POWER ALLOCATION ON 5G HETROGENEOUS NETWORK

MSc Thesis

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This is certify the thesis entitled **"Power Allocation on 5G Heterogeneous Network"** summited partial fulfilment requirement of fulfillment of the requirement for the degree of **Master's** with specialization in **Communication and Networking**, the graduate program of the Department of **Electrical and Computer engineering**, has been carried out by **Samson Desta** Id. No **PGComW/008/10**, under my supervision. We recommend that the student has fulfilled the requirement of and hence here by submit the thesis to the department.

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DECLARATION

I, Samson Desta Koyamo. hereby declare that this final thesis is my original work and has not been presented for a degree in any other university, and all sources of material used for this project have been fully acknowledged and refrenced

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ABS	:	Almost Blank Subframe
BER	:	Bit Error Rate
CDF	:	Commulative distribution function
CSI	:	Channel state information
DoF	:	Degree Of Fredom
FPA	:	Fixed Power Allocation
FSPA	:	Full Search Power Allocation Scheme
FTPA	:	Fractional Transmit Power Allocation Scheme
HetNet	:	Hetrogenous Network
IoT	:	Internet of Things
ISI	:	Inter-symbol interfrence
MAI	:	Multipe Access Interfrence
MIMO	:	Multiple input multiple output
MBS	:	Main Base Station
MUE	;	Mainbase Station User equipent
NOMA	:	Non Ortogonal Multiple Access
OFDMA	:	Ortogonal frequency division multiple access
PBS	:	Pico Base Station
PD	:	Power Domain
PDF	:	Probability Density Function

QAM	:	Quarature Amplitude Modulation
QPSK	:	Quarature phase shift key
QOS	:	Quality of Service
RRHs	:	Remote Radio Head
RRA	:	Remote radio Allocation
RX	:	Reciver Side
SBS	:	Small Base Station
SE	:	Spectral Efficency
SIC	:	Succsusive Interfrence Cancelation
SINR	:	Signal to Interfrfrence Noise Ratio
Tx	:	Transmitter Side
UE	:	User Equipment
5G	:	Zero Forcing

ABSTRACT

Wireless communications providing very high system throughput, extremely increase system capacity, number of mobile terminal has exponexially increase in 5G wireless network. how to effectively improve the users throughput challenging concept without considering additional bandwidth ,variety technology including new multiplexing technique and heterogeneous network implement on 5G mobile generation. Non-orthogonal multiple access is one of promising multiplexing technique on 5G heterogeneous scenario, in a heterogeneous cellular network (HetNet), consider that a base station in the HetNet is able to simultaneously schedule and serve K users in the downlink by performing the power allocation on non-orthogonal multiple access scheme on intra-subcarrier. This research primarily focus on power-domain non-orthogonal multiple access that utilizes superposition coding (SC) at the transmitter and successive interference cancellation (SIC) at the receiver on HetNet downlink coverage, multiple users and the proposed different power allocation scheme. First, achievable rate and link throughput of N users in each subcarriers and number of available subcarrier to build a single cell and multi-cell create HetNet, show that the effect of different power allocation on single frequency band on multi users N and link throughput can be largely reduced, if transmit power allocations among the K users do not satisfy the edge users achievable rate. Next, evaluate different power allocation scheme fixed power allocation scheme, fractional transmit power allocation scheme and full search power allocation scheme, to find suboptimal power allocation scheme and low computational power allocation scheme. Finally numerical simulations are conducted to validate the performance proposed optimal downlink power allocation scheme that maximize the average throughput individual to achieve better achievable rate on different users on placed on variety of channel gain users on single subcarriers performance metric transmit power and achievable rate. Results show that the total throughput of the system has been significantly improved.

