A BER Enhancement and Analysis of MIMO-OFDM in LTE Using Different Modulation Techniques

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Abstract : Multiple-input, multiple-output orthogonal frequency-division multiplexing (MIMO-OFDM) is the dominant air interface for 4G and 5G broadband wireless communications. It combines multiple-input, multiple-output (MIMO) technology, which multiplies capacity by transmitting different signals over multiple antennas, and orthogonal frequency-division multiplexing (OFDM), which divides a radio channel into a large number of closely spaced sub channels to provide more reliable communications at high speeds. This paper proposed various modulation schemers in MIMO-OFDM techniques in long term evolution network. At last performance of bit error rate and signal to noise ratio are analyzed and find out better modulation technique with combination of transmitter and receiver antenna system for advance communication application. The Alamouti STBC may be a promising approach to achieve higher SNR and lower BER in proposed research work.

Index Terms – LTE, STBC, Channel, SNR, BER, OFDM, MIMO.

I. INTRODUCTION

5G technology is the only hope that would let us bridge the tele-industry in terms of meeting the need with quality. It is estimated that there is a generation and usage of about 2.5*10^18 bytes per day. The statistics in the present day prove that the future needs will increase exponentially and so will the demand. Meeting these parameters like the data rates, speed for the users with current technologies like 3G, OFDM (Orthogonal Frequency Division Multiplexing) is quite impossible. It's high time that it is leap up to another degree and unfolds new methods to emerge into 5G-5TH Generation. Usage of appropriate modulating techniques and compatible devices would drive to the inception of a new era in the history of technology, which would be better than ever. The outright motto is to develop a waveform which holds high Spectral efficiency and minimal Peak to Average Power Ratio.

In present day use, the expression "MIMO" demonstrates something beyond the nearness of multiple transmit antennas (multiple input) and multiple receive antennas (multiple output). While multiple transmit antennas can be utilized for beamforming, and multiple receive antennas can be utilized for assorted variety, "MIMO" alludes to the synchronous transmission of multiple signals (spatial multiplexing) to duplicate phantom proficiency.

Generally, radio specialists treated characteristic multipath spread as a weakness to be relieved. MIMO is the main radio innovation that treats multipath proliferation as a wonder to be abused. MIMO increases the limit of a radio connection by transmitting multiple signals over multiple, co-found antennas. This is practiced without the requirement for extra power or bandwidth. Space–time codes are utilized to guarantee that the signals transmitted over the various antennas are orthogonal to one another, making it simpler for the receiver to recognize one from another. In any event, when there is observable pathway access between two stations, double radio wire polarization might be utilized to guarantee that there is more than one vigorous way.

OFDM empowers dependable broadband correspondences by conveying client information over various firmly divided, narrowband subchannels.[1] This course of action makes it conceivable to dispose of the greatest impediment to solid broadband interchanges, intersymbol obstruction (ISI). ISI happens when the cover between back to back images is enormous contrasted with the images' span. Typically, high information rates require shorter term images, expanding the danger of ISI. By separating a high-rate information stream into various low-rate information streams, OFDM empowers longer span images. A cyclic prefix (CP) might be embedded to make a (period) watch interim that anticipates ISI altogether. In the event that the gatekeeper interim is longer than the defer spread—the distinction in postpones experienced by images transmitted over the channel—at that point there will be no cover between contiguous images and thus no intersymbol obstruction. In spite of the fact that the CP somewhat decreases ghostly limit by expending a little level of the accessible bandwidth, the end of ISI makes it an exceedingly advantageous tradeoff.

A key preferred position of OFDM is that fast Fourier transforms (FFTs) might be utilized to rearrange usage. Fourier transforms convert signals to and fro between the time area and frequency space. Subsequently, Fourier transforms can misuse the way that any mind boggling waveform might be deteriorated into a progression of basic sinusoids. In signal handling applications, discrete Fourier transforms (DFTs) are utilized to work on ongoing signal examples. DFTs might be applied to composite OFDM signals, maintaining a strategic distance from the requirement for the banks of oscillators and demodulators related with singular subcarriers. Fast Fourier transforms are numerical calculations utilized by PCs to perform DFT calculations.[2]

MIMO-OFDM is an especially ground-breaking mix in light of the fact that MIMO doesn't endeavor to alleviate multipath spread and OFDM stays away from the requirement for signal adjustment. MIMO-OFDM can accomplish high phantom productivity in any event, when the transmitter doesn't have channel state data (CSI). At the point when the transmitter possesses CSI (which can be gotten using preparing arrangements), it is conceivable to move toward the hypothetical channel limit. CSI might be utilized, for instance, to apportion diverse size signal groups of stars to the individual subcarriers, utilizing the correspondences channel at some random snapshot of time.

