Downlink Joint Processing For Non Orthogonal Multiple Access

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ABSTRACT: *Cooperative communication is one of the emerging technologies that promise significantly higher reliability and spectral efficiency in wireless networks. It is a new form of diversity that allows users or nodes to share resources to create collaboration via distributed transmission and processing of messages. As candidate multiple access for future radio access, Non orthogonal multiple access (NOMA) over orthogonal multiple access (OMA) are adopted as downlink access scheme for future 5th generation mobile communication. In this paper, we compare user throughput when using orthogonal multiple access (OMA) and NOMA in macro femto network. We show through computer simulation the effect of imperfect interference cancellation on user throughput. We assist the performance of user selection when using fixed power allocation. Finally, we propose NOMA with COMP scenario whose performance improvement lead for user and cell throughput.*

Keywords: NOMA, JP, Heterogeneous

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1. Introduction

Heterogeneous Network (HeNet) is one of new technologies defined by 3GPP to improve LTE advanced network performance, it consists the deployment of macro cell with different cells such as microcells, femtocells, and picocells which enhance cellular network capacity [1].

Femtocells, also known as home eNodeB were first introduced in 3rd Generation Partnership Project (3GPP) Release 8, signaling that it had become a mainstream wireless access technology [2].

Femtocells promise improved indoor coverage and increased throughput for mobile data services while off-loading traffic from expensive macro radio access networks onto the low cost public Internet [3].

Femtocells access mode defines which user is allowed to use each femtocell. Two modes are defined, open access mode which every registered and unregistered user can access that femtocell but disadvantage of this mode is increased of signaling overhead. In the closed access mode only registered users are served by femtocell. Even femtocell provide higher signal quality than open access mode, the disadvantage of this type leads to high cross interference [4].

Figure 1 shows the HeNB architecture which consist of two main parts, the security gateway (SEGW) and HNB gateway (HNB-

GW). SEGW provides HNB with access to HNB management system (HMS) and HNB gateway, in addition to authentication of HNB, HNB-GW support HNB and UE registration [5].

Power control of HNB is interference management technique which mitigates interference to both macro user equipment (MUE) and home (femto) user equipment (HUE), it can be achieved by minimizing total transmission power of HeNB [6], [7]. The downlink transmission from HeNB will affect on nearby MUE when using co-channel deployment between macro and femto cell, strong interference from HNB may cause the received signal from macro to MUE degraded and unacceptable.

The enhanced Inter Cell Interference Coordination (eICIC) in heterogeneous networks is an efficient inter cell interference scheme compared to ICIC in LTE release 8 and 9 which that ICIC only consider data channels and didn't focus in interference between control channels [8], but in LTE release 10 solve this problem by two main solution, one in time domain multiplexing such as almost blank subframe (ABS), the other in frequency domain multiplexing such as carrier aggregation (CA).We show the performance of using ABS to mitigate HeNB interference[9].

The design of radio access technology (RAT) is one important aspect of improving system capacity. Radio access technology are characterized by multiple access scheme such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), or orthogonal frequency multiple access (OFDMA), which indicate how multiple users access and share the system resources [10].

Non orthogonal access code division multiple access (CDMA) is widely used in the 3rd generation mobile communication system. Orthogonal frequency division multiple access (OFDMA) is adopted in 4th generation mobile communication system e.g., LTE and LTE-advanced for achieving good system throughput.

As candidate multiple access for future radio access, Non orthogonal multiple access (NOMA) over orthogonal multiple access (OMA) are adopted as downlink access scheme for future 5th generation mobile communication.

In NOMA multiple users are multiplexed in power domain in base station (transmitter side) and in receiver side serial interference cancellation (SIC) are used to separate multiuser signals [11].

