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Uplink Improvement of Long Term Evolution Advance: A Survey Paper

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ABSTRACT: *The User Equipment's (UE) now days are able to provide different internet applications and services that raise the demand or requirement for high speed data transfer and Quality of Service (QoS).Accordingtothat,thenextgenerationofmobilecommunicationsystemsdeterminedbythese demands is expected to provide higher data rates and better link quality compared to the existing systems. In the last ten years, it has seen that significant advances of multiuser MIMO (MUMIMO) in wireless communication. MU-MIMO is now introduced in different standards or known to be as newgenerationwirelessstandardsforexampleLTE-Advancedand802.16m.Thenumberofusersis increasingdaybydaywithalargenumberofapplicationsandatthesametimedatarateswithhigh transmission and reliability of communication are required. Additionally, growing concern is also there about the green communication which relates to the special effects of the radiation emitted from wireless devices on the human body. We introduce the basic concepts of LTE Advance uplink as well as MIMO communication and some of the literatures are introduced in thispaper.*

Key words: *LTE Advance, MIMO, Coordinated Multi-Point, 3GPP, Wireless Network, Communication*
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I. INTRODUCTION

Transmitted power in Long Term Evolution known as Advanced (LTE-A) uplink (UL) which is strongly linked to the number of physical resource blocks (PRBs) allocated LTE-A. It allows the use of non-contiguousresourceallocationintheULtogetherwiththesimultaneoustransmissionalongwiththemultiple componentcarriersnamedascarrieraggregation.Thesefeaturesleadtoanincreaseinthespectralefficiency and also link the gain in the performance obtained from frequency diversity. Long Term Evolution known as Advanced (LTE-A) is the solution presented by the 3rd Generation Partnership Project (3GPP) acknowledged as the fourth generation mobile communications technology[1].

LTE-Aaimsattheambitiousdataratesof1GB/sinthedownlink(DL)and500Mb/sintheuplink(UL). In this sense, as a means to increase UL spectral efficiency LTE-A introduces new approaches. Among all ofthemtheallocationofnon-contiguousresourcesandtheuseofmultipleComponentCarriers(CC),also denoted as Carrier Aggregation (CA) in the 3GPP arena, are included. Both technologies bring the benefit of additional frequency diversity gain, but do not preserve the single carrier property [1].

LongTermEvolution-Advanced(LTE-Advanced)isastandardofcellularnetworkingthatoffershigher throughput when it is compared with its predecessor which is known as Long Term Evolution (LTE). Long Term Evolution-Advanced networks can transmit data with a speed of 1 GB per second which is comparatively higher when it compared with LTE networks having a maximum data transmission of 300 MBpersecond.Accordingly,thehighdemandofthecellularbandwidthshowsthatcarriersmayhavetouse LTE-Advancedwhichresultswiththeincreaseintheircapacityanditisnotnecessarytodeliversignificantly higherspeeds.LTE-AdvancednetworkusesMIMOtechnologyknownasmultiple-inputandmultiple-output to deliver or make the data transmission faster via more than one signal. MIMO requires multiple antennas to take input or to receive those signals, which can limit its use in compact devices such as mobiles, smart phones and tablets[2].

LTE-Advancedrequirements

BasedontherequirementsofITUforIMT-Advancedsystems,3GPPcreatedatechnicalreportsummarizing LTE-Advancedrequirementsin[3].TheIMT-Advancedkeyfeaturesdelineatedinthecircularletterinviting candidate radio interface technologies are givenbelow:

- A high degree of commonality of functionality worldwide while retaining the flexibility to support a broad range of services and applications in a cost efficientmanner;
- Compatibility of services with fixed networks and withinIMT;
- Interworking Capability with other radio accesssystems;

- High quality mobileservices;
- User equipment which is suitable for worldwideuse;
- User-friendly applications, services andequipment;
- Worldwide roaming capability;and
- Enhanced instantaneous peak data rates to support advanced servicesand
- Applications (100 Mbps and 1 Gbps for higher mobility and lower mobility respectively were established as targets for research).

II. BACKGROUND

Up link MU-MIMOTechnology

MIMO technology also known as Multiple-Input Multiple-Output which is a wireless technology that uses numberoftransmittersandreceiversforthetransferofbulkdataoralargenumberofdataatthesameinstant of time. In MIMO technology, multipath is a radio-wave phenomenon takes advantage of a collision where transmittedinformationcollidewithwalls,ceilingsandmanymoredifferentobjectsandbouncesveryeasily and quickly so that it reaches the receiving antenna many times via different angles and at slightly different times[4].