II. BACKGROUND

M. Paek et al., [2019] This work proposes a performance enhancement scheme using a coordinated multi-point (CoMP) with spatial phase coding (SPC) based on multiple-input-multiple-output orthogonal frequency-division multiplexing (MIMO-OFDM) in a heterogeneous network (HetNet) system. In the conventional system, the performance of the mobile terminal (MT) is degraded due to the inter-cell interference (ICI). When the MT is located on the cell edge, the performance and quality of service (QoS) of the MT are attenuated due to the interference caused by the signal transmitted from the adjacent base station (BS) or the signal broadcasted by other MTs. In order to increase the reliability of the MT, the proposed scheme uses a pre-coding and the CoMP scheme in HetNet. The proposed scheme can increase the signal-to-noise ratio (SNR) of the MT through the SPC scheme in the transmitter. Therefore, the proposed scheme can mitigate the performance degradation caused by the ICI and can enhance the reliability of the MT. The simulation results show that the proposed scheme has better bit error rate (BER) performance and has higher throughput than the conventional scheme. Therefore, the proposed scheme enhances the performance of the MT by using SPC with CoMP.[1]

S. Kundrapu, et al., [2019] The work revolves around the Orthogonal Frequency Division Multiplexing (OFDM), Filter Bank Multicarrier (FBMC) and Universal Filtered Multicarrier (UFMC). These techniques are compared and analyzed on the basis of Spectral Efficiency, Bit Error Rate , PAPR by utilizing various subcarriers and modulation techniques. The results evidently prove that the spectral efficiency is quite insufficient in the case of OFDM. The existence of cyclic prefix adds to this constraint. FBMC and UFMC proves to be highly fictional and the drawbacks in the previous case are neutralized by the usage separate filters for each subcarriers which further increases the PAPR value. On advanced analysis it is derive to conclusions that UFMC waveform technique is preferable for 5G on considering the value of PAPR. Optimization will add to the betterment of the situation. it is would study the spectral efficiency, power spectral density, peak to average power ratio and performance in terms of bit error rate in practical senses.[2]

R. A. Patil, et al., [2018] The fourth-generation (4G) cellular systems are assisted by radio access technologies comprising 3rd Generation Partnership Project (3GPP) Long-Term Evolution (LTE), and its improved version, LTE-Advanced (LTE-A). Generally speaking, Release-10 of 3GPP standards is referred to as LTE-A, furthermore, its achievable execution makes it a genuine 4G innovation as per the definitions are given by the International Telecommunication Union (ITU). LTE/LTE-A are rising communication technologies in transit toward 5G communication systems. The LTE-Advanced system uses multiple input multiple output (MIMO) and orthogonal frequency division multiplexing (OFDM) techniques in order to achieve a high data rate transmissions. In LTE maximum data rate expected is 100 Mbps for downlink transmission and 50 Mbps for uplink transmission. MIMO-OFDM realizes the utmost spectral efficiency and hence, delivers the maximum data throughput and capacity. [3]

K. Arora et al., [2017] Presently a days, there is colossal request of high information rate in order to suit tremendous number of clients. This need has additionally prompted the prerequisite of change in the present wireless advancements. As OFDM is the physical layer in the majority of the present wireless systems. This work exhibits various ways in which the performance of OFDM system can be improved. The performance parameter varies with the type of application. In case the demand of application is accuracy, BER (bit error rate) should be low but the receiver circuitry becomes more complex to decode complex channel coding techniques. In addition to make the communication more reliable, precoding techniques can be concatenated with channel encoding techniques.[4]

Y. Hong, et al., [2016] It is propose an adaptive indoor multiple input and multiple output (MIMO) orthogonal frequency division multiplexing (OFDM) visible light communication (VLC) system using a receiver module with angular diversity. In order to improve the capacity of indoor MIMO-OFDM VLC systems, tilted receivers are utilized to increase channel diversity, thus reducing channel correlation. With the help of singular value decomposition-based technique, which decomposes the MIMO VLC channels into independent parallel sub-channels, adaptive resource allocation, namely, bit and power loading, is used for these sub-channels to further improve the proposed system's capacity. Based on a 4×4 indoor MIMO-OFDM VLC system, it is investigate bit error rate (BER) performance of the proposed adaptive system with different polar angles in two typical indoor scenarios. Numerical simulation results show that with 50-MHz modulation bandwidth, average BER can be improved from 4.97×10^{-3} to 1.66×10^{-5} and from 1.90×10^{-3} to 1.59×10^{-6} for the two scenarios, respectively.[5]