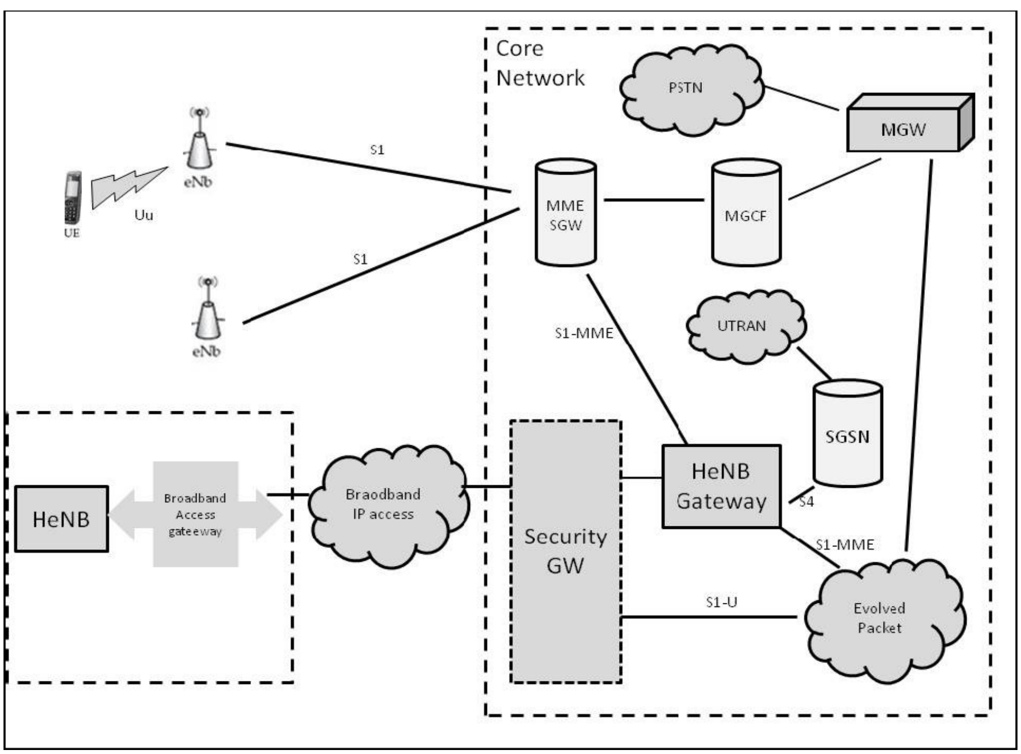


Figure 1. Femtocell architecture

Cooperative MIMO (Co-MIMO) technique also referred to as coordinated multi-point transmission (CoMP) has emerged as a key enabling technique to improve system spectral efficiency and effectively mitigate inter cell interference (ICI).

The cooperative transmission techniques involve two categories i.e. joint processing (JP) and coordinated beamforming (CB). Coordinated joint processing uses simultaneous transmissions of data from multiple transmission points to a single user in order to improve its received signal quality and actively cancel the interference from other cells. It involves sharing of data and channel state information (CSI). In coordinated beamforming, data for a single user is instantaneously transmitted from one of the transmission points; however, coordinated beamforming/scheduling is performed to reduce the interference caused to other cells [12].

In this paper we showed the effect of imperfect interference cancellation on user throughput when using serial interference cancellation in receiver side. We compare through computer simulation between two users selection schemes when using fixed power multiplexing allocated to users in transmitting side using non orthogonal multiple access. We showed improvement of using NOMA over OMA in heterogeneous network downlink. Proposed Joint Processing with NOMA scenario will be shown as the method which improves user and cell throughput. The remainder of this paper is organized as follow: NOMA concept described in section II. Mitigation interference scheme and COMP are described in section III and section IV, respectively. System simulation model are presented in section IV, followed by simulation results in section V. Conclusion of paper shown in section VI.

2. Non Orthogonal Multiple Access

NOMA is the one of the most promising technologies that it will play a central role in the 5th generation network. NOMA is a combination of OFDMA with superposition and interference cancellation techniques. It uses new path loss profile which utilizes pathloss difference for user multiplexing purposes and is proved more efficient than OFDMA.

2.1 NOMA Transmission

The basic concept of NOMA downlink as the eNB select two users have different channel gain and send two signals to each users but in different power allocation; figure 2 illustrates NOMA transmitter side where total power for any multiplexed two users is the same. User whose channel gain is better condition than the another user is allocated less power, so power allocated to each user and selecting two pair users affect not only to user throughput but also other user due to inter-user interference.

