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Performance Improvement of 5G Network Using Up/Down Link Co-Ordinated Multipoint Algorithm

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Abstract:
Recently, the Cisco global mobile traffic forecast has indicated that mobile data traffic will grow at a compound annual growth rate of 53 percentages from 2015 to 2020.The video data will account for 75% of the mobile data traffic in 2020. The trend confirms that more advanced wireless communication technologies will be required to support better user experience, especially for cell-edge users.In next-generation cellular systems, operators are required to provide better video service quality for users, especially for cell-edge users. Cell-edge users may occupy a large portion of radio resource blocks (RBs),Co-Ordinated Multi-Point (Co-MP) transmission and reception are introduced as a promising technology in the Long Term Evaluation (LTE) networks.In this paper, the QoS of 5G network in terms of throughput, SNIR, spectral efficiency and data rate is improved using Co-Ordinated Multi Point Algorithm (Co-MP).

Keywords: Mobile data traffic, Long Term Evaluation Networks, Co-ordinated Multi point algorithm.

I. INTRODUCTION

The wireless communications has been in existence, since first humans are learned to communicate. In early days humans would transmit the important event such as enemy invasions or royal births, through the sound of horns or the lighting of fires. Simple messages could be effectively transmitted in this manner, in order to communicate their information. The manpower expense is great, since watchtowers had to be built within the sight of each other and continually manned. The number of messages is able to use radio frequencies to communicate information over long distances, it can send voice or video at rate of more than hundreds of megabits per second and this technology has become so inexpensive that many people are able to afford a mobile phone in order to be in constant contact with others. The three parts of communication system are of transmitter, receiver and channel. In this the transmitter will takes, whether the analog or digital signal and then formats it for transmission over the channel. Wireless channels are water, air or vacuum depending upon the medium it may contains the obstructions such as buildings, terrestrial or planets. Transmitted signal are captured by the receiver and performs signal processing that can be transmitted over the channel of a form and can be viewed, heard or stored [1]. All of these system components introduce degradation to the transmitted signals. Further each system has a limit on the number of signals that can be transmitted over compensating for the degradation and by designing the signal processing within a communications system. The number of signals which can be transmitted at one time can be maximized and the signals degradation can be minimized. 3GPP Long Term Evolution (LTE) is a standard for wireless communications to achieve high spectral efficiency, high data rates as well as flexibility in frequency and bandwidth using frequency reuse of one in LTE networks is achieved. Inter-Cell Interference (ICI) resulted from the frequency reuse of one is main limitation in these networks. Co-ordinated Multipoint Transmission (Co-MP) has been proposed as an Inter-Cell Interference Coordination (ICIC) technique in Orthogonal Frequency Division Multiple Access (OFDMA) based LTE networks [2]. Co-MP forms a cluster of cooperating base stations that jointly transmit the data to users within it, focuses on evaluating Co-MP method and compare results with the conventional method. A broad comparison is performed by using a proposed mechanism depends on Monte Carlo simulations consider a performance metrics such as Signal to Interference plus Noise Ratio (SINR), capacity and throughput. Simulation results shows that Co-MP is used, the throughout has generally increased with significant increase at the cell-edge. Technology advanced from the 2G Global System for Mobile (GSM) to the 3G Universal Mobile Telecommunication System (UMTS), higher network speed and faster download speed allowed real-time video calls. The subsequent Long Term Evolution-Advanced (LTE-A)offered enhanced network capacity and reduced delay in application–server access, making triple-play traffic (data, voice and video) access possible wirelessly, anytime anywhere. 4G truly constitutes mobile broadband. Although3G was the first mobile broadband standard, it was originally designed for voice with some multimedia and data consideration and 2G was intended as the first digital mobile voice communication standard for improved coverage [5]. The data rate has improved from 64 kbps in 2G 2 Mbps in 3G and 50–100 Mbps in 4G. 5G is expected to enhance not only the data transfer speed of mobile networks but also the scalability, connectivity and energy efficiency of the network. It is assumed that by 2020, 50 billion devices will be connected to the global IP network, appear to present a challenge, in a true “networked society” remote controlled operation of appliances and critical commercial machines over a reliable 5G network will be possible with zero delay. Real-time control of machines by using mobile devices will be possible, making the Internet of things (IoT) more available to all. Finally, less energy-hungry network nodes will be required toward a greener world. Therefore 5g network are has high throughput, low-latency, high reliability, increased scalability and energy efficient mobile communication technology. The society of 2020 will be a connected society. The IoT (Internet of Things) together with intelligent and integrated sensor systems and in-home sensor networks will change the way of people to lead their lives. "Smart living" people will require constant and ubiquitous mobile connectivity to the network to upload their activity data and IoT control commands, Vehicular Ad-hoc Networks (VANETs) are constantly advancing by 2020, integrated with cellular networks will be in operation as VANET cloud, leading to a smarter and safer transportation system [4]. The number of devices is connected to the Internet passes tens or hundreds of billions in the coming decade the off-loading of networked data on unlicensed bands will play a critical role in network load balancing, providing guaranteed bit rate services and reduction in control signaling. It is important that 5G will provide seamless compatibility with dense heterogeneous networks to satisfy the high demand of real-time traffic.

