MIMO-OFDM WIRELESS COMMUNICATION SYSTEM PERFORMANCE ANALYSIS FOR CHANNEL ESTIMATION: A REVIEW

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Abstract - *MIMO-OFDM (Multiple Input Multiple Output Orthogonal Frequency Division Multiplexing) is a wireless communication technology that combines two advanced techniques: Multiple Input Multiple Output (MIMO) and Orthogonal Frequency Division Multiplexing (OFDM). MIMO technology involves using multiple antennas at both the transmitter and receiver ends to improve the overall performance and capacity of the wireless communication system. By using multiple antennas, MIMO can increase the data rate, reduce interference, and improve the range of the wireless link. OFDM is a digital multi-carrier modulation technique that divides the available bandwidth into multiple orthogonal subcarriers. Each subcarrier carries a portion of the data, and the subcarriers are modulated and transmitted simultaneously. This makes OFDM an effective technique for mitigating the effects of multipath fading and interference in wireless communication systems. MIMO-OFDM is widely used in many wireless communication systems, such as 4G LTE, Wi-Fi, and WiMAX, to provide high-speed and reliable wireless communication. It provides several advantages, including increased data rate, improved spectral efficiency, enhanced reliability, and improved resistance to fading and interference, compared to traditional single-antenna and single-carrier communication systems.*

Key Words: MIMO-OFDM, Channel Estimation, Pilot carriers, Minimum Mean square error.

1. INTRODUCTION

Mobile communication systems are wireless communication networks that provide communication services to mobile devices, such as smartphones, tablets, and laptops. These systems allow users to communicate with each other and with the outside world, regardless of their physical location. Mobile communication systems typically consist of a network of base stations, each with a defined coverage area, and mobile devices that are used by the users to communicate. The base stations are connected to the core network, which provides the necessary infrastructure and services to support communication between mobile devices. Mobile communication systems use a variety of technologies and standards, including cellular networks, Wi-Fi, and satellite communication, to provide a range of communication services, such as voice, text, and multimedia messaging, as well as high-speed data services. With the widespread adoption of mobile devices and the growing demand for mobile data services, mobile communication systems have become an integral part of modern society, enabling people to stay connected with each other and the world around them at all times.

1.1. MIMO-OFDM

Multiple Input Multiple Output (MIMO) is a wireless communication technology that involves using multiple antennas at both the transmitter and receiver ends of a wireless link. The goal of MIMO is to improve the performance and capacity of wireless communication systems. In MIMO systems, multiple antennas are used at both the transmitting and receiving ends to simultaneously transmit and receive multiple data streams. This allows the system to effectively exploit the spatial diversity of the wireless channel, resulting in increased data rates, reduced interference, and improved link range. MIMO technology can be applied in both single-user and multi-user scenarios, and it is widely used in many wireless communication systems, such as 4G LTE, Wi-Fi, and WiMAX, to provide high-speed and reliable wireless communication. MIMO can be implemented in different configurations, such as spatial multiplexing, beamforming, and diversity combining. The choice of MIMO configuration depends on the specific requirements and constraints of the wireless communication system. Overall, MIMO is a key technology for improving the performance and capacity of wireless communication systems, and it will continue to play an important role in the development of future wireless communication systems.

Orthogonal Frequency Division Multiplexing (OFDM) is a digital multi-carrier modulation technique used in wireless communication systems. It divides the available bandwidth into multiple orthogonal subcarriers, each of which carries a portion of the data. The subcarriers are modulated and transmitted simultaneously, and the data is reconstructed at the receiver. The main advantage of OFDM is its ability to effectively combat the effects of multipath fading and interference in wireless communication systems. By dividing the available bandwidth into multiple subcarriers, each with a relatively narrow bandwidth, OFDM can mitigate the effects of fading and interference by spreading the data over multiple subcarriers. OFDM is widely used in many wireless communication systems, such as 4G LTE, Wi-Fi, and Digital

Video Broadcasting (DVB), to provide high-speed and reliable wireless communication. It is also used in broadband wired communication systems, such as Digital Subscriber Lines (DSL) and cable modems, to provide high-speed data services over copper and coaxial cables. OFDM provides several advantages, including increased data rate, improved spectral efficiency, enhanced reliability, and improved resistance to fading and interference, compared to traditional single-carrier modulation techniques. Overall, OFDM is an important technology for improving the performance and capacity of wireless communication systems, and it will continue to play a significant role in the development of future wireless communication systems.