2.2 NOMA Receiver

At the receiver side, where user 2 has a better channel than user 1 and hence can decode any data that user 1 can successfully decoded. Using superposition coding scheme, user 1 treats signal of user 2 as noise and decodes its data from y_1. User 2, which has better channel, performs successive interference cancellation (SIC): it decodes the data of user 1 (treats its data as interference)

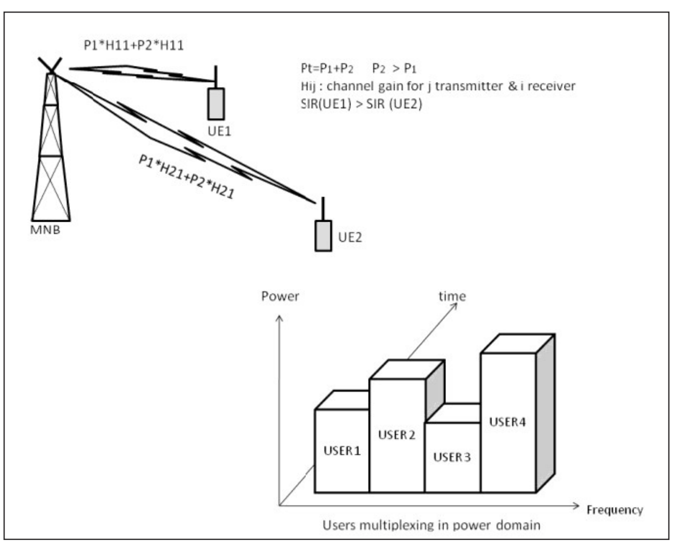


Figure 2. Illustartion of NOMA transmission side

and then proceeds subtract signal of user 1 from y_2 and decode its data, with each possible split power $P = P_1 + P_2$, [12], [13]. The following throughput of two users as:

$$R_1 = log_2\left(1 + \frac{P_1 |h_1|^2}{P_2 |h_1|^2 + N_{0,1}}\right) \quad (1)$$

$$R_2 = log_2\left(1 + \frac{P_2 |h_2|^2}{N_{0,2}}\right) \quad (2)$$

Where P_1 and P_2 are transmitted power for users i =1, 2. h_1 and h_2 are channel gain for two users, N is power of additive white Gaussian noise, R_1 and R_2 are throughput for two users. Figure 3 illustrates the receiver side of NOMA using SIC.

2.3 Imperfect Successive Interference Cancellation

In fact not all interference power is removed under cancellation; the parameter $\varepsilon \rightarrow [0, 1]$ gives the residual power of user after cancellation. The equation (2) after considering imperfect interference cancellation will be:

$$R_2 = log_2\left(1 + \frac{P_2 |h_2|^2}{\varepsilon_1 P_1 |h_2|^2 + N_{0,2}}\right) \quad (3)$$

Where ε is imperfect interference cancellation, $\varepsilon = 0$ for perfect interference cancellation. In simulation we show different values of ε.

2.4 Transmit Power Allocation

Due to power domain multi user multiplexing, the transmit power allocation (TPA) is important consideration in NOMA downlink, it affects the achievable throughput not only that user but throughput of system. In our simulation we compare between two transmit power allocated schemes, first used in [14], which called Pre defined user group and per group fixed