II. SYSTEM MODEL

Different research groups are working on 5G standards a few examples are Mobile and Wireless Communications Enablers for the Twenty–twenty Information Society (METIS), 5th Generation Non-Orthogonal Waveforms for Asynchronous Signaling (5GNOW), Enhanced Multicarrier Technology for Professional Ad-Hoc and Cell-Based Communications (EMPHATIC), 5G Infrastructure Public Private Partnership (5G-PPP), Network of Excellence in Wireless Communications (NEWCOM), 5G Innovation Center at the University of Surrey, NYU WIRELESS and the Electronics and Telecommunications Research Institute (ETRI), Korea. These groups are researching different technical and probable standardization aspects of 5G [3]. METIS enlisted top telecommunication companies such as NSN, Ericsson, and T-Mobile and Orange academic institutions, such as the Royal Institute of Technology in Stockholm (KTH), Poznan University of Technology, Kaiserslautern University of Technology, Polytechnic University of Valencia and University of Oulu as its partners. METIS recently published their final report containing the main outcomes of architecture, high level architectural illustrations, a channel model and over 140 technology components and their test bed evaluations. The filter bank multi-carrier (FBMC) to be a successful enabler for designing flexible air interfaces. Simulation report presents evaluations of 5G key performance indicators (KPIs) such as traffic volume per subscriber, traffic volume per area, average user data rate during busy hours and actual user data rates [6]. Also presented different Radio Access Network (RAN) architectures and traffic flow in different scenarios such as indoor offices, shopping malls, stadiums, and outdoor dense urban environments. They are moving forward with the **METIS-II** project envisaging an overall 5G RAN design, collaborative evaluation of 5G RAN, and global consensus building among all standardization groups. The average sum rate of Co-MP-CB and JP transmission mode can respectively be expressed as follows [5].

