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Interference Mitigation in LTE- Advanced MU-MIMO through Beamforming Technique

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***ABSTRACT*—3GPP LTE advanced is an evolving standard targeting 4G wireless system, LTE-Advanced introduces new functionalities such as Carrier aggregation, enhanced use of multi-antenna techniques. In this work, the different multi-antenna techniques such as single user MIMO (SU-MIMO) and multiuser MIMO (MU-MIMO) cases are investigated. In MU-MIMO case, interference is more when compared with SU-MIMO case. To overcome this challenge, the beamforming technique is used under the assumption of perfect channel knowledge at the transmitter availability. We evaluate the system performance of SU-MIMO and MU-MIMO cases in the different scenarios, with and without beamforming technique in terms of Bit-Error-Rate (BER) and Signal to Noise Ratio (SNR). For the stimulation purpose we use MATLAB software package.**

***Index terms* Beamforming, Carrier aggregation LTE,LTE-Advanced, MU-MIMO, SU-MIMO**.

I. INRODUCTION

Third generation partnership project (3GPP) standards are structured as Releases.3GPP release 8 incorporates the specifications of Long Term Evolution (LTE). Demand for higher data rate lead to the introduction of LTE-advanced, the backward compatible enhancement of LTE release 8[10] that is fully specified in 3GPP release 10 [1]. It completely fulfills the IMT Advanced 4G requirements set by the International Telecommunication Union (ITU)[9]. To achieve this high data rate, it is essential to increase the transmission bandwidth than that supported by a single carrier.

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The term called carrier aggregation [2] incorporating OFDM is used in LTE-Advanced, which utilize more than one carrier and thus increase the overall bandwidth. Enhanced MIMO concept [2],[8] is another important aspect of LTE-Advanced. It is categorized into two forms based on the number of users. Transmitting the stream of data to a single user is termed as single user MIMO (SU-MIMO) whereas if the transmission takes place simultaneously to multiple users are termed as multi user MIMO (MU-MIMO). Since there occurs a simultaneous data transmission in MU-MIMO it results in interference .To mitigate the problem of interference in MU-MIMO, LTE advanced extend the single user dedicated beamforming of LTE to multiple users. Beamforming concentrates the array to signal coming from only one particular direction or to receive signals in one direction and ignore signals in other directions. The paper is organized as: section-I discuss about SU-MIMO, section-II covers the details about MU-MIMO, the concept of beamforming is elaborated in section-II, section-IV presents the simulation results and discussion, we conclude the paper in section-V.

II. SINGLE USER MIMO (SU-MIMO)

Spatial multiplexing of multiple modulation symbol streams to single user equipment (UE) is referred to as single user MIMO (SU-MIMO). SU-MIMO can be applied in both uplink and downlink. In uplink single user equipment transmits the signals to the base station whereas in downlink the base station transmits the signal to user equipment. SU-MIMO uplink and downlink cases are discussed below.

A. Uplink SU-MIMO Technology

In LTE-Advanced, SU-MIMO with up to four transmission-antennas satisfies peak spectrum efficiency of 15bps/Hz as specified for the LTE-Advanced uplink. Closed loop SU-MIMO, codebook-based precoding and rank adaptation are applied to the Physical Uplink Shared Channel (PUSCH) as per the IMT- advanced requirements. The eNode B selects the coding weight from a codebook to maximize achievable performance (SINR or user throughput after precoding) based on sounding reference signal (RS), which is used for channel quality estimation. The eNode B notifies the user equipment (UE) of the selected precoding weight together with the resource allocation information used by PDCCH. The precoding for rank one contributes to antenna gain, which is effective in increasing cell edge user throughput. However, considering control information overhead and increase in Peak to Average- Ratio (PAPR), frequency- selective precoding is not very effective in increasing system throughput, so only wide band precoding has been adopted. Also, for rank two or higher, when four transmit antennas are used, the codebook has been designed not to increase the PAPR [3]. The demodulation RS, which is used for channel estimation, is weighted with same precoding weight as used for the user data signal transmission. By applying different cyclic shift to each layer, orthogonalization of the layers is achieved, but orthogonalizing the code region together with this method is adopted [4].