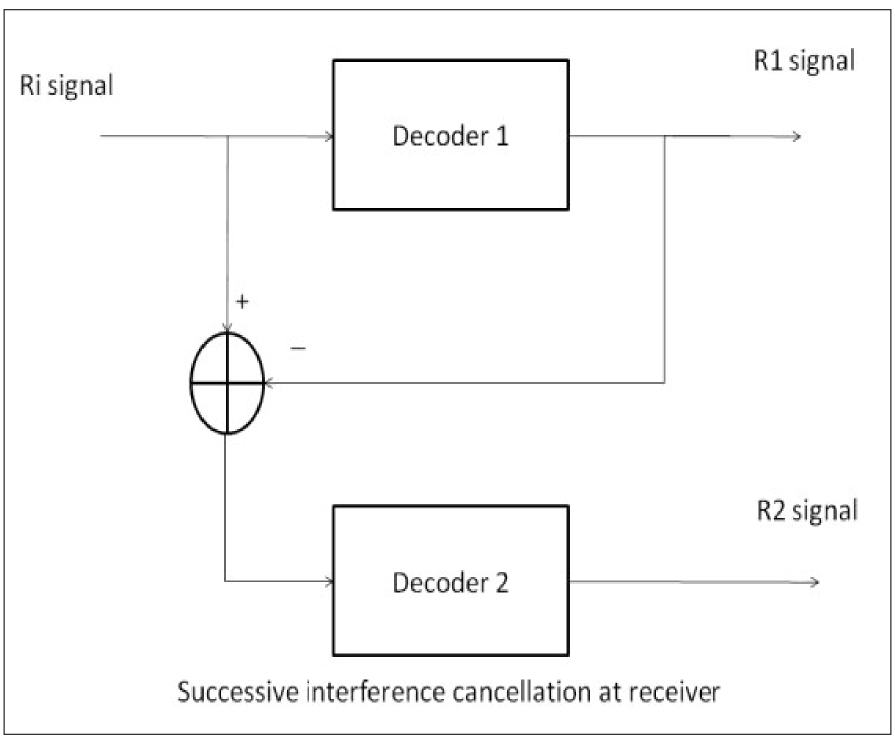


Figure 3. Illustartion of NOMA receiver side

power allocation (FPA) and our proposed scheme is user sorting power allocation. In first scheme, the users are divided into two different user groups according to their channel gains and pre defined threshold. In FPA, the users can be paired together only if they belong to different user groups. In the second scheme; user selection power allocated (USPA)

- PF scheduling sorting Users corresponding to maximum priority for each user.
- Users selected by PF are sorted in descending order according to their signal to interference ratio (SIR), so high SIR are the top of this list.
- Divided this list to two groups
- The users can paired together from different group (top of group 1 will be paired with top of group 2,etc)

3. Mitigation Interference Scheme

In heterogeneous network, when macrocell network operates on the same carrier as HeNBs, HeNB-macrocell interference can result degrading performance in some scenario, indoor.

MUE which can't be associated to HeNB due to presence of CSG (closed subscriber group) nodes, MUEs are affected by interfering signal coming from HNB, also MUEs close to building (near outdoor) may experience to interference then may lead to degrade signal to interference ratio. Inter femto interference is other interference will be taken account in our simulation, since due HUE can be associated to HeNB in the same apartment or macrocell, the interference comes from HeNB neighbor apartment may be strong. Two mitigation interference schemes will be used in our simulation; Autonomous power control method and enhanced ICIC in time domain which named as almost blank subframe (ABS).

3.1 Power Control

To limit the impact interference of femtocell on existing heterogeneous network, it desired to limit transmission power control of CSG HeNBs; we used method which described in [15]. The following equation represents the power control algorithm for HeNB