$$R_{sum}^{CB} = \sum_{j=1}^{B} E\{\log_2(1+\gamma_j^{CB})\} \quad (1)$$

$$R_{sum}^{JB} = \sum_{j=1}^{B} E\{\log_2(1+\gamma_j^{JB})\} \quad (2)$$

5GIC, UK's only research body dedicated to 5G research, recently achieved a remarkable breakthrough in wireless speed gain: a speed of 1 Kbps speed in a wireless point-to-point (P2P) communication [7]. Korea in its GIGA 5G is focusing mainly on improving reliability, device-to-device (D2D) communication technologies and the mobile hotspot network (MHN) protocol stack. 5G forum the Republic of Korea is also seeking innovations and market research for the future standard. To achieve high speed enhancement, the first step is to use the mm-wave spectrum (3–300 GHz range) as thecarrier frequency together with opportunistic traffic off-loading onto an unlicensed spectrum (5 GHz WI-Fi). The current cellular licensed carrier spans from the saturated 750 MHz to the 2600 MHz spectrum. The design of the under-utilized physical layers (PHY layers) of the mm-wave spectrum is required. In addition, massive MIMO beam forming traffic off-loading onto unlicensed spectra and codification of radio resources will provide faster data transfer and guaranteed availability, the propagation behavior penetration characteristics and path loss of 28 GHz and 38 GHz carriers resulting from urban structures. 5G will have a well-connected core network and RAN [9]. The backbone network may even shift from fiber to mm-wave wireless connectivity and the interconnected base stations should use high bandwidth wired connections. As the number of connected devices increases, a typical macro-cell may be heavily burdened to maintain connectivity with a huge number of devices (around 10 k per cell). [10] Therefore, the architecture must be less complex and evolved to accommodate an increased amount of signaling and payload overhead. The performance of an advanced 5G architecture, deploying mm-wave RAN in the Giga KOREA 5G has been reported. The graphical representations of the antenna array structures for 3D beam-forming and the beam control mechanism facilitates fast handover among different beams. 3D beam-formation is achieved with the help of a 2D array of patch antenna. Highly directive beams of radio transmission signals formed in 3-dimensional spaces, originating from the 2D array of patch antenna help to achieve Space Division Multiple Access (SDMA). This essentially can be termed Beam Division Multiple Access (BDMA). In user equipment, they installed the patch antenna arrays consisting of a 2D number of patch antenna [12]. A quick handoff capability between different beams makes the radio access technique robust, secure and highly reliable. 5G wireless mobile system is expected to deliver significantly higher capacity to meet the exponential growth of mobile data traffic and to accommodate considerably larger number of wireless connections. In addition, 5G wireless mobile system should be engineered to support better existing and emerging including broadband multimedia, quality-of-service (QoS) delay, reliability and higher spectral efficiency. The future mobile technologies should be much more cost-efficient since mobile operators have been reducing revenue per unit of data over the past years.

III. CO-ORDINATED MULTIPOINT ALGORITHM

Long Term Evolution (LTE) is a standard for wireless communications to achieve high spectral efficiency, high peak data rates, as well as flexibility in frequency and bandwidth going to deploy in 5G network. By using co-ordinated data transmission in multi-cell networks, high spectral efficiency is achieved. The Inter-Cell Interference (ICI) resulted from the frequency reuse of one of its main limitation in these networks. Co-ordinated Multipoint [8] (Co-MP) has been proposed as an Inter-Cell Interference Coordination (ICIC) technique in Orthogonal Frequency Division Multiple Access (OFDMA) based LTE networks. Co-MP forms a cluster of cooperating base stations that jointly transmit data to users within it.

Evaluating Co-MP method and compare results with the conventional method [11]. A broad comparison is performed by using a proposed mechanism which depends on Monte Carlo simulations considering performance metrics such as Signal to Interference plus Noise Ratio (SINR), capacity and throughput. Simulation results show that the Co-MP is used the throughput has generally increased with a significant increase at the cell-edge. We choose the CoMP-JP mode can be rewritten as [7],