Keywords: non-orthogonal multiple access, ,quality of service, Base Station , multi user, fractional transmit power allocation,full search power allocation, fixed power allocation

1. INTRODUCTION

1.1 Background

Now a day’s wireless communication network has received significant interest in day-to-day activities and industry in human day to activities, which enhanced the development of the promising wireless networks, which can significantly improve the end user experience. The future wireless cellular network will provide high system throughput and SE via advanced future non-orthogonal multiple access technologies, which plays a vital role in determining the performance of future wireless technology. With the users of intelligent terminals and the development of mobile network business, the capacity of future wireless network must fulfill the stringent quality of service requirements. Hence, the future of mobile communication systems is facing challenges, mainly in the following two aspects.

A large number of UE connected to wireless network via limited resources, these resources are spectrum,time and power. The increasing rate of the number of latest device or modern mobile phone requiring mobile data services demand increase day to day, in reality the demand is increasing by 2 times with in. In the next 2 or 3 years, the data load will be five hundred up-to one thousand times more than it is now and there will have about sixty billion user terminal access to wireless networks in the world [1]. For future wireless communication the main concern is green communications has become an emerging need in the design of communication system, based on current situation information communication technology industry requires a low power or energy usage.

In report on information communication technology (IOT), Two percent of global greenhouse gases due the rapid improvement future wireless networks and the emergence of vast network end devices communication industry will consume a large amount of energy in the future [2]. Thus, different author to find the solution in above listed problem on wireless network, which should support higher throughput, lower latency, larger system capacity, and lower energy consumption on end device or different terminals [3]. The future wireless communication systems aim to improve the quality of service in future communication at different aspects. It will be expected to offer higher achievement related to system capacity , through put, and the capacity reach ten Tbps per square kilometer and over all data rate (multi-Gigabits per second), it under enhanced mobile broadband. Future mobile communication including 5G and 6G should also enable an ultra-high density or it support a lot of nodes in small area, ultra-low complexity, this state as different algorithm have their capability of complexity and energy consumption, which mainly supports the development of the Internet-of-Things (IoT) [4]. Specifically, internet of things gives an opportunity to realize smart cities, smart homes, long-range object tracking, etc. Besides, 5G should provide ultra-low latency (as low as a millisecond), ultra-high reliability (transmitted packet is extremely low and strong security [5], which helps to achieve mission-critical control such as autonomous vehicles, robotics, industrial automation, etc.

There are many technologies for realizing the 5G wireless communication system,

- such as massive multiple-input-multiple-output (MIMO) [5]
- millimeter wave [6]
- visible light communication(VLC) [7]
- Moreover, non-orthogonal multiple access

The paper focus on power allocation on down-link power allocation on the case of downlink transmission on non-orthogonal multiple access systems, and diffent users are placed on the same subcarrier share resource these like power, time and bandwidth on multi users. To find suboptimal power allocation scheme to achieve that multiple users on the same subcarrier can communicate with each other on various locations with in cell range and minimize the intercell interference.Multiple access technology not only determines the basic capacity of the network and the system complexity but also have a high impact on deployment cost of the entire . Traditional mobile communication systems, e.g. 1G-4G, adopts orthogonal multiple access technology, which including frequency division multiple access (FDMA), time division multiple access (TDMA), code division multiple access (CDMA), and orthogonal frequency division multiple access (OFDMA) [8, 9], to avoid multiple interference between users.

In 4G and other existing communication systems, the reason of the general use of orthogonal multiple access is to reduce the computational complexity of the transmission and the multiple access interference (MAI) due to different users are allocated to orthogonal power region within time, frequency or code domain in orthogonal multiple access technologies. From the viewpoint of multi-user information theory, orthogonal multiple access systems can reach the inner boundary of multi-user capacity region [10]. However, the orthogonal multiple access systems are not competent to support large-scale connections with different quality of service requirements.