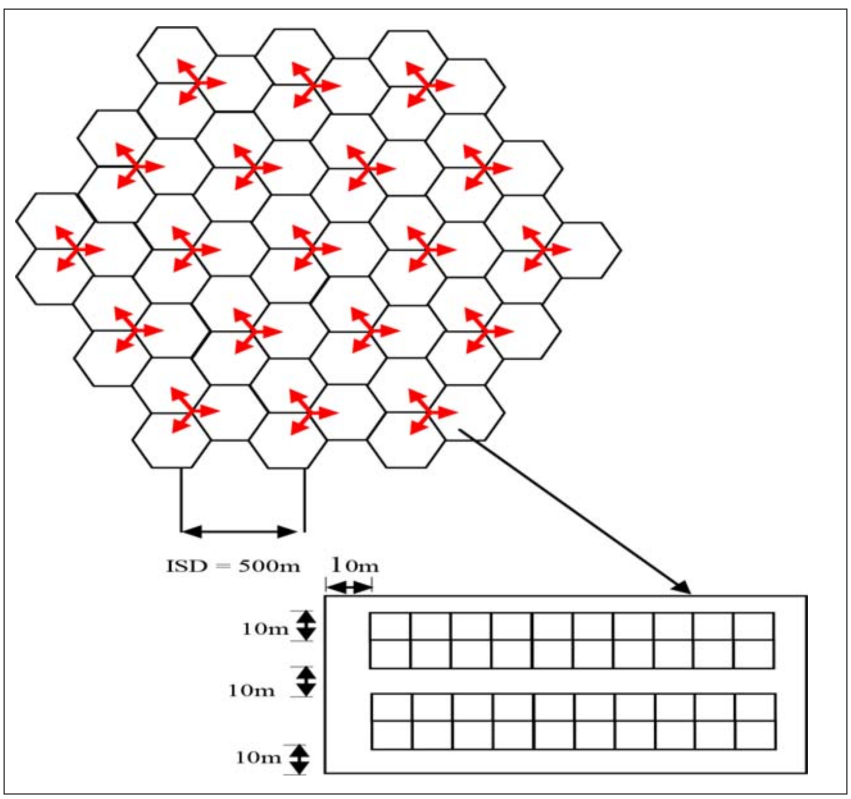


Figure 4. System simulation model

$$P_{TX} = max\ (P_{TX,\ min},\ min\ (P_{TX,\ max},\ P_{RX} + PL - \lambda)) \qquad (4)$$

Where P_{TX} is HeNB transmission power, $P_{TX,\min}$, $P_{TX,\ max}$ are the minimum and maximum transmission powers which values are -10 dBm and 20 dBm, respectively. P_{RX} is the power received from the strongest macro (MNB), PL is the assumed pathloss in dB, and λ is the target minimum C/I value in dB. The target is to minimize interference to macro network, while the pathloss determines the desired HeNB coverage; it should be set to maximum pathloss for any link between HeNB and its HUE in same apartment (the value in our simulation is 60dB)

3.2 Almost Blank Subframe (ABS)

The basic idea is to have some subframe which femtocell is not allowed to transmit data. This scheme is called Almost blank subframe (ABS), ABS is TDM (time domain multiplexing) scheme for enhanced inter-cell-interference coordination (eICIC). To alleviate this issue, subframe resources are split among macrocell and femtocell to improve reliability [15], it means that macrocell can use all resources but femtocell can use only half of all subframe.

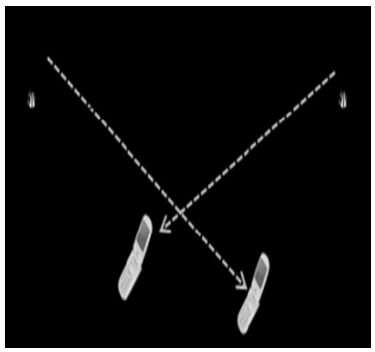
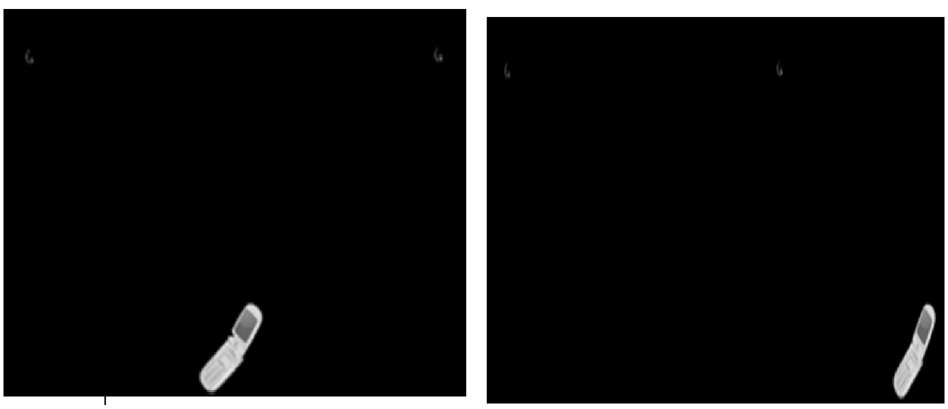


Figure 5. Coordinated Scheduling/Beamforming Scheduling



a) Joint Transmission b) Dynamic cell selection

Figure 6. Joint Processing

Although this scheme affect on indoor UEs which mitigate interference from HeNB when HeNB is silent, it also affect on outdoor UEs close building. In order for a UE to connect, it needs to first acquire the eNB and achieve synchronization. Figure 5 shows SIR achieved for indoor and outdoor in case of interference cancellation (IC) and without IC.

