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# Performance Analysis of 8 X 8 MU-MIMO in Uplink of LTE-A

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**ABSTRACT: The 3rd Generation Partnership Project (3GPP) uses radio access technologies Long-Term Evolution (LTE), and its advanced version, LTE-Advanced (LTE-A). Release-10 of 3GPP standards is called as LTE - A. As per the definitions of the International Telecommunication Union (ITU), it will be considered as a 4G technology because of its attainable performance. LTE/ LTE-A are rising communication technologies in transit toward 5Gcommunication systems. In this paper performance analysis of MU-MIMO is carried out in LTE-A uplink. Thisresearch work deals with investigations based on the performance analysis comparison of Turbo coded MU - MIMO in LTE-A networks using Zero Forcing (ZF) and Minimum Mean Square Error (MMSE) receiver and tap delay channel models like VehA and VehB. Uplink throughput is evaluated in terms of Signal to Noise Ratio (SNR) with antenna configuration of 2 × 4 × 8 for uplink transmissions using MATLAB simulation and compared.**

**Keywords:** MU – MIMO, LTE, LTE-A, VehA, VehB, Uplink.

## I. INTRODUCTION

3GPP LTE-A standard used to increase peak data rates up to 1Gbps for low mobility and 100Mbps for high mobility scenario. The aim of the high data rate is to support advanced services and applications [1]. These striving targets can be accomplished with the help of MIMO and OFDM techniques together as a MIMO-OFDM [2]. But still, because of high peak to average power ratio (PAPR) of the transmitted signal OFDM is not acceptable for the uplink transmission. Single carrier frequency division multiple access (SC-FDMA), also known as DFT-Spread OFDM (DFT-S-OFDM), has been adopted by 3GPP as the LTE uplink multiple access scheme [3].

Uplink MIMO transmission has been presented in 3GPP LTE and LTE-A standards to increase spectrum efficiency. In order to boost this spectrum efficiency user equipments (UEs) have less number of antennas than base station (eNB) antennas. One of the key MIMO strategy to acknowledge rapid transferring is spatial multiplexing (SM). With SM, multiple layers of data can be transmitted simultaneously in the same set of frequency-time resources. Up to four layers SM can be supported by the specifications of LTE-A, which increase the peak data rate of LTE-A uplink from 75 Mbps to 300 Mbps. Both SU-MIMO and MU-MIMO can be used. And for MU-MIMO, each of the co-scheduled UEs may transmit multiple layers of data as well. LTE and LTE-A both adopt single-carrier frequency-division multiple access (SCFDMA) in the uplink.

In MU-MIMO similar resources are used by multiple users and transmitted at the same time. At the receiving end these transmitted signals are divided in spatial domain. In Release 10 LTE – A allows 4 × 4 MIMO in uplink transmissions with number of receiving antennas at eNB are more than number of transmitting antennas at UE. This combination of MU – MIMO gives significant increase in sum throughput [4, 5]. Linear receivers and interference cancellation receivers are used with this type of arrangement in order to increase sum throughput [6-8]. In case of linear receivers to resolve all receiving signals at eNB, number of users with single transmitting antennas should not be greater than number of receiving antennas at eNB [9]. In a cell if number of UEs are greater than the number of receiving antennas at eNB then problem of scheduling arises [8, 10].

In LTE-A, link adaption is used if UE is with single transmitting antenna. In case of link adaption, Modulation and Coding Scheme(MCS) adapts Channel State Information (CSI).

This quantized CSI is in terms of feedback from eNB to all scheduled UEs as a Channel Quality Indicator (CQI), is explained in [11]. The spatial as well as multipath diversities were exploited in [12] with the help of multi band MIMO coding context in UWB schemes. The study of LSE and MMSE estimators in case of block style as well as comb style pilot preparation are carried out in [13].