Figure 1 MIMO Technology uses multiple radios to transfer more data at the same time [4]

MIMO technology takes advantages of multipath behavior by using multiple and “smart” transmitters and receivers such that with an added “spatial” dimension leads to the dramatically increase inperformance and range. MIMO allows the transmission, send and receive multiple spatial streams via multiple antennas at the sametime.

MIMO makes the work of antennas more and more smarter by enabling them and combining them with the data streams arriving from different sources and at a different interval of time which helps effectivelyto increase the capturing power of receiver signal. Smart antennas are very effective and used spatial diversity technology such that it always puts surplus antennas to good use. If there are more antennas than thespatial streams, the concerning advantage is additional antennas can add receiver diversity and increaserange.

2.1.1. Uplink MIMO

Whencomparisonisdone,UplinkMIMOschemesforLTEwilldifferfromdownlinkMIMOschemes.Itis used to take into account terminal complexity issues. MU-MIMO can be used for the uplink. Multiple user terminalsmaytransmitsimultaneouslyontheresourceblockwhichistobesame.Thisisalsoreferredtoas SDMA known as spatial domain multipleaccess.

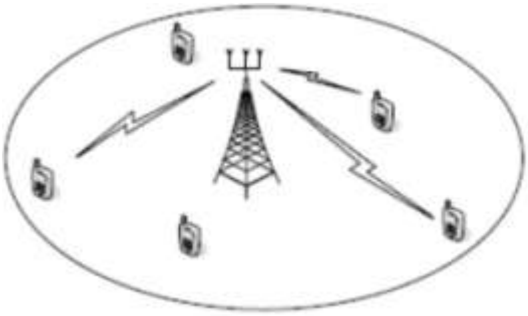

Figure 2 Multiuser MIMO Systems

This scheme requires only one transmit antenna for the entire process at UE side which is a very big advantage. The UEs shares the same resource block which have to apply mutually in an orthogonal pilot patterns. To exploit the benefits of two or more than two transmit antennas but still keep the UE cost comparatively low, antenna subset selection can beemployed. In the beginning, this method will be used. For example, a UE will have to transmit by two antennas but only have one transmit chain and amplifier. A switch will have to choose then antenna that provides the best channel to the eNodeB [4].

WhyMU-MIMO?

- More users and more devices per user: There is a constant gain in the total number of users who uses smart phones and tablets leads to the significant increases in the total number of Wi-Fi network users. The average numberofdevicesconnectedinUnitedStatesaspertheusageisexpectedtoexplodefromninedevicestoday to more than twenty devices by 2020. Many users regularly carry at least two devices: A mobile phone and a laptoportabletcomputer.Thus,Wi-Finetworksaremorecrowdedandthetotalnumberofservingdevicesin a limited amount of spectrum is a big issue as well as a challengetoo.
- Strong appetite for data: Wi-Fi is used for content consumption and also in an increasing manner. The most consuming content is streaming music and video on mobile devices such as smartphones and tablets. High-quality video content demands through set-top boxes, televisions, laptops and mobile apps also for over-the-air data synchronization with cloud storage, Skype, video conferencing, and NAS. All of them require high bandwidth as well as data too. Wi-Fi network capacity must increase dramatically to meet thisdemand.
- Needforsimpleclients:Withtheproliferationofsmartphonesandtabletswhichhavelimitedphysicalspace toaccommodatecomponents,thereisarequirementofsingleantennasoastorequiringasingleantennaisan attractive benefit. Particularly it happens when the smartphones experiences very higher throughput while reducing cost andspace.
- Cellular offload: In 2013, Global mobile data traffic grew 81% and is expected that in between the year 2013 to 2018, there is an increment of nearly 11-fold. Wherever possible, this increased the necessity for data on themobilenetworkswhichisdrivingthecellularcarriersallaroundtheworldtooffloadmobileWANtraffic to Wi-Fi. As both the subscribers and devices tend to connect over Wi-Fi networks whenever it comes in the coverage or in reach. These trends indicate that Wi-Fi offloading will continuously increase exponentially over the succeeding few years with the proliferation of Wi-Fi hotspots and as mobile subscribers continue to intensify consumption of data over mobiledevices.
- Demandinenterprisenetworks:89%ofenterpriseITdepartmentsalloweachoftheiremployeestobringtheir devices (BYOD). Significantly more and more devices and new applications to facilitate employee mobility whichincreasesflexibilityandtheproductivityofemployeemeanenterprisenetworksarehandlingheavyWi- Fi traffic and their demands of connectivity will continue to increase. The drastic increase in the number of devices will lead to the increase in the employees personal devices i.e. known to be as smartphones, laptops etc.toenterprisenetworksisdrivingtherequirementforenterpriseITtoreplacetheirEthernetnetworkswith Wi-Fi in enterprise networks[5].