$$R_{sum}^{CB} = \sum_{j=1}^{B} E\{\log_2(1+\gamma_j^{CB})\} \quad (3)$$

$$\prod_{j=1}^{B}(1+\phi.\alpha_{jj}^2) < 2^C \quad (4)$$

5G is the next major step in mobile radio communications uses Orthogonal Frequency Division Multiple Access (OFDMA) as its radio access technology; together with advanced antenna technologies the scarcity of bandwidth, spectrum and power in wireless systems has driven the need for spectrally efficient communication systems. In a cellular communication system such as Long Term Evolution (LTE), the Inter-Cell Interference (ICI) is one of the main factors that influence the data rates of the users at the cell-edge and affects the average spectral efficiency of the cell. In a conventional cellular system, the BS is located in the cell center and it only serves the users in its coverage area. The signals transmitted from other BSs cause interference, especially at the cell-edge, different coverage areas overlap and giving rise to Inter-Cell Interference (ICI) reduces the spectral efficiency of the cell [13]. The Channel State Information (CSI) of various links is made available to an entity (central unit) then the interference from other cells can be avoided by designing a beam-former. This pre-canceling of interference by beam-forming and power allocation is called Pre-coding. Transmission to a user is to be collaborated by multiple BSs or network points, to remove the interference this is referred to as Co-MP transmission. To occur, the Channel State Information (CSI) from all the BSs need to be available at the central unit for pre-coding. This constitutes the centralized joint processing algorithm, a set of BSs form a cluster of cooperative cells. But, coordinating BSs for coherent joint processing puts tremendous requirements for high speed backhauling (10 Gbps over fiber or up to 4 Gbps over microwave links for the CSI to be available at the central unit.

$$\prod_{j=1}^{B}(1+\phi.\alpha_{jj}^2) \geq 2^C \quad (5)$$

The performance gain of involving the multiple antennas of conventional techniques are tremendous and proved that the Channel capacity increases with minimum number of antennas over the transmitter (Tx) and receiver (Rx) without increasing the bandwidth or power. Some of the benefits of MIMO are array gain, diversity gain, multiplexing gain, interference reduction and avoidance. But to exploit all of this may not be possible. The performance gain in spectral efficiency due to the coordination of multiple antennas i.e. there is a significant increase in spectral efficiency as the number of coordinated antennas is increased. Without coordination, the increase in spectral efficiency is less with the increase in the number of antennas.

JOINT SYSTEM ANTENNA:

Coordinating multiple BS antennas in general is referred to as Network Multiple Input Multiple Output (NW MIMO), Distributed Antenna Systems (DAS) and Joint Transmission (JT). Coordination between BSs can be achieved on the Uplink (UL) and Downlink (DL).The received UL signal at multiple BSs may be combined using techniques such as Maximum Ratio Combining (MRC) etc. This is perceived to be implementation dependent with no impact on the radio interface. Coordination in the DL is referred to as Co-ordinated Multi-point transmission or Joint Transmission. In MU-MIMO, the DL and the UL correspond to the Broadcast (BC) and Multiple Access Channel (MAC), respectively [14]. The Co-MP transmission can be compared to the MU-MIMO. The proposed work mainly focus on Co-MP transmission and henceforth, any reference to Co-MP refers to the DL transmission, in the downlink the co-ordination multipoint schemes are divided into:

a) Dynamic scheduling is achieved through coordination between multiple cells in an extension of ICI coordination in LTE, refers to this as a Co-ordinated Scheduling or Co-ordinated Beam forming. The data to a Mobile Station (MS) is transmitted from one of the BSs and suggests that scheduling decisions are co-ordinated the generated beams and scheduling decisions need to be co-ordinated. The user data only need to present at one serving BS, unlike Joint transmission.

b) Joint transmission and reception among multiple cells, to this Joint Processing/Transmission a single Mobile Station (MS), receives its data from various BSs. Thus, improves the received signal strength and canceling interference. Coherent joint processing puts tremendous requirements on backhaul, as the user data needs to present at all the coordinating BSs. The theoretical gains in terms of average and cell-edge user throughput with joint processing Co-MP are substantially larger compared to co-ordinated beam-forming in this system only Joint Processing Co-ordinated Multipoint Transmission method has done as shown in Fig.1