Existing LTE-A system uses 4 × 4 MIMO for uplink transmission. In this paper, the advantage of spatial multiplexing among antenna are taken into account, and 8 × 8 MIMO for uplink transmission is proposed. This proposed system is compared with ZF and MMSE receiver in VehA and VehB channel. This system performance is analysed in terms of cell throughput. The organization of the paper is as; the UL MU-MIMO system model is discussed in section II, LTE uplink signal processing is explained in section III, Algorithm in section IV, Simulation parameters are given is section V, Results and discussion in section 6 and work is concluded in section VII.

## II. UL MU – MIMO SYSTEM MODEL

The proposed MU – MIMO scheme which is used in uplink of LTE-A is as shown below.

The single base station eNB employs eight receiving antennas and $UE_k$ implies two user equipments, each with four transmitting antennas. The channel formed between transmitting and receiving antennas is known as Multiple Access Channel (MAC) [14, 15].

$$Y = \begin{bmatrix} h_{11} & \cdots & h_{18} \\ \vdots & \ddots & \vdots \\ h_{81} & \cdots & h_{88} \end{bmatrix} X \qquad (1)$$

where X = input

## III. LTE UPLINK SIGNAL PROCESSING

LTE uplink signal processing for a link level simulator is as shown in Fig. 2.

