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Performance Analysis of LTE Systems with Convolutional Encoding over Fading Channels

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Abstract: The advanced wireless systems feature Long-Term Evolution (LTE) is one of the wide band standards. This paper delivers detailed performance evaluations of LTE systems which implement 2X2 and 4X4 Multiple-Input Multiple-Output (MIMO) configurations through Rayleigh fading channels. The system uses convolutional encoder and viterbi decoder to achieve better system performance. The proposed test method evaluates system performance through the implementation of convolutional encoding and decoding under multiple modulation types QPSK, 16-QAM and 64-QAM. The simulation results presents how the error control coding method benefits the performance in severe fading wireless environment.

Keywords: Convolutional Encoder, LTE, MIMO, OFDM

I. INTRODUCTION

Endless increases in data service requirements created the need for advancing dependable communication solutions. The wireless industry currently uses LTE as a highly promising technological system. LTE operating as part of MIMO systems provides the fundamental structure needed to reach high data speeds and improve spectrum performance [1-4].. Forward and reverse links of these systems use Orthogonal Frequency Division Multiplexing (OFDM) [5]. and Single Carrier Frequency Division Multiple Access (SC-FDMA) respectively to achieve efficient performance in severe channel environments. The wireless communication channels display natural vulnerability to multipath fading that leads to performance reduction in the system [6-10].. The solution of communication system errors depends heavily on error control coding methods which show great promise for error correction. The chosen best method in channel coding techniques for error mitigation relies on convolutional encoding. This technology remains crucial when handling channel impairments. Spatial diversity which is a core capability of MIMO systems becomes even stronger when robust channel coding techniques are integrated into the system design.

II. SYSTEM MODEL

The LTE network consists of base station named as evolved node B (enodeB), mobile nodes and the core network. The base stations are connected to core network and there is a connection among all the base stations. Where the mobility management and resources also managed by base station only. The below figure 1 represents architecture.

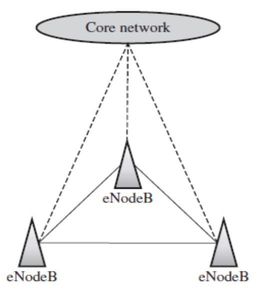

Fig. 1: LTE Architectural diagram

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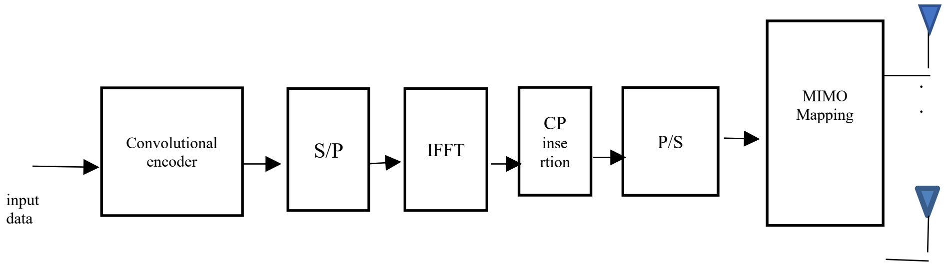

Fig. 2 LTE system block diagram (transmitter)

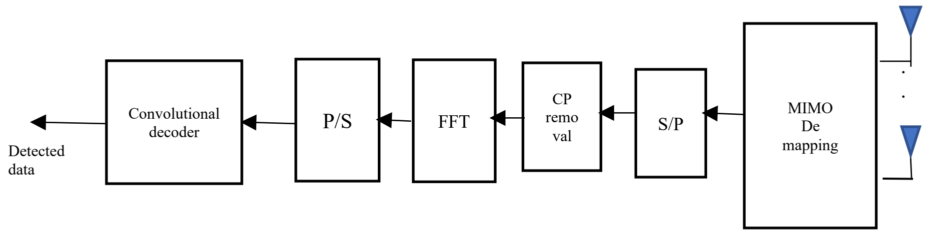

Fig. 3 LTE system block diagram (receiver)

The block diagram of the LTE system transmitter and receiver sections are shown in figures 2,3. In the transmitter side data is generated first, encoded with convolutional encoder and passed through multiple sub carriers and finally transmitted through multiple antennas. At the receiver side, the received data is demapped and passed through FFT block and then decoded with Viterbi decoder to get back the data.