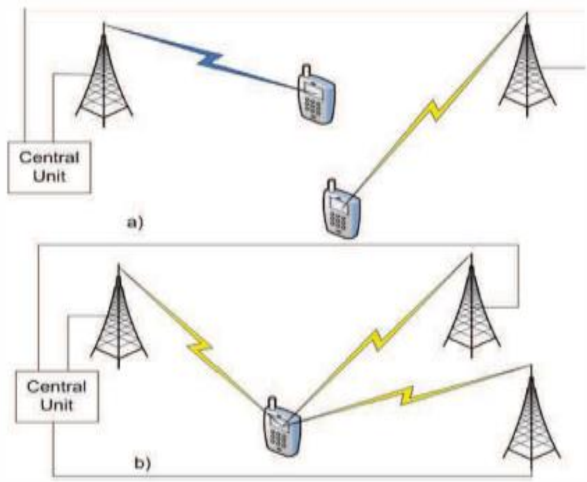

Figure.1. (a) Co-ordinated Scheduling or Co-ordinated Beam forming (b) Joint Processing / Transmission.

CO-ORDINATED MULTIPOINT:

Joint processing between Base Stations (BSs) is included in the more general framework of Co-ordinated Multi Point (Co-MP) transmission schemes, has been identified as one of the key techniques for mitigating inter-cell interference in future broadband communication systems, a group of BSs acts as a single and distributed antenna array and hence, data to a single user is simultaneously transmitted from more than one BS.[15] From a practical point of view, one of the major drawbacks related to the implementation of joint processing, as the number of users and BSs increases, is the amount of feedback 288 needed from the users and the large signaling overhead related to the inter-base information exchange. Therefore, the design of efficient algorithms and principles that could reduce these complexity requirements is of great interest in the field of joint processing. To achieve these solutions that restrict the use of joint processing techniques to a limited number of BSs or areas of the system have been proposed. In these the network is typically divided into clusters of cells, and the joint processing schemes are implemented within the BSs included in each cluster. Consider that downlink of a static cluster of BSs. An example for static cluster of 3 cells Joint Transmission takes place as shown in Fig 2.

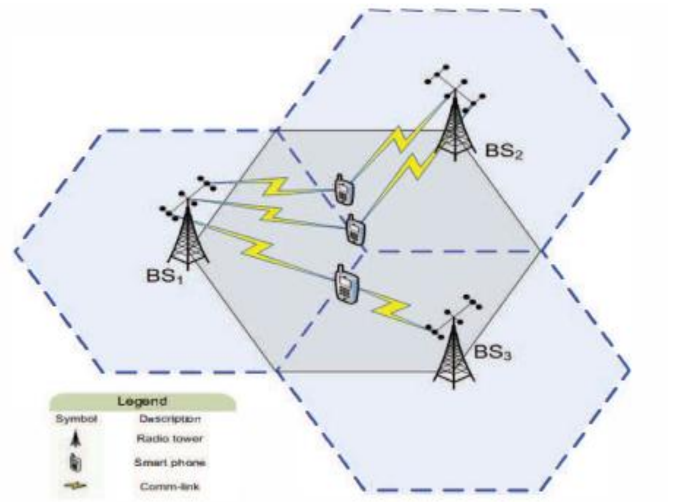

Figure.2, Static cluster of three cells with Joint Transmission

JOINT PROCESSING SYSTEM MODEL:

A system of hexagonal grid of cells that consists from K cells, each of has a BS at its center with NT = 2 antennas. In each cell, there are M users, each has NR = 2 antennas. Assume a cluster of K' cells in Co-MP Joint Transmission take place of K' E K. Joint Transmission between BSs is allowed, the data to each user is simultaneously transmitted from multiple BSs. The matrix H of size [M N R X K NT] includes the channel vectors of the system.