S. R. Chaudhary et al., [2014] In recent years, wireless broadband communication has gained attention due to ever growing demands of multimedia and internet services. The major challenges faced by wireless communication are availability of resources like bandwidth and transmission power. Also the wireless channel suffers from impairments like fading and interference. Technologies that achieved above requirements are Multiple Input Multiple Output (MIMO) and Orthogonal Frequency Division Multiplexing (OFDM). Channel impairments must be mitigated at the receiver by using equalization techniques. In this work , BER performance improvements of MIMO-OFDM systems using different equalization techniques such as Zero forcing (ZF), Minimum mean square error (MMSE) and Maximum likelihood (ML) are shown and compared. Simulations are carried out under Rayleigh frequency flat channels.[6]

A. Ogale, et al., [2013] Multiple Transmit and receive antenna are now widely used to form multiple input., multiple output (MIMO) channels to increase the capacity as well as to reduce the Bit Error Rate (BER). This work describes the combination of MIMO system along with Orthogonal Frequency Division Multiplexing (OFDM) system which offers important features of both the system. Use of Hybrid MIMO-OFDM system is considered broadly for wideband transmission to mitigate Intersymbol interference to enhance the system performance. In this study 2 × 1 and 2×2 Hybrid MIMO-OFDM system is studied and Matlab-Simulink technique is used for the analysis for these systems. The performance of MIMO-OFDM model is measured in terms of BER and Throughput results of system analyzed with 64 QAM taking image as an input. The result shows that adding one antenna at the receiver side can improve the performance of the system.[7]

Z. Iqbal, et al., [2012] Use of Wireless communications for Metropolitan Area Network (MAN) in consumer electronics has increased significantly in the recent past. This work, presents the performance analysis of four different channel coding and interleaving schemes for MIMO-OFDM communications systems. A comparison is done based on the BER, hardware implementation resources requirement, and power dissipation. It also presents a memory-efficient and low-latency interleaver implementation technique for the MIMO-OFDM communication system. It is shown that among the four coding and interleaving schemes studied, the cross-antenna coding and per-antenna interleaving performs the best under all SNR conditions and for all modulation schemes. It is also the best scheme as far as the hardware resource implication and power dissipation are concerned, which are particularly important in the context of consumer electronics. Next, using the proposed interleaver, a MIMO-OFDM based transmitter employing a double data stream 2×2 MIMO spatial multiplexing system is built.[8]

Table 1: Summary of literature survey

S. No	Author Name	Year of Publication	Proposed Work	Outcome
1	M. Paek	IEEE, 2019	A coordinated multi-point with spatial phase coding based on MIMO-OFDM	Better bit error rate performance and higher throughput
2	S. Kundrapu,	IEEE, 2019	OFDM Filter Bank Multicarrier, Universal Filtered Multicarrier.	The spectral efficiency is quite insufficient in the case of OFDM.
3	R. A. Patil,	IEEE, 2018	Turbo coded MIMO-OFDM in LTE-A networks using 64-QAM.	The LTE-Advanced system uses MIMO and OFDM.
4	K. Arora	IEEE, 2017	The performance parameter varies with the type of application.	communication more reliable, precoding can be concatenated with channel encoding
5	Y. Hong,	IEEE, 2016	visible light communication system using a receiver module with angular diversity.	BER can be improved from 4.97×10^{-3} to 1.66×10^{-5}
6	S. R. Chaudhary	IEEE, 2014	MIMO-OFDM systems using different equalization techniques such as ZF	Channel impairments must be mitigated at the receiver by using equalization.
7	A. Ogale,	IEEE, 2013	Combination of MIMO system along with OFDM	One antenna at the receiver side can improve the performance
8	Z. Iqbal,	IEEE, 2012	Four different channel coding and interleaving.	The cross-antenna coding best under all SNR conditions.

III. PROBLEM FORMULATION

The following gaps are identified as per the review and analysis-

1. Variant modulation is missing in most of the research work as maximum of the research work relies on 64 QAM or 32 QAM.
2. Efficient use of temperature variance is missing so that BER rates may affect badly.
3. It can be spread with no impediment of balance procedure utilizing OFDM and MIMO.
4. The OFDM frameworks recurrence missing synchronization in the type of Carrier Frequency Offset (CFO).
5. Need of improvement in bit error rates with different channel capacity and channel fading variants.