Up link Transmit DiversityTechnology

Transmit diversity can be considered as a technology in wireless communication in order to enhance the performance of the system. Some relevant methods of transmit diversity have been represented based on link-levelresearchbutdonotconsiderMAIwhichisknownasmultipleaccessinterference,existingbetween subscribers in the uplink of multi-user system. TD techniques are also known as Transmit diversity which expect to be included in the uplink of the upcoming Long Term Evolution - Advanced (LTE-A) systems to boost the user performance in comparatively less Signal-to-Noise Ratio (SNR) conditions [6]. Most of the mobile communication channels must resist the effects of fading caused by multipath propagation. An importantwayofquantifyingfadingisintermsofameasurecalledthecoherencebandwidthwhichindicates the quantity of bandwidth that will fade in a correlated fashion at any instant intime.

2.2.1. Transmission Modes in MIMO LTE System

In MIMO system there are two types of mode and known as the most popular modes that are utilized in our LTEanalysiswhichTransmitsDiversitymodeaswellasSpatialMultiplexing.Diversitymodescanbeused either in the receive Diversity or in the Transmit Diversity side, where as in received diversity side it is known for the simply combining operation of different types of replicas of the same transmitted signal. Transmit Diversity requires the signal transmission of Space Time Coding operation. In LTE there are different modes of Transmit Diversity defined asbelow:

a) Transmit diversitymode

The Transmit Diversity techniques where only transmitted signal replicas are used to diminish error rate in thereceiverside.TransmitDiversitywithtwotransmittersideantennasandonereceiversideantennaalong with one data stream is defined as below codes. Space Frequency Block Coding (SFBC) are defined when two eNodeB antennas are there for transmit diversity operation. Space -Time Block Coding derived SFBC is commonly known is Alamouti codes. The range created by the transmitter utilizes diversity of space and time as well as frequency diversity. The space-time coding scheme of Alamouti can achieve full spatial diversity gain. TxD issue is for single ranks i.e. it does not maintain multi stream transmission [7]. In LTE for SFBC transmission, the symbols are transmitted from two eNodeB antenna ports on adjacent pairs of subcarriers are asfollows

$$\begin{bmatrix} Y^0(1) & Y^0(2) \\ Y^1(1) & Y^1(2) \end{bmatrix} \quad \text{(i)}$$

Where $\mathbf{Y^P}$ **(K)** denotes the symbols transmitted on the k_{th} subcarrier from antenna port p. One important characteristic of such codes is that the signal streams being transmitted are orthogonal and a simple linear receiver is required for optimal performances. Through diversity gain utilization, the reliability of diversity scheme increases. As a result of the diversity gain, there is a decrement in the rate of error. The data rate is also logarithmically improved with respect to the quantity of antennas, as antenna diversity increases the SNR linearly.

$$C = B \log_2(1 + SNR) \quad \text{(ii)}$$

MIMO system’s diversity gain is mostly characterized by the number of independent fading diversity branches,alsocalledDiversityOrder.ThediversityorderisgivenastheslopeofBLERversusSNRcurves on a log-log scale. Nt transmit antennas and Nr receive antenna are presented in a MIMO system, it has a diversityorderofNd=Nt.Nr.Thediversityorderhasconsequenceonthesystemreliabilitysinceprobability of one of the diversity branches having high SNR is higher compared to only onebranches.