$$R_{sum}^{CB} = \sum_{j=1}^{B}\{\log_2(1+\Gamma_j^{CB})\} \qquad (6)$$

The set Z represents all the interfering base stations, i.e. base stations that are using the same sub-band as user x. The shadow fading Ys is a random variable described by a lognormal distribution, Ys- N (O, BdB). The path loss Yp follows the 3GPP Long Term Evolution (LTE) model, Yp (dB) = 14B.1 + 37.610 log10(r) r is the distance. "h" of size [NR x KNT] stands for the channel between the m-th user and the K BSs. The channel vector between the m-th user and the k-th BS is modeled as

hmk = h'mk.JyP'Ys (7)

The shadow fading Ys is a random variable described by a log-normal distribution, Ys- N (O, SdB). The path loss Yp follows the 3GPP Long Term Evolution (LTE) model, Yp (dB) = 14S.1 + 37.610gl0 (rmk), rmk is the distance between the m-th user and the k-th BS in kilometers, h:k includes the small-scale fading coefficients, complex Gaussian value, is a vector Gaussian channel.

The m-th user and k-th BS can be computed by decomposing the channel into a set of parallel, independent and scalar Gaussian sub-channels. From basic linear algebra, every linear transformation can be represented as a composition of three operations: rotation, scaling and another rotation. In the notation of matrices, the matrix hmk has singular value decomposition (SVD) [16]:

hmk = UAV (8)

U of size [NR x NR] and V of size [NT x NT] are (rotation) unitary matrices and A of size [NR x NT] is a rectangular matrix whose diagonal elements are non-negative real numbers and off-diagonal elements are zero. The diagonal elements A1 2': A1 2': ... 2': An. are the ordered singular values of the matrix h:n, where nmin =min (NR ' NT), the squared singular values AT are the eigenvalues of the matrix hmk h'mk and also of h'mk hmk.

INTERFERENCE CO-ORDINATION MECHANISM:

Propose a mechanism to compare Co-MP Joint Transmission (Co-MP-JT) with Non-Co-MP. The mechanism is to produce average per-user SINR, average per-user spectral efficiency and average per-user throughput as function of distance from Base Station for Co-MP-JT and for Non-Co-MP, as well as the CDFs of the mentioned parameters. The proposed mechanism assumes a topology that consists of a grid of M cells and K users that are randomly distributed in each cell. Use frequency reuse in whole topology and the available subcarriers in each cell are divided equally between users. Once subcarriers are allocated to each user, the corresponding throughput is determined. Repeat the mechanism for 1000 Monte Carlo simulations. Then the average per-user SINR, average per-user spectral and average per-user throughput (according to Shannon formula and according to CQI table) as a function of average per-user distance from Base Station, as well as their CDFs for both Co-MP-JT and Non-Co-MP. One BS is replaced by an increase in signal power due to the decreased path loss from another BS. Therefore, Co-MP-JT provides significant improve for cell-edge users' SINR. The problem of improving cell-edge throughput of LTE networks has been an extensive area of research in both academia and industry. Co-MP has been proposed as an ICIC technique to solve the cell-edge problem, more than one base station coordinates in such a way they form a cluster, jointly transmits to users within it. It is found that Co-MP gives high SINR and throughput improvements compared to the conventional methods. This improvement increases as getting closer to the cell edge. Therefore, Co-MP is a very promising technique for improving the cell-edge throughput.

IV.RESULTS AND DISCUSSION

Creation of a dense mobile communication system with base station, under service i.e. initialization of network shown inFig.3, further analysis on the network will be done.