A. MIMO Configuration

The LTE system operates through two combinations of 2X2 and 4X4 configuration. The system utilizes spatial multiplexing functions together with Zero Forcing (ZF) equalization at the receiver to compensate channel effects while operating through Rayleigh channels.

Rayleigh Fading: Models a purely non-line-of-sight environment. Only random scattering affects all signal paths which reach the receiver through multiple paths in this fading type. This model serves as one of the standard approaches for urban areas which lack powerful direct signal transmission. Signal amplitudes under Rayleigh fading perform according to a Rayleigh distribution because they do not receive any direct Line-of-Sight signals. The model successfully represents communication conditions where scattering occurs densely in urban and indoor cellular environments.

B. Modulation Schemes

The method through which data travels across wireless networks functions as a cornerstone for air-based information transmission in wireless communication. The proposed system evaluates different modulation schemes which include QPSK,16-QAM and 64-QAM.

C. Channel Coding

Communication systems rely on channel coding as their essential component to improve reliability throughout data transmission over unsteady and affected channels. Channel coding adds redundant information to data that lets detection and error correction happen when transmission errors appear. The LTE system in this application implements a convolutional encoder with 3 constraint length and 1/2 code rate. The Viterbi decoding algorithm enables the receiver to determine the most probable sequence during data decoding operations. The process demonstrates outstanding performance in decreasing both fading and noise effects which leads to substantial Bit Error Rate (BER) enhancement of the system. The pairing of convolutional encoding with Viterbi decoding operates as a vital component which delivers strong communication capabilities in areas where severe multipath fading exists [11-12]..

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III. PROPOSED METHODS

A. Transmitter Design

The transmitter starts with input bits from the bitstream that contains the transmission data during this stage. The encodng process selects the convolutional encoder to work on this bitstream. The OFDM-encoded symbols with added cyclic prefix undergo antenna mapping to Multiple-Input Multiple-Output (MIMO) arrays in configurations of 2X2 and 4X4.

B. Channel Model

After signal transmission the signal progresses through the predetermined fading channel model that describes signal strength degradation during environmental propagation. When implementing the radio communication system, the channel includes both the AWGN (Additive White Gaussian Noise) model along with environmental noise elements from thermal effects. AWGN affects the signal transmission by adding white Gaussian noise that produces errors in received data. Real-world transmission conditions become achievable with both fading channel models and additive white Gaussian noise system simulation.

C. Receiver Design

The receiver attempts to extract the original data from a signal that suffered channel-related deformation including fading and noise effects.

Without Encoding: The received symbols move directly to demodulation in this protocol so the received signal becomes discrete symbols which represent the original digital representation of bits. The demodulated symbols can be converted back to bits by applying inverse mapping based on the transmission modulation scheme.

With Encoding: During encoded transmission the receiving symbols first experience demodulation because the same process applies regardless of whether encoding exists. The Viterbi decoder receives demodulated symbols from the device for decoding convolutionally encoded signals. The Viterbi algorithm performs inquiry for the optimum sequence of transmitted bits which generated the received sequence after considering the additional data implemented through convolutional encoding. Using this method will retrieve the initial bit sequence and correct transmission-based errors which happened in transit.

IV. NUMERICAL RESULTS

The parameters used for simulation are represented in the table 1. The proposed system implemented with three different modulations and bit error rate is measured.