b) Spatial multiplexingmode

In comparison with the diversity modes mentioned in the above section, the mode of Spatial Multiplexing whichrelatestothesplittingofincominghighdataratestreaminto$N_t$transmitindependentdataratestreams. TheSpatialmodeofmultiplexingismostsignificantinthedatathroughputpointofviewinLTEsystem.In MIMOsystemwith$N_t$transmitantennasthenominalspectralefficiencycanbeenhancedbyanumberofN_t stream can be successfully and separately decoded. Multiplexing gain is defined as the factor N_t . In spatial multiplexing (N_t x N_r) MIMO system, the greatest data rate grows as[8]

$$\min(N_t,N_r)\log_2(1+SNR) \quad \text{(iii)}$$

TheSpatialMultiplexingmodeinLTEisdesignedasmode4anditisrecognizedasclosedloopSpatial Multiplexing mode .In SISO OFDM systems, the maximal data throughput is influenced by the available bandwidthandtheparameteroftheOFDMsignal,forexample,thenumberofsubcarriersandthemodulation order like QPSK, 16QAM, 64Q AM. For given Frequency bandwidth B the maximal data Throughput calculated in bits per second can be approximated as given in belowequation:

$$Throughput(T) = \frac{N_{FB}.N_{CC}.N_{0FDM}.}{T_{cub}}.ECR \quad \text{(iv)}$$

Where NFB is the number of frequency Block in the certain frequency band (B); NSC is the number of subcarrierinonefrequencyblock;NOFDMwhichisthenumberofOFDMsymbolspresentinonesubframe equal to 12 and 14 respectively . Now we have 5 MHz bandwidth N_{FB} =25, N_{SC}=12, N_{OFDM} =14, in LTE system has 16QAM modulation scheme so N_b= 4 and ECR=0.369, also here sub frame duration 1ms. Now subsituting all this values in equation (iv) got maximum data Throughput for 5 MHz bandwidth equal to 6.1Mbps[8].

Up link Multi cellReception

CoMP (Uplink Co-ordinated Multi-Point) is a promising technique for enhancing the capacity of 4G networks [9]. The uplink is gaining increasing attention because of the drastic increase of subscriber- generated data in the form of photos, videos and file-sharing. In practice, sharing of uplink received signals acrosscellsisrestrictedbybackhaulbandwidth.Inaddition,thereceiveraperture,orthesignificantnumber of signals from antennas at nearby cell sites that can be processed at a particular cell, may be restricted due to hardwareconstraints.

Uplinkcommunicationintheinterferencerestrictedcellularsystemsisdifficultandhasbeenstudiedfordecades .Intheuplinktransmission,besidesitsownavailableresourcesamobilestation(MS)isconstrained by the co-channel interferences (CCI). Coordinated multipoint or cooperative MIMO is one of the capable concepts to improve cell edge user data rate as well as spectral efficiency. Long Term Evolution (LTE) and mobile WiMAX utilises

Multiple-Input Multiple-Output (MIMO)-Orthogonal Frequency Division Multiplexing(OFDM)andachieveenhancedspectralefficiencywithinonecell.Inthismethodcoordination ofbasestationstostayawayfrominterferenceandconstructiveexploitationofinterferencethroughcoherent base station cooperation is achieved. Conceptually, we extend single-cell MIMO techniques, such as multi- user (MU-MIMO), to multiple cells. The techniques of cooperation aim to avoid or exploit interference in ordertoimprovethecelledgealongwithaveragedatarates.CoMPcanbeappliedbothintheuplinkaswell as downlink. One of the primary differences between CoMP Multi-User (MU) MIMO systems and single- cell MU MIMO systems is present in the per base station power constraint. By exploiting CoMP, coherent transmission with coordinated base stations can considerably improve both the cell average throughput as well as the cell edge throughput[10].

One way to implement a multi-cell joint processing system is to deploy a centralized processing server which is linked with all the base-stations through high-capacity backhaul links. When the capacities of the backhaul links are sufficiently large, the joint processing system which is implemented across the different cells in the network can be displayed as a multiple-access channel in the uplink in addition to a broadcast channel in the downlink, which leads to the concept of network MIMO [11].

III. LITERATURESURVEY

Multi-user MIMO communication can give significant gains by using spatial multiplexing. However, it needs better feedback to provide correct channel state information at the transmitter (CSIT) for minimizing the interference of multiuser. 3GPP LTE provides support for MU-MIMO, but it is not enough to extract sizable gains. In this paper, our basic and primary goal is to exploit the system's resources efficiently for MU-MIMO in LTE. We observed that the TM5 i.e. known as the transmission mode 5 committed for MU- MIMO(Multi-userMultipleinputMultipleoutput)utilizeswidebandfeedbackmethodwhichisveryusefulforprovidingchanneldirectionalinformation(CDI)orprecodingmatrixindicator(PMI)intheexistingLTEstandardof3GPP(Rel.8).Thereforeinthis work,werecommendtotakeadvantageofthesub-bandfeedback for providing more and more accurate and frequent update of PMI. However, in order to support this or maintain this feedback method, we have to or need to propose a new downlink control information (DCI) format for TM5 i.e. transmission mode 5 that will contain additional fields or supplementary data when it compare with the existing DCI format 1D[12].