IV. PROPOSED METHODOLOGIES

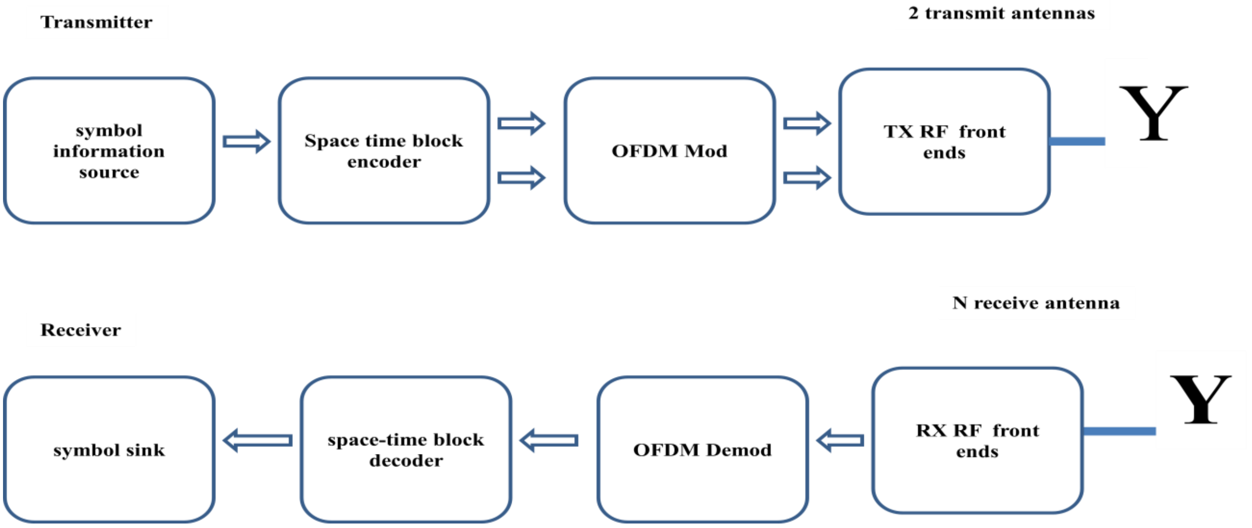

Figure 1: Flow Chart

In planned procedure, above all else data is sent into M-PSK(Upto 1024-PSK), wherever the given data or signal is balanced. At that point when apply Alamouti STBC on the regulated signal. Introduce the channel for estimation of the estimations of BER. Right now include a few commotions and transmit that flag through channel. At that point evacuate STBC and demodulate the given signal.

Table 1: Simulation Parameters

Parameter	Value
Number of transmit antennas	4
Number of receive antennas	8
Number of subcarriers	64
Guard interval percentage	1/4
M-PSK Modulation	8-128
Subcarrier space between two pilots	1
Signal to noise ratio	25 dB
Symbols	1000-2000
Number of transmit antennas	4

TX=4 AND RX=8 WITH 128-PSK AND ALAMOUTI STBC

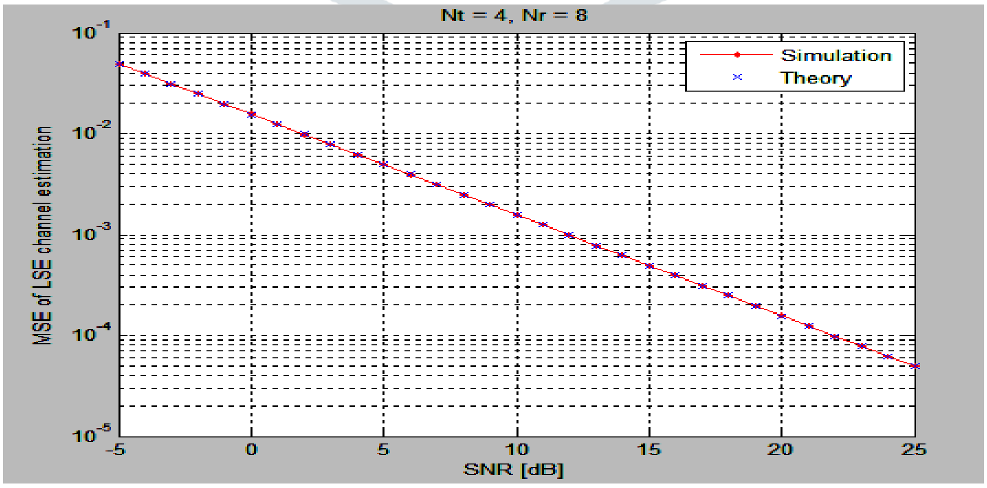

Figure 2: MSE vs SNR graph for Tx=4 and Rx=8 to

Figure 2 is showing output graph between mean square error and signal to noise ratio. To increasing SNR performance, MSE is decreasing, which is significant.