1.2. MIMO - OFDM SYSTEM

Multiple Input Multiple Output (MIMO) - Orthogonal Frequency Division Multiplexing (OFDM) is a wireless communication system that combines the benefits of both MIMO and OFDM technologies. MIMO-OFDM systems use multiple antennas at both the transmitter and receiver ends of a wireless link, along with the OFDM modulation technique, to improve the performance and capacity of the wireless communication system. In MIMO-OFDM systems, the available bandwidth is divided into multiple orthogonal subcarriers, each of which carries a portion of the data. The multiple antennas at both the transmitter and receiver are used to transmit and receive multiple data streams simultaneously, effectively exploiting the spatial diversity of the wireless channel to provide improved data rates, reduced interference, and increased link range.

MIMO-OFDM is widely used in many wireless communication systems, such as 4G LTE and Wi-Fi, to provide high-speed and reliable wireless communication. The combination of MIMO and OFDM technologies provides several advantages, including increased data rate, improved spectral efficiency, enhanced reliability, and improved resistance to fading and interference, compared to traditional single-antenna and single-carrier modulation techniques. Overall, MIMO-OFDM is a key technology for improving the performance and capacity of wireless communication systems, and it will continue to play a significant role in the development of future wireless communication systems.

2. LITERATURE REVIEW

In this literature survey section, we have studied the previous research paper related to the MIMO-OFDM system, the summary of these papers is given below in the detail:

Ganesh et.al: MIMO-OFDM channel estimation under Rayleigh fading is studied. Simulations are run using two distinct techniques, LS channel estimation, and MMSE channel estimation. The simulation findings demonstrate that the BER is lower when using a comb-type pilot carrier for channel estimation in a MIMO- OFDM system than when using a block-type pilot carrier, and that the MSE is lower when using MMSE than when using LS channel estimation. The results show that the MMSE channel estimator outperforms the LS channel estimator.

Abdelhakim, Ridha: We suggest assessing the impact of channel length on the efficiency of LS and LMMSE estimation methods for LTE Downlink networks. To reduce ICI and ISI, a cyclic prefix is appended to the beginning of each OFDM symbol that is at least as long as the channel. Unfortunately, the channel may exhibit unexpected behavior that causes the CP length to fall short of the channel length. The LMMSE outperforms the LS estimator in simulations when the CP length is comparable to or greater than the channel length, but at the expense of complexity due to its dependence on the channel and noise statistics. On the other hand, LMMSE's superior performance is limited to low SNR values and gradually decreases as SNR increases. Comparatively, LS outperforms LMMSE in this range of SNR values.

Archana et.al: The results of this research show that in the low-to-medium signal-to-noise ratio (SNR) range, the BER is much lower in the STBC-OFDM system compared to the SM-OFDM system. Therefore, STBC-OFDM may be employed to improve performance even at low SNR. Nonetheless, SM-OFDM can not only deliver double the throughput but also a negligible error rate at high SNR. According to the findings, OFDM may be integrated with STBC or SM systems. The quality of received pictures sent by both models is assessed with throughput and BER. The output images corroborate previous findings that the STBC-OFDM system creates much less noise in the received picture than the SM-OFDM model. Research into MIMO-OFDM hybrid models may be required to better comprehend the receiver's power consumption pattern and design complexity about bit error rate and throughput rate.

Juhi et.al: The need for mobile data services has skyrocketed in recent years, and certain mobile carriers have seen even more rapid expansion than the industry average. A recent prediction indicates that mobile data traffic will double annually through 2014, amounting to a compound annual growth rate of about 100% worldwide. LTE-Advanced and WiMAX- 2 can employ up to 8x8 MIMO, depending on the system's level of development. Demodulation/detection and channel state information estimation both benefit from the introduction of new reference signals. That's why modern SU/MU-MIMO systems have focused so intently on improving their signaling. However, one of the primary difficulties in implementing MIMO in cellular networks is the extreme vulnerability of MIMO receivers to channel interference. If system designers want to limit the amount of disruption they cause to adjacent cells, they'll need to dial down the transmission power and data rate. However, due to their inherent design, MIMO systems need a higher received signal-to-interference-noise power ratio to transmit the same amount of data (SINR). Receiver and transmitter advancements in signal processing have been employed to mitigate or eliminate interference. Thus, we were able to learn from this text that a MIMO system only involves using a transmitter and receiver equipped with many antennas. Its purpose is to improve network stability and data transfer rate without requiring more bandwidth or power to communicate. Processing techniques including pre-coding, diversity coding and special multiplexing distinguish between the two primary types of MIMO: multi-user and single-user. When it comes to Multiple-Input Multiple-Output communications, reconfigurable antennas have been employed to create pattern and frequency diversity. This article shows that the majority of these methods have significant practical limitations, especially when it comes to the complexity and channel information necessary for their effective application to 3G cellular networks.