4. Coordinated Multipoint Transmission

Depending on whether the user data is shared among all the transmission points within a CoMP cluster, downlink CoMP transmission schemes can be divided into two main categories: coordinated scheduling/beamforming and joint processing.

4.1 Coordinated Scheduling/Beamforming Scheduling (CS/BS)

In CS/BS as shown in figure 5, user data is only available in one cell, and coordinated beamforming and scheduling is done between cells to reduce interference to other cells.

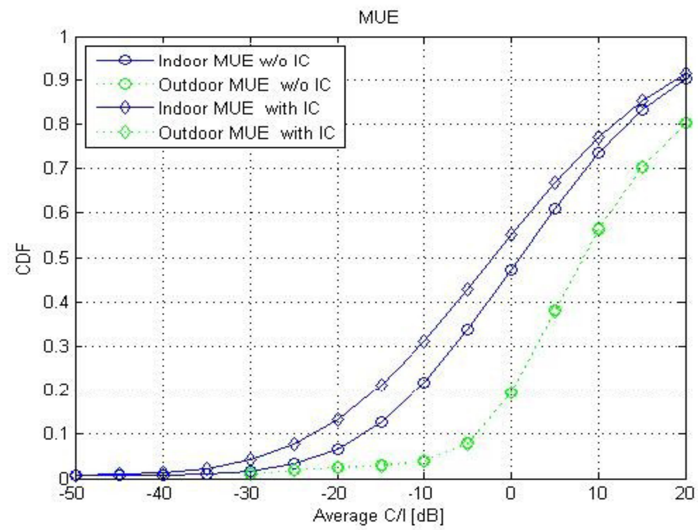


Figure 5. Average C/I for MUEs

4.2 Joint Processing (JP)

In joint processing approach, user data is available simultaneously at all transmission cells. JP is further categorized into Joint Transmission (JT) and Dynamic Cell selection (DCS) as shown in figure 6a and 6b respectively. In JT the same resource block (RB) of physical downlink shared channel (PDSCH) is transmitted from multiple cells among coordinated cells. In DCS, RB of PDSCH is transmitted from one cell among the coordinated cells. The unique cell is dynamically selected by fast scheduling where minimum pathloss is considered [16] and [17].

5. System Model Simulation

Simulation model is Macro-Femto cell deployment (heterogeneous network) which according to model described in [16] which some assumption and parameters used in simulation. We employed 19-hexagonal macrocell with an inter site distance (ISD) of 500m; each macro node cell site includes three cells with antenna boresights pointing in the three horizontal directions separated by 120 degrees. The system bandwidth is 10 MHz, it means 50 RBs (Resource blocks).Macro transmission power in each cell equal to 46 dBm.25 macro UEs are dropped randomly following a uniform distribution in each cell dropped within the cell site area. Dual strips model of HeNBs are randomly dropped in each cell, dual strips are composed of two building separated by one strip as shown in Figure. 4. A uniformly distributed is independently generated for each apartment.

HeNB and associated HUE are dropped in random location with minimum separation 3 m for each apartment, note that HeNB are assumed to be closed subscriber group (CSG) cells, we assume that both HeNBs and macro are synchronized in both time and frequency domain.

HUEs may associate to either its HeNB in its apartment or macrocell depending on received power, while MUE (macro user equipment) can only associate to MNB (macrocell), minimum distance between MNB and MUE is 35 m [15].

In our simulation we use 35% of MUEs are dropped indoor in random location. We assume two transmit antennas at the eNBs and two receive antennas at the UEs.

UEs are assumed to be served using transmission mode 4 (TM4) as described in the LTE terminology [6]. The maximum HeNB transmission power is 20 dBm.