MU-MIMO transmission scheme has drawn a lot of attentions during the modern development of Long Term Evolution (LTE) systems. Multiuser multiple-input multiple-output plays a apparent role in the transmission. Based on the feedback information or response of the downlink channel, evolved NodeBmay accomplish multiple accesses via MIMO technology in MU-MIMO Transmission Mode and allow user equipment's to distribute resources in frequency as well as time domain. In this paper, we review several signal detectors and on the basis of which evaluate their performance in MU-MIMO transmission. The reviewworktargetedoraimedastochecktheortoevaluatethefeasibilitystudyofreceiversinLTEsystems. Differentscenariosandcorrelationshavebeenconsideredintheevaluationaswellasinassessmentprogress, forexamplelowandhighspatialcorrelation,feedbackdelayandrealchannelestimation.Theresultof

Simulation shows that the benefits can be obtained by MU-MIMO transmission in the spatial correlated MIMOchannelbecauseofthehigherconditionnumberinthechannel.Theinterferenceawarereceiversare also robust in Multiuser multiple-input multiple-output transmission with imperfect conditions of working, including channel errors of estimation and precoding matrix index response or feedback delay[13].

3GPP has completed a thorough study on coordinated multipoint transmission as well as reception techniquestofacilitatethecommunicationswhichiscooperativeacrossmultipletransmissionandreception points such as cells, for the Advanced system of LTE. In the CoMP operation, multiple points coordinate with each other in such a way that the transmission signals varies from point to point such as from the one pointstootherpointswhichdonotincurseriousinterferenceorevencanbeexploitedasasignificantsignal. The basic goal of the study is to evaluate the potential performance profit or benefit of CoMP techniques and the implementation aspects which includes the complexity of the standards support for CoMP. This article is having some of the deployment scenarios in which CoMP techniques will likely be much more beneficial and offers an overview of CoMP schemes that might be supported in LTE-Advanced given that the modern silicon or DSP technologies and designs of backhaul available today. In addition, practical implementation as well as operational challenges are also discussed. We also assess or evaluate the performance benefits of CoMP in these scenarios of deployment with traffic which varying from low load to a very high load[14].

Network Multiple Input Multiple Output is like to be a family which suppresses of techniques in which each user in a wireless system is served through the all access points within its influenced range. By coordinating tightly, the transmission of signal and reception of signals at multiple access points, Network MIMO transcends the restrictions on spectral efficiency due to inter-cell interference. Taking prior informationtheoreticanalysesofNetworkMIMOtothenextlevel,thispapercomputethespectralefficiency gains obtainable under realistic propagation and operational conditions. Our study relates with the simulationsindetailand,forspecificity,isconductedwithintheframeworkandoutlineoftheIEEE802.16e Mobile WiMAX system. The relevant physical-layer functionalities of Mobile WiMAX are precisely replicated. In addition to make possible the coordination between the access points, we postulate an indoor deployment organized around a backhaul of Gigabit-Ethernet. The results confirm that Network MIMO stands to provide a multiple fold rise in spectral efficiency under such conditions[15].

Adaptive algorithm for MIMO detection under LTE-A system is based on the detection of sphere is proposed in this paper. The algorithm proposed in this paper uses M-algorithm for reference to eliminate unreliable constellation candidates before the search is being performed, and the number of constellation reservation is adaptively tune up according to SNR. Simulations show about the LTE-A downlink performance of BER also represents as the proposed detection algorithm which is nearly the same as maximum likelihood (ML) detection algorithm. On the other hand, the complexity is reduced by on an approximation of 30% as compared with full constellation sphere detection [16].

IV. CONCLUSION

ThispapersummarizestheLTEAdvancedimprovementsthathavebeenevaluatedandspecifiedthroughoutthe respective study and work item phase within 3GPP. The different features deliver varying performance gains and will have certain impacts on the system complexity and cost. LTE-Advanced is an evolution of LTE and was finalized about three years after LTE Release 8 in 3GPP standardization. This paper presents a basic introduction to the fundamentals of Uplink LTE-A techniques communication. Uplink LTE- A is a radio communications technology or RF technology that is being mentioned and used in various latest technologies these days. Basically we surveyed different technologies of Uplink LTE advanced where communication strategies are distributed to the end user for better uplink highspeed.

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