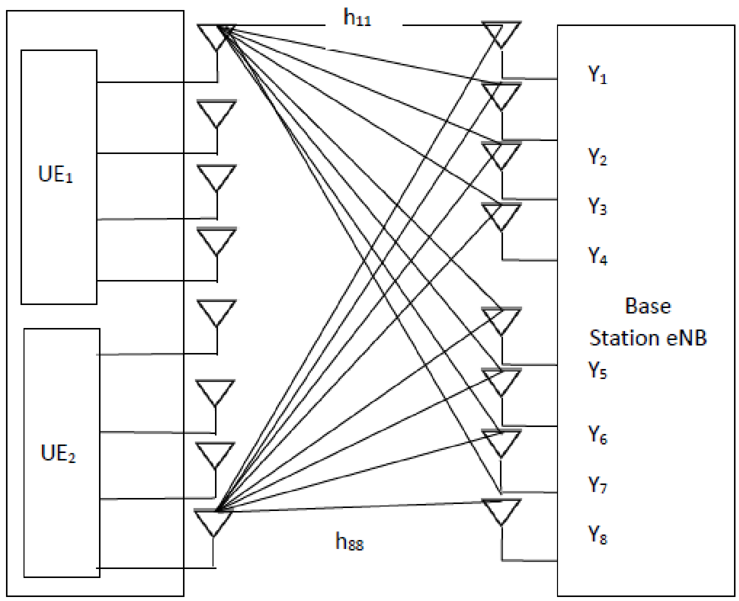


**Fig. 1.** Block diagram of 8 X 8 MU MIMO Uplink.

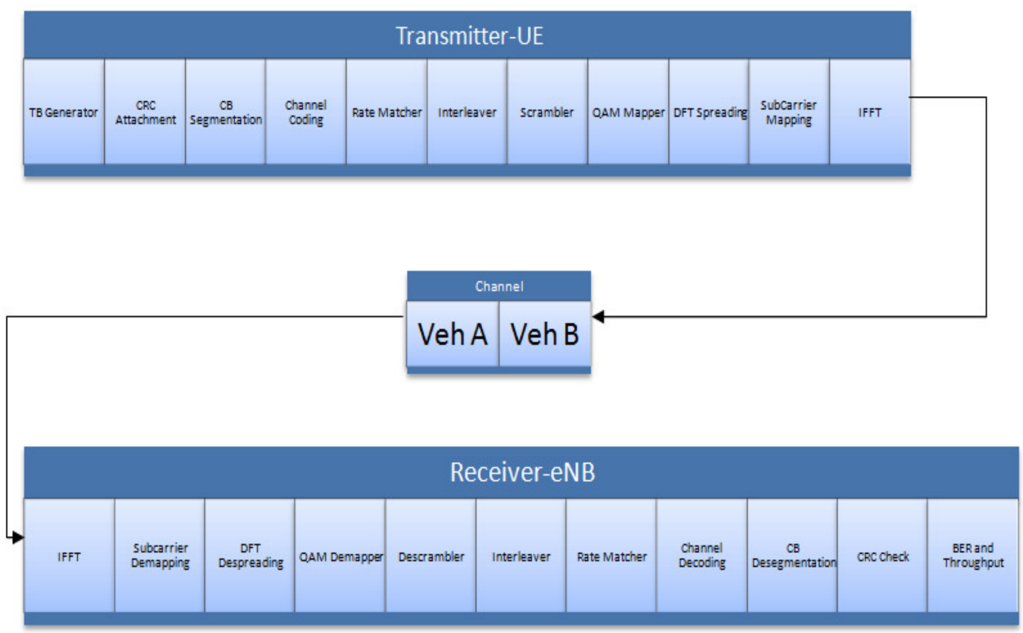


**Fig. 2.** LTE uplink signal processing for a link level simulator.

*A. Transmitter*

The Transport Block (TB) is passed from the Uplink Shared Channel (UL-SCH) transport channel. The physical layer procedures include, as described in, a 24-bit TB Cyclic Redundancy Check (CRC), followed by a segmentation in Code Blocks (CBs) due to the finite size of the turbo coder interleaver and CB CRC addition. The output of the segmentation is coded by the 1/3 turbo code matcher. The CBs are finally concatenated and the coded TB is then transmitted.

*B. Receiver*

Signal processing at the receiver is inverse to the transmitter. Firstly, the CP is removed, then the IFFT is calculated and the reference signals are removed. The data is split according to the number of UEs and the assigned number of RBs. At this point, the DFT precoding is removed. Afterwards, the receiver algorithm is called, which currently is implemented via hard demapping.

Fig. 2 depicts the receiver chain, including the complete channel decoding, code block concatenation, and CRC calculation. After decoding the data, BER and throughput are evaluated.

## IV. ALGORITHM

1. Start
2. Set CQI = 15 and simulation will be performed in this CQI loop
3. Set SNR range to carry out simulation
4. Load various parameters which configures simulator.
5. Start simulation loop
6. Transmitter consist of 2 UEs each UE with 4 transmitting antennas is used
7. Tap delay based channel models VehA and VehB are consider.
8. Set number of receive antennas to 8 at eNodeB.
9. Feedback from receiver to transmitter sent in the form of Rank indicator (RI) and Precoding Matrix Indicator (PMI)
10. Save result.

## V. SIMULATION PARAMETERS

This simulation is carried out at system bandwidth of 20 MHz. Channel Quality Indicators (CQI) implies Modulation and Coding Schemes (MCS).

**Table 1: Simulation Parameters.**

| Parameter | Value |
|---|---|
| Bandwidth | 20 MHz |
| Modulation Technique | 64-QAM |
| Uplink Carrier Frequency | 1.9 GHz |
| Spacing of Subcarrier | 15 kHz |
| Channel Estimation | Perfect |
| MIMO Antenna Configuration | 2 X 4 X 8MU MIMO |
| Channel Model | VehA, VehB |
| Receiver | ZF, MMSE |
| CQI | 15 |
| Number of Resource Blocks | 100 |

This simulation is carried out at CQI = 15 means 64 QAM is used. The simulation is carried out on hundred subframes.

## VI. RESULTS AND DISCUSSIONS

The performance of MU MIMO LTE- A uplink transmission is evaluated. There are various MIMO channels like frequency flat and frequency selective are available. In case of frequency-selective MIMO channels, OFDM is used along with MIMO. This MIMO - OFDM is useful for elimination of ISI and ICI. In this research work VehA and VehB channel models are presented. These channel models are analyzed with ZF and MMSE equalizers. The MMSE channel estimator is a statistical estimator. This requires knowledge of noise variance and PDP of channel to perform channel estimation. System bandwidth of 20 MHz is considered. This simulation is carried out with no signaling delays between e Node B and User Equipment. These simulations are carried out using Vienna LTE-A link level simulator [16].