The deployment configuration channel is co-channel for both macro eNBs and HeNBs; they share the same spectrum. 5ms reporting periodicity is assumed while mobile speed is assumed to be 3m/s. Proportional fair is downlink scheduler in our simulation that at each Transmission Time Interval (TTI), the user to be scheduled will be the one showing maximum priority, computed as follows:

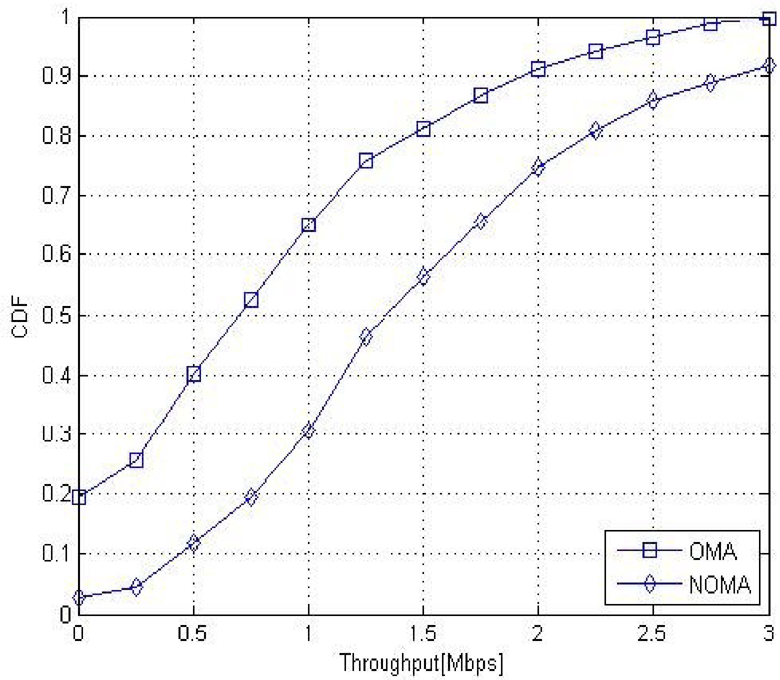


Figure 6. Comparison of user throughput between OMA & NOMA

$$R_{requeted} / R_{served} \quad (5)$$

Where $R_{request}$ is the instantaneous requested rate based on SINR and R_{served} is the average served data rate up to the previous TTI.

4. Simulation Results

We show in figure 6 comparison of cumulative distribution function for our heterogeneous network (macro and femto) model using orthogonal multiple access (OMA) and non orthogonal multiple access (NOMA) and see how NOMA boost user throughput comparing to OMA, this is because user throughput of orthogonal multiple access is limited by orthogonal bandwidth allocation. Figure 7 shows comparison between two schemes; Pre defined user group and per group fixed power allocation (FPA) and; user selection power allocated (USPA).Due to using high difference in channel gain USPA scheme lead improvement in user throughput than FPA.

7. Conclusion

In this paper, we evaluate LTE heterogeneous network (macro femto network) with closed femto cells. We assess performance of ABS (time multiplexing of eICIC method) that allows for a remarkable improvement of macro performance.

We proposed user selection with fixed power allocation scheme for NOMA downlink in heterogeneous network (USPA) and comparing with FPA scheme.

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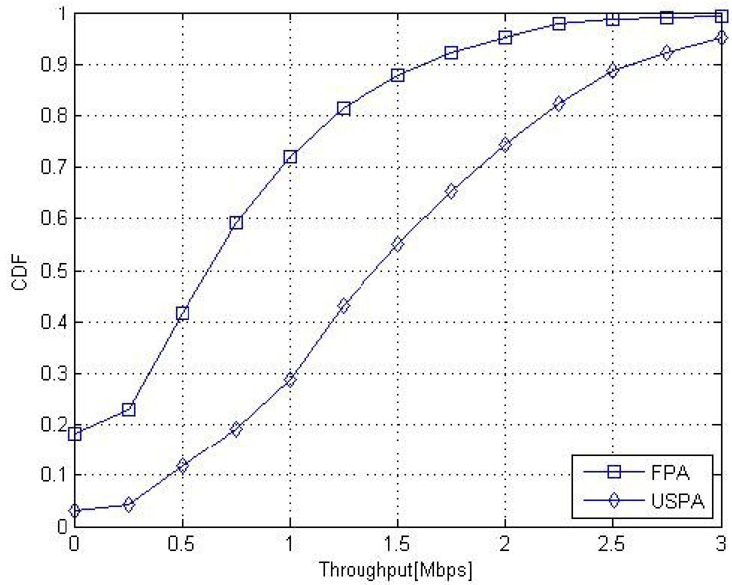

Figure 7. Comparison of user throughput between FPA and USPA

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