Vipin, Parveen: This study reveals that the MSK modulation scheme performs admirably in the scenario of multi-bit transmission from the MIMO OFDM system. Throughput, Bit Error Rate, Ergodic Capacity, Symbol Error Rate, Signal-to-Noise Ratio, and Outage Capacity are some of the metrics used to evaluate MSK modulation's efficacy. The ongoing study clears several paths for researchers of the future to explore.

B.K. Mishra et.al: Different modulation schemes, such as QPSK, 16-QAM, and 64-QAM in a MIMO-OFDM system, have been shown to perform differently when it comes to channel estimation using Least Mean Squared (LMS), Leaky Least Mean Squared (LLMS), and Modified Leaky Least Mean Square (MLLMS) algorithms. The primary goal is to increase SNR and decrease BER by manipulating the step size. As can be seen from the data shown above, decreasing the step size (=0.0025) improves the steady-state error up to the range of 0.96 to 10-1 and the SNR value up to the range of 15 to 5 dB. also Based on the results of a comparative analysis, it appears that the Modified Leaky Least Mean Square algorithm performs better than the Leaky Least Mean Square algorithm and the Least Mean Square algorithm when used in conjunction with a Multiple Input Multiple Output (MIMO) and Orthogonal Frequency Division Multiplexing (OFDM) system. We found that the MLLMS method had the best improvement percentile among the tested algorithms. The results show that the Modified Leaky Least Mean Square algorithm has the lowest BER and maximum SNR, allowing for the largest possible channel capacity for data transmission. By optimizing for low BER, high SNR, and small MSE, the Modified Leaky LMS (MLLMS) algorithm boosts channel capacity (MSE).

Monika, Mahendra: It is stated that MIMO-OFDM systems, with the help of channel estimate methods, have the potential to meet the requirements of future wireless communication systems. The effectiveness of different channel estimating methods, including those based on training data, channel observation, and hybrid methods, are also reviewed. In contrast to the LS and ALS estimators, the MMSE channel estimator may provide estimates in a shorter amount of time despite its complexity.

Yu et al: recommended benefiting from the synergy of MIMO, cognitive radio, and orthogonal frequency division multiplexing. Using orthogonal space-time block codes in MIMO, they claim to be able to maximize the digital transmission rate while reducing the effects of multipath fading and improving BER performance. Since the combination increases the signal-to-noise ratio, their findings are also positive (SNR).

Gupta et al: We propose combining MIMO and OFDM systems with wideband transmission to reduce intersymbol interference and boost performance. They have argued that the system's performance may be enhanced by including spatial and frequency variety. A variety of equalizers and space-frequency (SF) block coding has been studied for MIMO-OFDM. The best equalization strategy for BER analysis has been proposed.

Jie et al: advocated for a MIMO-OFDM system hybrid as a means to increase data transmission speeds. Specifically, they have proposed a scenario in which multi-path effects and frequency selective fading coexist. Compared to MIMO OFDM without STBC, they discovered that the BER performance of the latter was superior.

Darsena et al: Discuss the use of the cyclic prefix OFDM in MIMO broadband wireless communication systems (CP). It plays a role in the STFBC formula. As a solution, they have offered two MIMO channel shortens. It is dependent on the linearly restricted minimization of the mean output energy of the signal at the reduced channel's output. Their findings demonstrate that the suggested blind channel shortens approach suffers just a small performance hit when compared to non-blind channel shorteners, and this is achieved without significantly increasing the computational complexity of the system.

Xin et al: In this presentation, we analyzed MIMO-OFDM systems with Rayleigh fading channels using adaptive modulation (AM) with a discrete rate. In this case, the fading gain value is segmented into many areas for each sub-channel. The modulation determines the adjustments made. The average BER and spectral efficiency (SE) have been gathered. As a consequence of their work, we now know that the enhanced switching-based SE approach is superior to the conventional one.

Seyman et al: The authors propose a feed-forward multilayer perceptron (MLP) neural network, trained using the Levenberg-Marquardt method, for estimating channel parameters in MIMO-OFDM systems. Comparing the suggested approach for performance assessment with the bit error rate (BER) and mean square error (MSE) performances of least square (LS) and least mean square (LMS) algorithms, they find that the neural network channel estimator outperforms both.