B. Downlink SU-MIMO Technology

Downlink peak spectral efficiency specified by IMT-Advanced is 30bps/Hz. To achieve this, downlink SU-MIMO transmission has to support a maximum of eight layers [5]. The number of transmission layer is selected by rank adaptation. The most significant issue in supporting up to 8 layers is the RS structure (CSI-RS and UE-specific RS) used for the channel quality indicator (CQI) measurements and PDSCH demodulation[7].

1) Channel state information (CSI) RS

For CQI measurement with up to 8 antennas, new CSI-RSs are specified in addition to cell-specific RS defined in LTE Rel. 8. In LTE-Advanced, interference to the PDSCH of LTE REL.8 UE caused by supporting CSI-RS must be minimized. To achieve this, CSI-RS are multiplexed once every several subframes. This is because the channel estimation accuracy of CQI measurement is low compared to that for demodulation, & the required accuracy can be obtained as long as the CSI-RS is sent once per feedback cycle.

2) UE-specific RS The UE- specific RSs are specified for SU-MIMO transmission, to allow demodulation of 8 layers. The configuration of the UE-specific RS in LTE-Advanced is different from those of LTE REL.8, extending it for SU-MIMO and adaptive beamforming, such as by applying two dimensional time-frequency orthogonal code division multiplexing (CDM) to multiplexing between transmission layers [3].

III. MULTIUSER MIMO (MU-MIMO)

When the individual streams are assigned to various users, this is called Multi User MIMO (MU-MIMO). In the uplink, each user sends the data to a base station at different time but in downlink, base station broadcast the data to all the user simultaneously. So MU-MIMO is automatically adapted to downlink.

A. Downlink MU-MIMO Technology

In LTE-Advanced MU-MIMO, the peak data rate, the system capacity & cell edge user throughput is increased as compared to LTE Release 8 [6]. With MU-MIMO transmission, various signal processing techniques (adaptive beam transmission, adaptive power control and simultaneous multi cell transmission) are applied at the end B to reduce the interference between transmission layers. When these transmission techniques are applied, the eNode B multiplexes the UE-specific RS with the PDSCH, allowing the UE to demodulate the PDSCH without using information about transmission technology applied by eNode B. This increases flexibility in applying transmission techniques on the downlink. On the other- hand PMI/CQI/RI feedback extensions are needed to apply these transmission techniques.

IV. BEAMFORMING

Beamforming provides targeted illumination of specific areas, thereby increasing directional gain and reducing the interference from other directions provided that the MIMO channels are highly correlated. Single user and multi user beamforming requires multiple antenna elements to be spaced half wavelength of the transmitted signal.

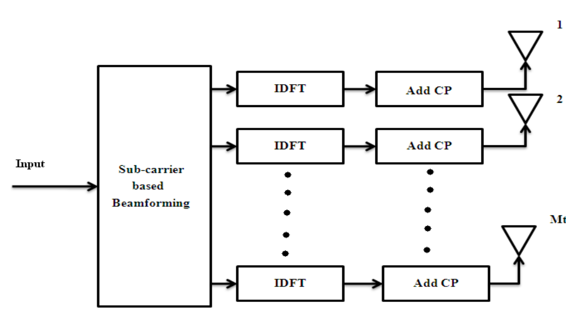

Fig. 1. Transmit Beamforming

In Fig. 1. Beamforming is applied to separate sub-carrier to reduce the interference among the carriers. Then IDFT is applied to convert the symbol from time domain to frequency domain to analyze symbol characteristics. Cyclic prefix is added in order to reduce the inter symbol interference (ISI).

All the symbols are transmitted through 1st antenna, then it switches to 2nd antenna and so on. Reverse operation takes place in receive beamforming as shown in Fig.2.