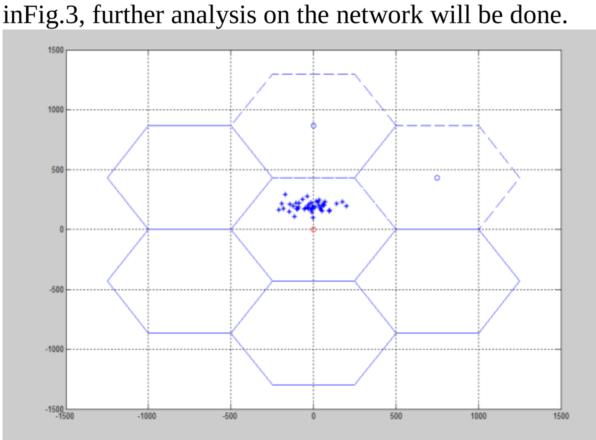

Figure.3. Creation of network with dense mobile users and service

The average per-user throughput has the function of average per-user distance from the BS for Non-Co-MP and Co-MP-JT according to Shannon formula [17]. The throughput in this case is linearly proportional to the allocated bandwidth and logarithmically proportional to - SINR. It has similar trends as that of SINR. The throughput performance of Co MP-JT is better than of Non-Co-MP and as farther from the BS towards the cell-edge notice the difference between the methods in terms of increased throughput of Co-MP-JT with respect to Non Co-MP as shown in Fig.4.

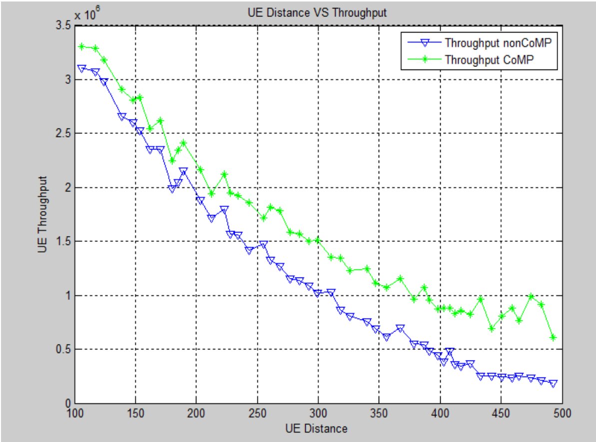

Figure.4. Distance versus throughput

The average per-user throughput has function average per-user distance from the BS for Non-Co-MP and Co-MP-JT according to CQI table. The graph is similar to that of Shannon formula. The difference is that all SINR above 20 dB (SINR that corresponds to the highest CQI index) are mapped into the highest CQI index and all have the same corresponding spectral efficiency. Thus, as it is obvious in the graph, it starts with the highest possible value of Throughput according to the CQI table, and starts to decrease when the associated SINR starts to be less than 20 dB. Co-MP-JT has better performance than Non-Co-MP in terms of throughput as shown in Fig.5.

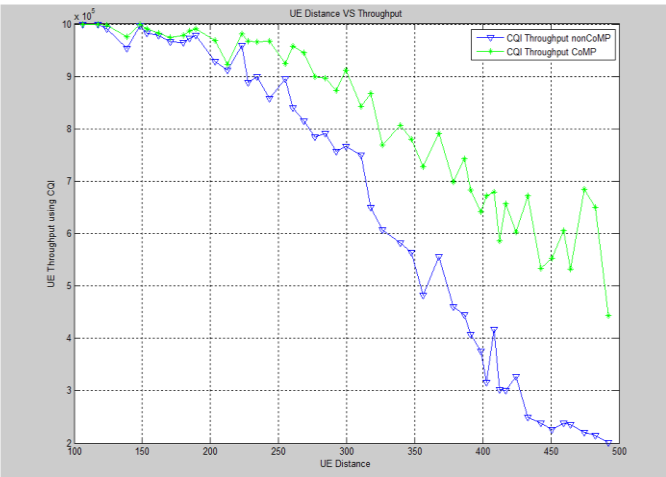

Figure.5. UE Distance versus throughput

The CDF of average per-user SINR, Spectral Efficiency, Throughput according to Shannon's formula and Throughput according to the CQI table, respectively. It is clear that in all these graphs, Co-MP-JT outperforms Non-Co-MP in terms of the mentioned parameters. This is a consequence and in accordance, to the previous results that showed these parameters as a function of average per-user distance since Co-MP-JT is always better than Non-Co-MP scheme as shown in Fig.6

