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IMPROVING THE PERFORMANCE OF 4th GENERATION CELLULAR SYSTEM BASED ON LONG TERM EVOLUTION SYSTEM USING COORDINATED MULTI-POINT AND NON-ORTHOGONAL MULTIPLE ACCESS

A THESIS

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ABSTRACT

Long Term Evolution-Advanced (LTE-A) technology is designed to increase the user capacity and data rate of mobile networks to meet rapid growth in demanded mobile applications. One main challenge of LTE-A networks is to use unitary Frequency Reuse Factor (FRF) to improve system capacity and increase user satisfaction. However, FRF one leads to Inter-Cell Interference (ICI). ICI arises as a prohibitive problem due to simultaneous transmissions over the same frequency resources in adjacent LTE-A cells. ICI decreases Signal to Interference plus Noise Ratio (SINR) especially for cell-edge users that are relatively far from the serving evolved Node B (eNB). Thus, it has a negative impact on user throughput, it decreases spectrum efficiency and it reduces the quality of provided services.

In this thesis, there are two ways for mitigating ICI and improving the cell-edge user performance in LTE-A system. First, there is Coordinated Multi-Point (CoMP) transmission and reception which is considered as the interference mitigation method from the network side and second, there is Interference Rejection Combining (IRC) receiver which is considered as the interference mitigation method from the User Equipment (UE) side.

CoMP technology is the major enhancements in LTE-A. In the Downlink (DL), CoMP allows multiple eNBs to transmit to a UE collaboratively. This is done through Dynamic Point Selection (DPS), Joint Transmission (JT), or Coordinated Scheduling/Beam-forming (CS/CB).The eNBs communicate with one another through the backhaul network such as X2 interface via fiber optics. Among these three types of DL CoMP techniques this thesis is interested in JT. JT is particularly promising in the presence of ICI because the signals transmitted from multiple eNBs are coherently combined by the UE in a constructive manner, achieving high SINR and throughput for the UE.

Moreover, the UE combats ICI through the employment of IRC. Recently, IRC based on the conventional Minimum Mean Square Error (MMSE) criteria has been proposed to mitigate ICI for cell-edge users. The conventional MMSE receiver treats the interference as noise. IRC employs the correlation matrix of the interfering signal across the receive antennas. In order to address ICI, IRC receiver is adapted. The performance of linear IRC receiver structures is investigated for interference suppression for CoMP-JT with open loop Cyclic Delay Diversity (CDD) and closed loop precoding matrix.

Also, this thesis is interested in Multiple Input Multiple Output (MIMO) systems. MIMO is considered an essential part of LTE-A in order to employ several transmit and receive antennas at both ends. MIMO is capable of providing a large increase in capacity, throughput and spectral efficiency compared to traditional single antenna systems.

Furthermore, transmitted signals from different antennas are precoded for maximizing the received Signal to Noise Ratio (SNR). LTE-A uses precoders, which mostly engages pure phase correction and no amplitude change. The open loop with CDD and closed loop spatial multiplexing MIMO are the two types of precoding that are used in LTE-A.

A cell-edge user selects two eNBs that jointly transmit the desired signal from three available ones. The capacity selection criteria is proposed for selecting the two eNBs. The effect of fading correlation between elements of transmit and receive antennas is illustrated.

Also, the effect of the desired eNB power to interference eNB power ratio using IRC receiver is studied.

For open loop precoding matrix MIMO, the performance of CoMP-JT is enhanced with dynamic cell selection and two schemes are compared for open loop with CDD.

Also, for closed loop precoding matrix MIMO, the performance of CoMP-JT is enhanced with dynamic cell selection and closed loop with global precoding matrix selection. The conventional method for selecting the precoding matrix is denoted as the local precoding scheme. In this scheme the UE selects the precoding matrix for each eNB based on its corresponding channel. On the other hand, in the global precoding scheme the UE selects the two precoding matrices for the serving and remote eNBs jointly to fit the distributed channel from the two eNBs. Both the local and global precoding matrix require the same number of feedback bits. However, the global precoding scheme requires more search in the UE.

Furthermore, another method for enhancing capacity, data rate, improving spectrum efficiency and massive connectivity is Non-Orthogonal Multiple Access (NOMA). NOMA is considered a promising multiple access scheme in the Fifth Generation Partnership Project (5GPP). The main concept of NOMA is that the same frequency and time resources can be used by multiple users. In particular, NOMA allocates less power to the users with better channel conditions and these users can decode their own information by applying a Successive Interference Canceller (SIC) receiver. Consequently, the users with better channel conditions will know the messages intended to the others. On the other hand, NOMA allocates more power to the users with bad channel conditions and these users can decode their own information directly without SIC.

In this thesis, the performance of NOMA with CoMP-JT is investigated. NOMA with CoMP-JT is combined with IRC receiver for open loop and closed loop precoding matrix. Also, in the case of closed loop precoding matrix the far user selects the precoding matrices for MIMO in a joint fashion to fit the independent MIMO channels from two eNBs. Moreover, a comparison between NOMA with CoMP-JT and NOMA without CoMP for different modulation schemes is clarified. The geometric mean and fixed power allocation are used. The effect of fading correlation between elements of transmit and receive antennas is illustrated. Also, the effect of different distance ratio between remote eNB and near user of serving cell is studied. Moreover, two cases are studied for the different size of serving and remote cells. In the first case, the serving cell is larger than the remote cell. In the second case, the serving cell is smaller than the remote cell. Also, a comparison between the previous two cases with identical two cells is clarified.

A comprehensive system level simulation has been presented in this dissertation to evaluate the performance of these algorithms, whereas the simulation results show that the CoMP-JT using open loop MIMO with proposed precoding scheme, in case of cell selection, considerably improves the performance. The relative gain that is achieved due to selecting the transmitting eNBs in medium correlation is higher than the case of low correlation. This supports the claim that the additional processing and overhead needed to implement the techniques presented in this thesis are well paid-back for in terms of performance. Also, global selection of the precoding matrices outperforms local selection. Also, for both cases, selecting the two jointly transmitting eNB provides additional performance gain. This justifies the extra processing in the UE side. Moreover, increasing the ratio of desired signal power to interference signal power gives better performance. This supports the need for power control in LTE-A. In all cases, the Extended Typical Urban (ETU) channel shows a better performance than the Extended Pedestrian Amodel (EPA) due to the increased frequency selectivity.

In addition to that, simulation results show that the NOMA-CoMP-JT-open loop with cyclic scheme 2 gives better performance than the NOMA-CoMP-JT-open loop with cyclic scheme 1. Moreover, the NOMA-CoMP-JT with global precoding matrix scheme outperforms NOMA without CoMP. Also, when the distance ratio between remote eNB and near user of serving cell is increased, the performance of system improves because the interference from remote eNB decreases. Moreover, the performance improves when serving cell has lager size compared to remote cell size. In addition to that, using IRC gives much better performance than using MMSE in the presence of ICI in all cases.