Performance of MU MIMO in VehA channel is shown in fig. 3 and 4.

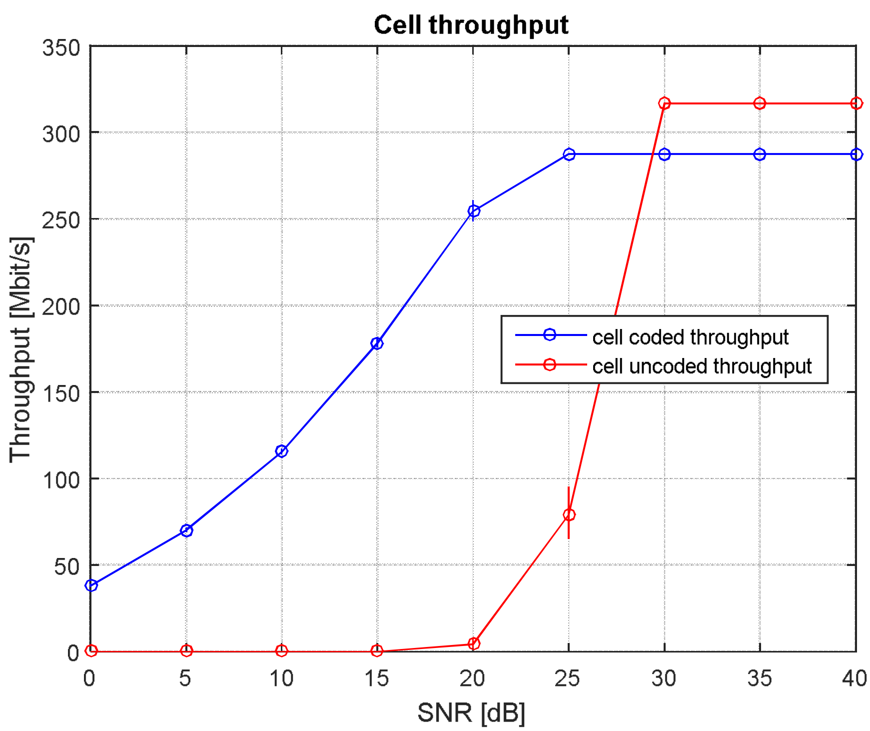


**Fig. 3.** 2 X 4 X 8 MU MIMO using ZF under VehA channel at 20 MHz at CQI 15.

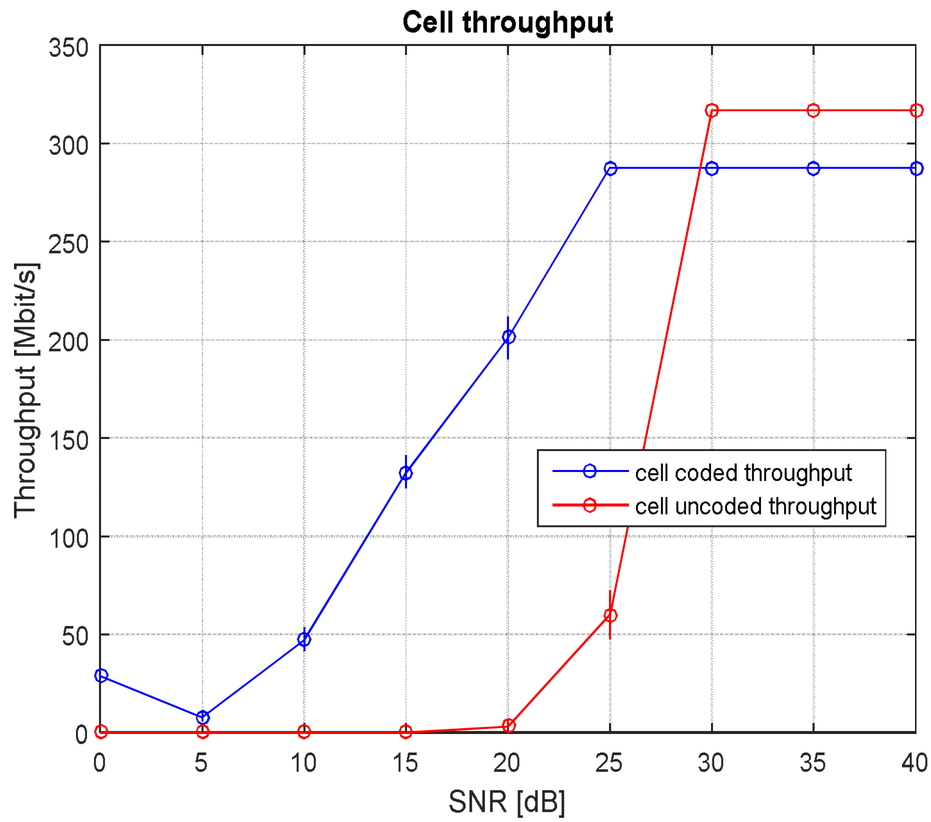


**Fig. 4.** 2 × 4 × 8 MU MIMO using MMSE under VehA channel at 20 MHz at CQI 15.

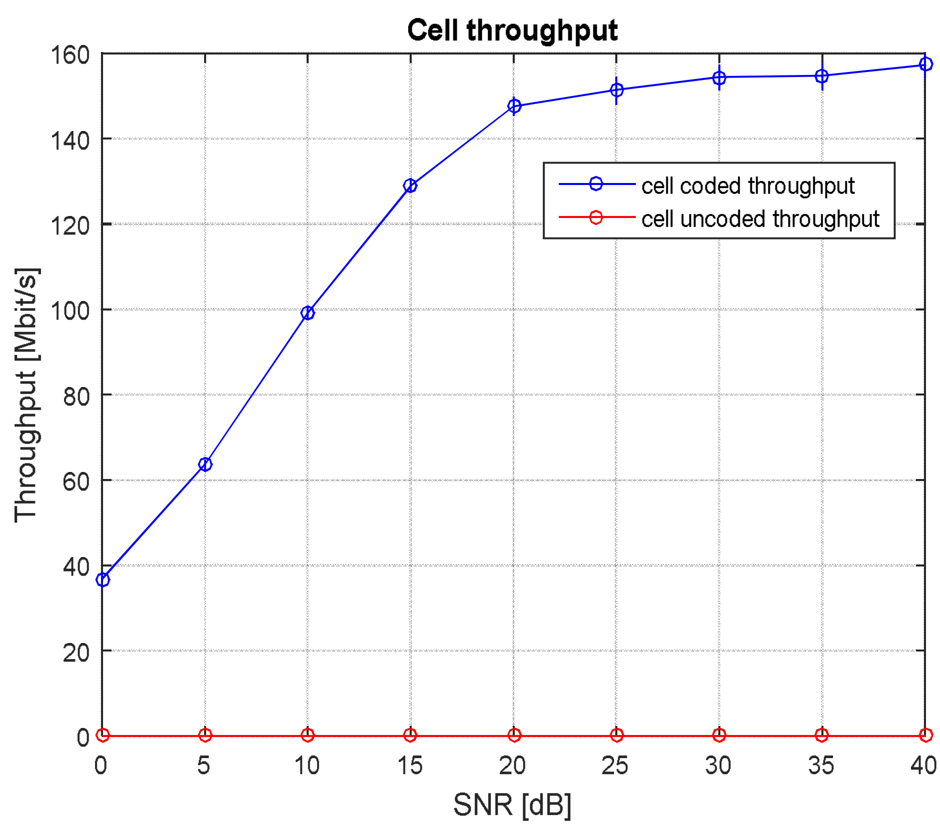


**Fig. 5.** 2 × 4 × 8 MU MIMO using ZF under VehB channel at 20 MHz at CQI 15.

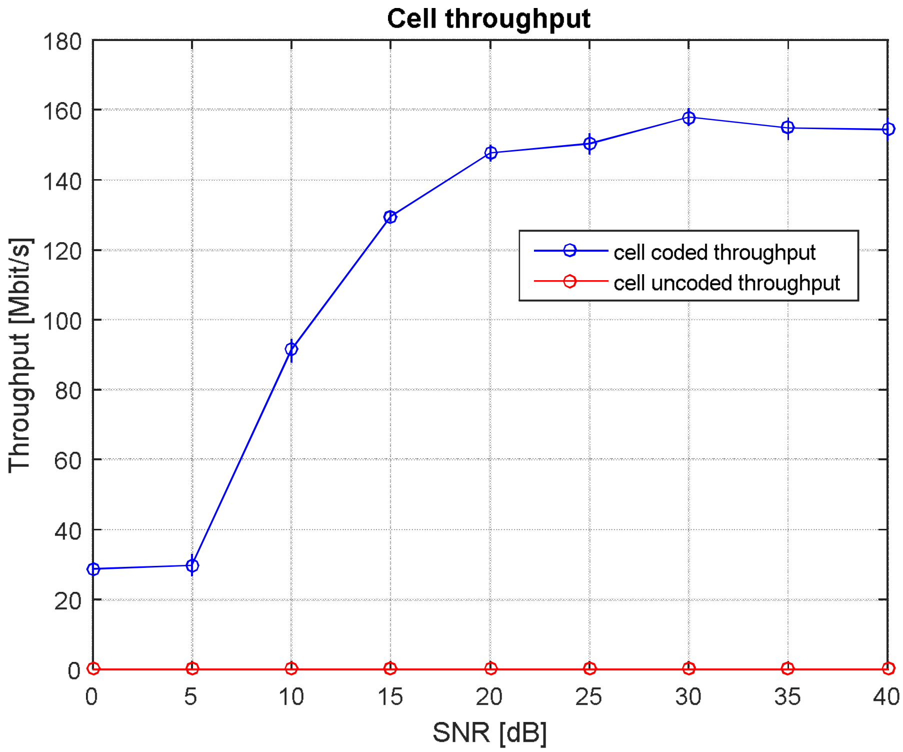


**Fig. 6.** 2 × 4 × 8 MU MIMO using MMSE under VehB channel at 20 MHz at CQI 15.

As shown in Fig. 3, 2 × 4 × 8 MU MIMO is performing better at low signal to noise ratio below 25dB with ZF receiver. As shown inFig. 5 and 6, ZF receiver is performing better than MMSE for complete SNR range from 0dB to 40dB. The comparision between VehA and VehB channel shows that VehA channel is giving more cell throughput as compare to VehB channel. But the computational time required for ZF receiver is greater than that of MMSE receiver in VehA as well as in VehB channel. So there should be trade off between these two parameters.

## VII. CONCLUSION

In this paper performance of MU MIMO is analysed in LTE–A uplink. In case of MU MIMO the data streams from different users are allowed to multiplex with different antennas. In case of SU MIMO, data rate of a single user increases but increase in cell capacity is possible in MU MIMO. Therefore, MU MIMO is well capable to handle multiple calls. So MU MIMO in LTE-A is implemented and analyzed.

The performance is analysed in terms of cell throughput. VehA channel gives cell throughput of near around 300 Mbps and VehB channel gives around 160 Mbps. ZF receiver is performing better at low SNR in VehA channel as well as its also performing better in VehB channel. These simulation results shows that there is a significant improvement with this proposed technique as compared to existing technique.

## VIII. FUTURE SCOPE

The practical LTE–A system should be analyzed in order to have robustness and validity of results.

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