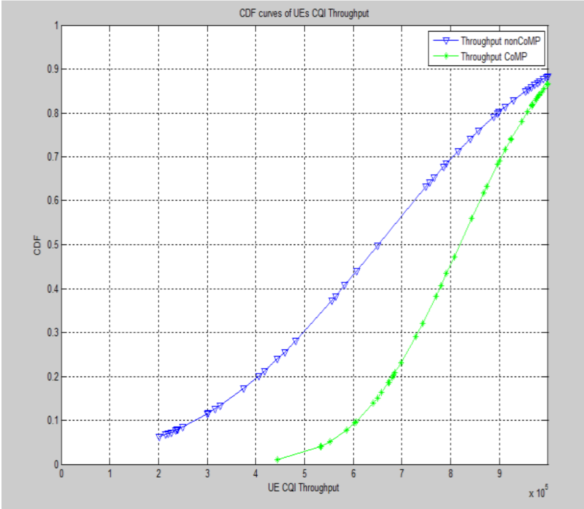

Figure.6. UE CQI throughput versus CDF

The CDF of average per-user SINR, Spectral Efficiency, Throughput according to Shannon's formula and Throughput according to the CQI table, respectively. It is clear that in all these graphs, Co-MP-JT outperforms Non-Co-MP in terms of the mentioned parameters. This is a consequence and in accordance, to the previous results that showed these parameters as a function of average per-user distance since Co-MP-JT is always better than Non-Co-MP scheme as shown in Fig.7.

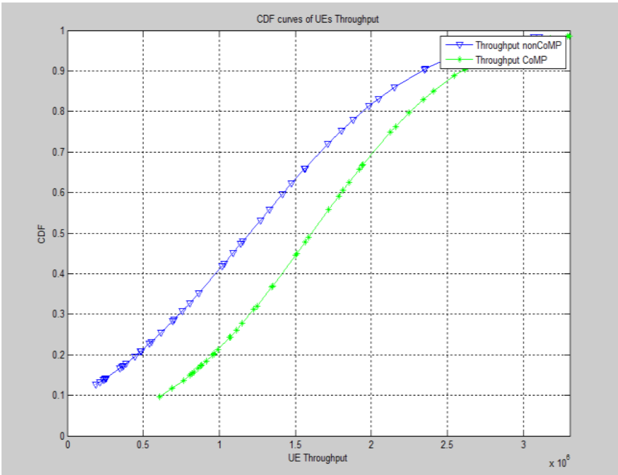

Figure.7. UE throughput versus CDF

Throughput is the maximum rate of production or rate at which something can be processed. In communication networks, such as Ethernet or packet radio, throughput or network throughput is the rate of successful message delivery over a communication channel. The data may be delivered over a physical or logical link, or it can pass through a certain network node. Throughput is usually measured in bits per second (bit/s or bps) and sometimes in data packets per second (p/s or pps) or data packets per time slot. The system or aggregate throughput is the sum of the data rates that are delivered to all terminals in a network. Throughput is essentially synonymous to digital bandwidth consumption; it can be analyzed mathematically by applying the queuing theory, the load in packets per time unit is denoted as the arrival rate (λ) and the throughput in packets per time unit, is denoted as the departure rate (μ). The throughput of a communication system may be affected by various factors, including the limitations of underlying analog physical medium, available processing power of the system components and end-user behavior.

V. CONCLUSION

The problem of improving cell-edge throughput of 4G/5G networks is an extensive area of research in both academia and industry. Co-MP has been proposed as an ICIC technique to solve the cell-edge problem, more than one base station coordinates in such a way they form a cluster which jointly transmits to users within it. It is found that Co-MP gives high SINR and throughput improvements compared to the conventional methods. The interesting fact is that this improvement increases as getting closer to the cell edge. Therefore, Co-MP is a very promising technique for improving the cell-edge throughput in 5G networks.

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