TABLE 1: Simulation Parameters

PARAMETER	VALUE
Input	10000 bits
Modulation	QPSK, 16 QAM, 64 QAM
Channel type	Flat fading, EVA 5Hz
Channel	Rayleigh
Error control code	Convolutional encoding
Antenna Configuration	2X2, 4X4

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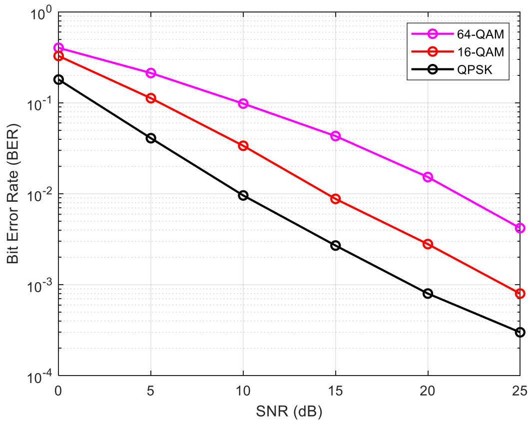

Fig. 4 BER Vs SNR of 2X2 system

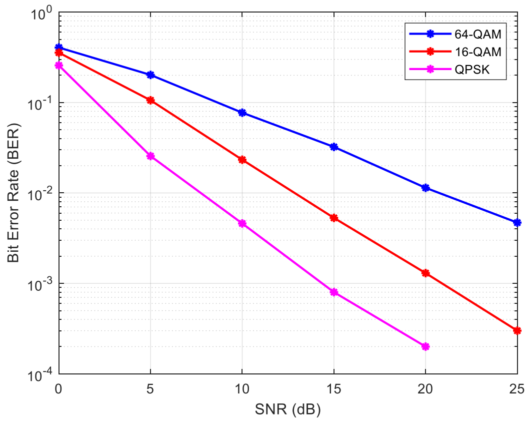

Fig. 5 BER Vs SNR of 4X4 system

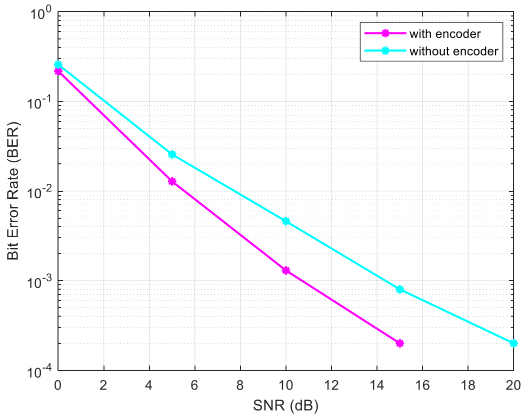

Fig. 6 BER Vs SNR of 4X4 system with convolutional encoder

The performance evaluation of a 2×2 MIMO system appears in Figure 4 and a 4×4 MIMO system shows its BER performance in Figure 5. The data illustrates that rising modulation order simultaneously produces higher bit error rate (BER) statistics. Higher-order modulations like 16-QAM or 64-QAM have their symbols arranged closely in the constellation diagram so they become more vulnerable to interference and noise.

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The BER performance of the 4×4 MIMO system using QPSK modulation becomes low in Figure 6 when error control is added through convolutional encoding. The implementation of error control coding produces demonstrable improvements on bit error rate performance. By implementing convolutional coding into the transmitted data stream the receiver obtains capabilities to detect and repair errors which arise from fading along with noise and interference during channel transmission.

When measured in terms of performance the 4×4 and 2×2 MIMO systems produce equivalent results in spatial multiplexing. The design of spatial multiplexing enables independent data stream transmission from each antenna in order to boost data throughput. Increased inter-stream interference occurs as a result of this implementation strategy. The performance stays equivalent due to efficient signal processing methods at the receiver including MIMO detection and channel equalization.

V. CONCLUSION

The effectiveness of convolutional encoding proves valuable for enhancing the reliability of LTE MIMO systems according to this paper. The proposed system demonstrates constant superiority over standard encoding methods because it provides superior error correction functionality for establishing more dependable data transfer. Data transmission systems with convolutional encoding achieve better performance and lower bit error rate through this encoding technique in demanding operating conditions. The practicality and resilience of LTE MIMO systems makes it a good solution to enhance their reliability.

Future research should focus on implementing advanced error control coding approaches including LDPC and polar codes to accomplish additional system performance growth. The application of this approach requires testing using systems equipped with extended numbers of transmitting and receiving antennas to demonstrate functionality for future generation communication networks.

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