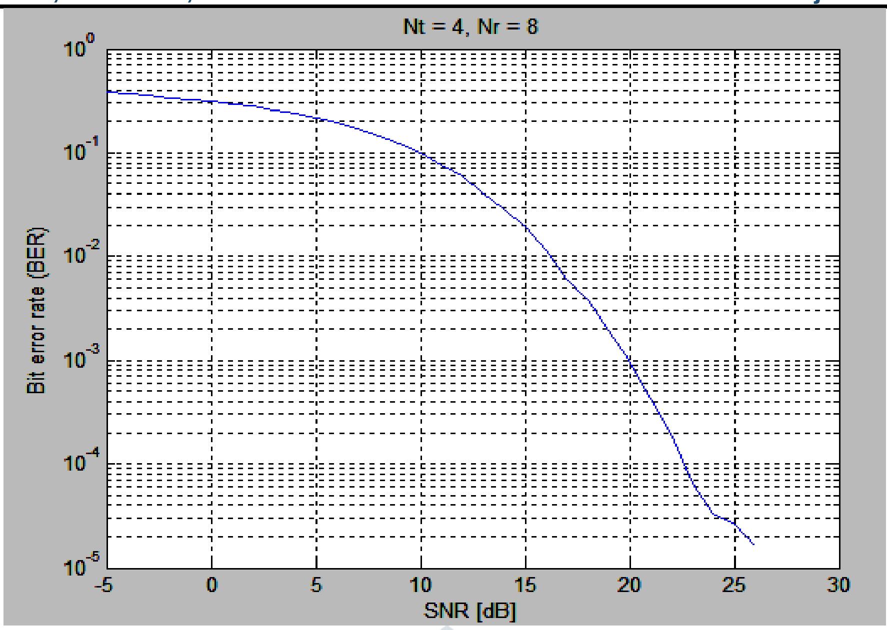

Figure 3: BER vs SNR Curve for Tx=4 and Rx=8 with 128-PSK with improved SNR

Figure 3 is showing output graph between bit error ratio and signal to noise ratio. Here modulation scheme is 256-PSK, after analyzing both graphs, it is clear that antenna combination of 4Tx8Rx gives better SNR (27dB) than previous approach. BER achieved $10^{-4.9}$, which is also improved.

Table 2: Simulation Result for 128 PSK with improvement

Tx-Rx Antenna	BER	MSE	Max .SNR
4Tx-8Rx	$10^{-4.8}$	$10^{-2.0}$	27

From table 2, it is can say that for significant performance of SNR as well as BER MIMO dimension 4Tx-8Rx is considerable and BER value is less than previous.

After simulation of 4Tx and M-Rx antenna configuration (where M=4,8,16,32,64,128,256). Table 3 shows that simulation result of proposed work and previous work and proposed work is better than previous work in terms of number of transmitter number of receiver antenna and BER, MSE and SNR.

Table 3: Comparison chart of proposed work with Base Work

Parameters	**Previous Work**	**Proposed Work**
Method	Spatial Phase Coding With CoMP	Alamouti-STBC
Modulation	Q-PSK	M-PSK (M=8 To 256)
BER	$10^{-4.5}$	$10^{-4.9}$
MSE	-	$10^{-4.5}$
SNR	-5 to 25 dB	-5 to 27 dB
Number of subcarriers	256	64 -128
Throughput	1 bps	2 kbps
Tx Antenna	2	4
Rx Antenna	2	8

Therefore proposed work result is better than previous work so STBC-OFDM approach is considerable and significant result is achieved.

V. CONCLUSION

MIMO-OFDM is very promising technique to improve communication services. In this paper STBC approach is proposed to improve performance over MIMO-OFDM system. The evaluation of Alamouti code in MIMO-OFDM simulation with various TX and RX antenna is presented. QPSK modulation schemer gives significant better result than other modulation scheme.

Simulated results shows that proposed scheme better than Spatial Phase Coding with coordinated multi point transmission scheme. Result is calculated in terms of bit error rate and signal to noise ratio. Therefore antenna combination of 4T X 8Rx gives better SNR i.e 27dB and BER obtain $10^{-4.8}$.

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