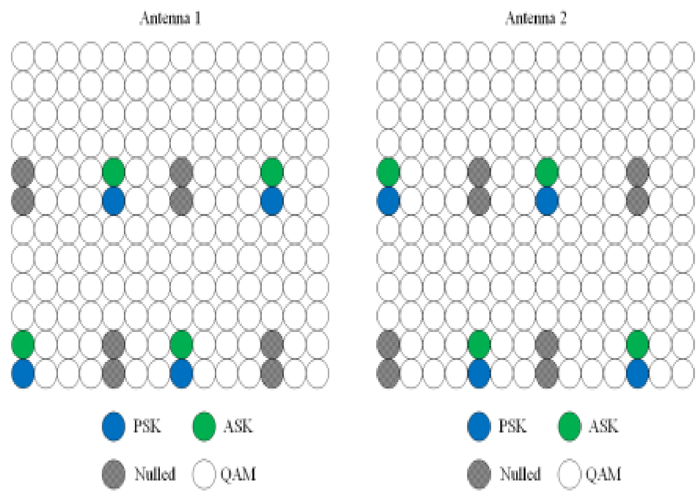

Figure-6: 2 NRx Frequency OSBCE system is going to be proposed.

8. PROPOSED VERSUS MODE 2 RESULTS AND DISCUSSION.

The suggested configurations together with the LTE configurations are shown functioning in a TUx channel environment in figure-7. In addition, the symbol error rate (SER) and the bit error rate (BER) are given in this figure as a function of the symbol noise ratio (SNR). The performance of the recommended MIMO F.OSBCE is superior to that of its LTE counterpart, even though it has a lower price tag. The LTE standard calls for the usage of five receive antennas; however, the configuration that is being recommended employs just two of these antennas, which results in a higher SER. In addition, when utilizing the proposed configuration with NRx = 2, the A(m) k SER outperforms the A(m) k SER with perfect CSI up until the SNR is less than 50 dB.

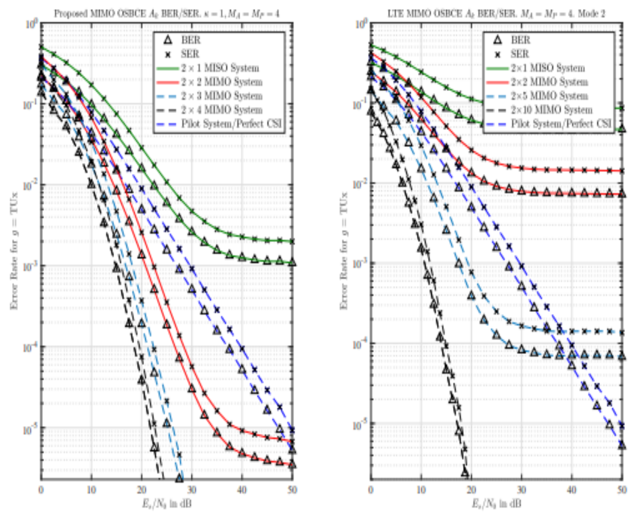

Figure-7: 2 NRx F. OSBCE - ak BER & SER vs. SNR - Proposed & Mode 2.

9. DISTRIBUTION PROPOSAL FOR MIMO 1-D T.OSBCE

MIMO 1-D T.OSBCE (Multiple-Input Multiple-Output One-Dimensional Target-Orthogonal Space Block Code with Error Correction) is a communication technique that is designed to improve the reliability of wireless transmissions. The goal of T.OSBCE is to transmit data over multiple antennas while minimizing interference between antennas and increasing the signal-to-noise ratio (SNR) at the receiver.

To propose a distribution for MIMO 1-D T.OSBCE, we first need to understand the basic principles of the technique. In T.OSBCE, the transmitted signal is divided into multiple parallel streams, each of which is transmitted on a different antenna. These streams are designed to be orthogonal to each other, which means that they do not interfere with each other during transmission. At the receiver, the signals from each antenna are combined to recover the original data.

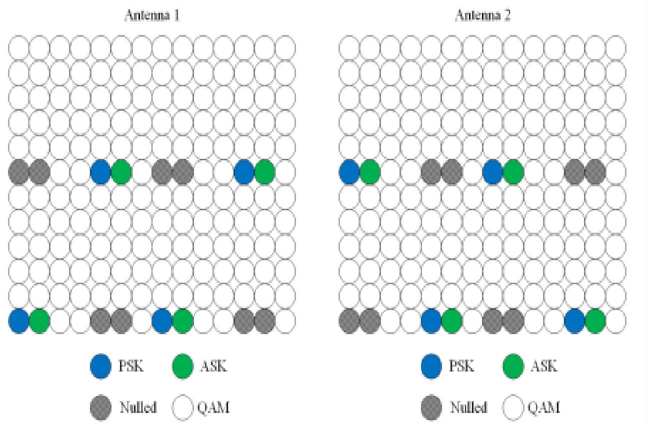

Figure-8: NRx Time OSBCE system – proposed

10. CONCLUSION

When wireless communication networks are ultimately implemented, the RG configurations that have been made accessible for OSBCE will be put to good use. When constructing the RG arrangements, this goal was kept in mind. To do this, they use a wide variety of implementation strategies, including an LTE-A prototype setup. There are two separate strategies, and the titles Mode 1 and Mode 2 reflect the labels applied to each strategy. After a successful Mode 1 encoding reception, the MASK signals, and MPSK symbols are combined and delivered to several RE sites for decoding. Since the RE sites are being nulled, no other transmit antennas are broadcasting MPSK symbols. OSBCE may be utilized without issue in Mode 1 since the encoding allows for the extraction of the requisite MASK symbol for each transmits aerial. All other transmitting antennas' RE sites are temporarily disabled to prevent interference with Mode 2 operations. This is done so that the same frequency may be used for the transmission of MPSK- and MASK-encoded signals through the same aerial. Although Mode 2 has the potential to achieve higher spectral efficiency than Mode 1, its overall performance is significantly lower. The performance of the non-default Mode 1 configuration is better than that of the default Mode 2. The default setting is Mode 2. Mode 2 is the default mode. The recommended RG settings for OSBCE provide better mean squared error (MSE) performance than the LTE RG setup. This is especially true for the MIMO Mode 2 examples. To attain the same degree of performance, the proposed RG would only need half as many receive antennas as the pilot-based system, but it still only generates half as many interpolation points as the pilot-based system.

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