Vakilian et al: An antennae-based MIMO OFDM system with space-frequency (SF) block coding was proposed. Radiation patterns that can be changed are employed. They think the reconfiguration must be performed automatically on their part. Their suggested method may support frequency diversity, reconfigurable radiation patterns, and spatial variety over fading channels that are selective in one or more frequencies. According to their findings, their method outperforms competing SF codes in terms of variety and coding gain.

Doi et al: Joint decoding of block-coded signals in an overloaded MIMO-OFDM system was presented, and its complexity was kept to a minimum. For the block-coded signals, they suggest a collaborative decoding approach that uses two stages. The measures they use to narrow down the pool of possible codewords are efficiently calculated. This is because joint maximum likelihood symbol detection is used in the decoding process. The number of possible codewords is cut down effectively using their suggested approach. They have shown a complexity reduction of around 1/174 while transmitting 4 signal streams.

Chen et al: Data concealment using the orthogonal frequency division multiplexing (OFDM) technique was demonstrated over an error-correcting coded channel. The effects of antenna diversity, maximum multipath delay, and Doppler shift have been demonstrated. This demonstrates the BER performance of the MIMO-OFDM. When compared to other coding channels like SISO and OFDM as well as MIMO, the MIMO-OFDM system is less accurate. The data concealing capability, the BER of the carrier data, and the BER of the secret data are all taken into account.

Sharma et al: It is hypothesized that the MIMO system is effective in the likelihood of information detection and can send and receive data using several antennas at once. To increase spectral efficiency and decrease ISI, they have combined OFDM and MIMO systems.

Sezer et al.: Taking into account both average and peak power limits, we provide a solution to the optimum channel switching issue to maximize the average capacity of the transmitter's connection with the main receiver. For the optimization problem where the solution meets the conditions equally, the authors present an alternative similar optimization problem. Their theoretical findings have been backed up by numerical instances.

Li et al: We spoke about the k-user MIMO interference channel, which requires M transmit antennas and N reception antennas. They suggest an interference cancellation strategy to boost receivers' access to global channel state information (CSI). If simply the limitation on degrees of freedom was imposed, their suggested strategy would perform better than existing methods in terms of resisting the correlation of transmitters and tolerating interferences.

EI et al: Advised a comprehensive and realistic simulation for forecasting RoF system performance. A 60 GHz 2x2 MIMO-OFDM RoF system has been proposed. It is predicated on spatial variety (SD). Spatial multiplexing (SMX), which boosts data rate but not necessarily reliability, is aided by this. They tested this system in a line-of-sight (LOS) desktop environment and compared its performance using a variety of approaches, such as diversity, modulation, and channel coding rate. A greater data rate may be attained with a 22 MIMO OFDM SMX system, they discovered.

Namitha et al: The high peak-to-average power ratio (PAPR) across separate antennas has been proposed as a problem with the MIMO-OFDM technology. Selective mapping (SLM) has been proposed as a method for lowering PAPR in OFDM and MIMO-OFDM without introducing any signal distortion. They see the need of delivering side information (SI) with each OFDM data symbol as a shortcoming of the SLM approach to transmission. Using the Hadamard sequence, they have shown a simple SLM method. They theorized that without communicating SI, it might significantly lower PAPR in MIMO-OFDM systems.

Qiao et al: We propose a combination of MIMO and OFDM to increase the efficiency of the necessary bandwidth for underwater acoustic (UWA) transmissions. In the direction of MIMO-OFDM communication at UWA, they have surveyed and reported their findings. The complexity and efficiency of the algorithms have been compared across the various papers.

3. CONCLUSION

The principal component analysis (PCA) technique for channel transformation and the benefits of applying BSS methods in MIMO multiuser detection are highlighted. The usefulness and efficacy of DWTs have also been proved in the context of signal de-noising, which is shown in the results section. As shown, the proposed Enhanced ICA system is both more successful at signal separation and more resistant to channel noise, whether it is BER or impulsive noise. The findings show that the suggested system improves in terms of BER performance and robustness, while the complexity of the detector system is reduced. Furthermore, the suggested technique is successful regardless of the length of the input data, making it a particularly attractive option for large datasets. The suggested Enhanced ICA is utilized to address these problems, and it is more sensitive to the starting settings for the input weight of the separation matrix than the current MN-IAMO and COA techniques.

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