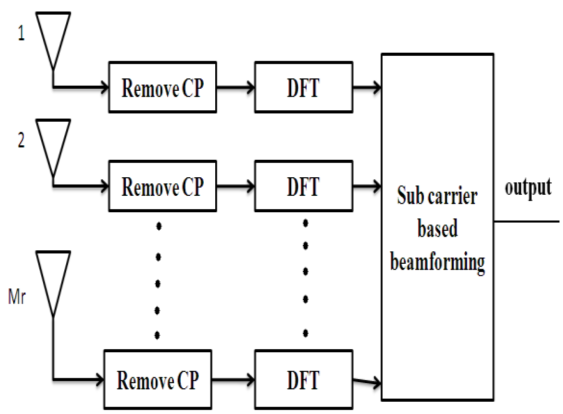

Fig. 2. Receive Beamforming

V. RESULTS AND DISCUSSIONS

We simulated a graph using MATLAB to evaluate the system performance with the following assumptions

- Perfect channel state information is known at transmitter side
- Rayleigh fading channel with mean zero and variance one is used
- Zero mean additive complex white Gaussian noise is used
- Number of subcarriers: 64

With these considerations, graph is plotted between Bit Error Rate (BER) and Signal to

Noise Ratio (SNR) for the following cases:

1)1*1 OFDM

2)2*2 –OFDM

3) 2*2 OFDM with Beamforming

4) 4*4 OFDM with Beamforming.

From Fig. 3. It is evident that an increasing number of antennas improve the system performance which can be further improved by incorporating Beamforming technique. It is made clear by comparing the result of 2*2 OFDM with 2*2 OFDM with Beamforming.

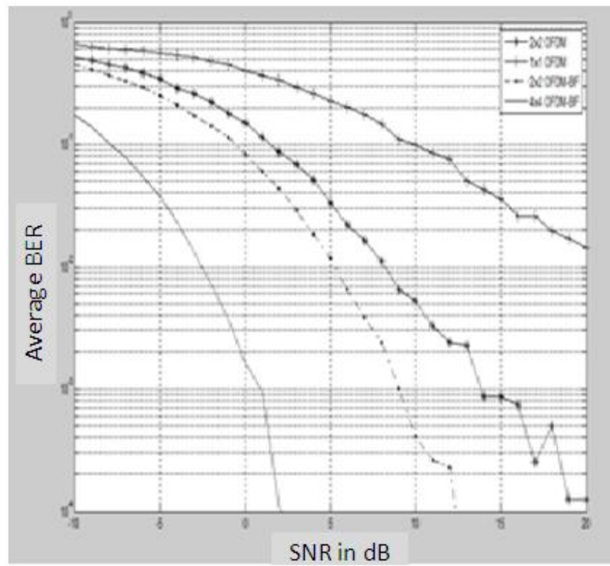

Fig. 3. Graph between BER vs SNR

Table I

Performance metrics

Parameter	SNR	Average BER
1*1 OFDM	-10	0.6
	20	0.003
2*2 OFDM	-10	0.5
	20	0.0002
2*2 OFDM-BF	-10	0.4
	13	0.0001
4*4 OFDM-BF	-10	0.2
	2	0.0001

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From Table I it is inferred that 4*4 OFDM-BF provides low BER of 0.2 at the SNR of - 10 db while comparing all the other cases.

VI. CONCLUSION

In this paper, we investigated different multi-antenna techniques such as single user MIMO (SU-MIMO) and multiuser MIMO (MU-MIMO). The problem of interference existing in MU-MIMO is addressed and inferred that it greatly reduces the system performance. Beamforming technique is introduced to mitigate the interference problem. Using MATLAB, we simulated the graphs for different MIMO cases with and without beamforming. From the obtained graph we observed that the system performance can be improved by applying beamforming.

FUTURE WORK

We aim to increase the quality of service (Qos) for the cell edge user using the more recent advanced technique in LTE-Advanced called coordinated multipoint transmission and reception (CoMP).

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