The difference between the distance between two users can affect the whole target rate of users, because of the limited degrees of freedom (DoF), some users have near to base station or it said to be have better channel gain have higher priority and other users far from base station it said to be poor channel quality must wait to use available resource, which leads to more severe unfairness and longer delay or not satisfied user. In addition, when the degree of freedom is assigned to a user which having a far from base station user, the efficiency of previous multiplexing techniques for orthogonal multiple access systems is low [11] [12, 13].That is why we focus on non-orthogonal multiple access technologies, which have promising to address the challenge and achieve the requirements of 5G

1.2 Statement of the Problem

The main statement of the problem of the paper address different users are serving traffic at different channel gain unfairness resource allocation on assigned user on the subcarriers, it affect the quality of service on edge user on faded channel In the case of quality of service defined by the ratio of outage probability and a target rate. considering target rate $\widetilde{R_m^i}$ for each user m allocated in each subcarrier i, in our case user m (near from base station), and subcarrier i. Considering the channel state information, in this case outage probability for user m or far user on subcarrier i given by.

$$pr\{R_m^i \geq \widetilde{R_m^i}\} \geq 1 - \delta_m^i \tag{1.1}$$

In this case the achievable rate greater than or equal to target rate the value of 1 minus outage probability must be less than or equals achievable rate. The challenge is target rate is greater than achiveble rate, so it not fulfill Edge user throughput.

The achievable rate have the following requirement

$$R_m^i = \begin{cases} R_{m,m}^i \; if \; R_{m\rightarrow j}^i \geq \widetilde{R_n^i} \\ R_{m,j}^i \quad otherwise \end{cases} \tag{1.2}$$

The above formulation state that $R_{m,m}^i \; and \; R_{m,j}^i$ the achievable rate of user of user m in subcarrier i with channel state information and without signal interference cancelation respectively.

$$R_m^i = \log_2(1 + \frac{p_m^i |h_m^i|^2}{\sigma^2}) \tag{1.3}$$

User m in subcarrier i with the effect of signal interference cancelation.

$$R_{m,j}^i = \log_2(1 + \frac{p_m^i |h_m^i|^2}{\sigma^2 + p_m^i |h_m^i|^2}) \tag{1.4}$$

User m in carrier of i without effect of successive interference cancelation.

1.3 Objectives of the Research

1.3.1 General Objective:

The main objective of this research is to conduct the performance analysis power allocation techniques in 5G heterogeneous network.

1.3.2 Specific Objectives

- ❖ To analyze the performance of fixed power allocation and dynamic power allocation.
- ❖ Evaluate different power scheme.1. Fixed power allocation scheme 2. Fractional power allocation scheme three. Full search power scheme based on 5G downlink NOMA scenario system parameter achiveble rate and transmit power.
- ❖ To analyze low complexity suboptimal power allocation schemes for multiple users.

1.4 Thesis Contribution

To analyze the downlink NOMA power allocation scheme, to find best power allocation related to achievable rate and complexity perspective. Fixed power allocation scheme, fractional power allocation scheme and full search power allocation scheme the performance metric sum rate and transmit power the theoretical final output by MATLAB application software.

Moreover, show cell edge user throughput enhancement on the case of non-orthogonal multiple access in the case of power domain in down link scenario

1.5 Scope of Thesis

- To determine the system capacity between two multiple access technology (NOMA and OMA) will show the effect on over all system capacity.
- To determine and evaluate NOMA power allocation scheme on the case of downlink transmission on the case of single subcarrier on multiple users, these are these are different power allocation , equal power allocation and full ssearch power allocation scheme performance metric achievable rate vs transmit power with matlab code.
- To find low computional complexity power allocation scheme on the case of proposed power allocation.

1.6 Limitation of the Study

In this thesis focus only

- Downlink NOMA scenario
- Considering Performance comparison on three Power allocation scheme, 1.fixed power allocation scheme 2. Full search power allocation scheme 3.Fractional transmit power allocation scheme.
- Channel is time varying one or Rayleigh faded channel not consider other types of faded channel
- Theoretical evaluation based on 2018 MATLAB application software simulation

1.7 Thesis Organizaion

The thesis structure represent by six chapter.

The first chapter it explain introduction and general overview of 5G modern Non rtogonal multiple access multiplexing technique on 5G technology , statement of the problem, objective of the thesis, contribution,scope and limitation of the thesis. The rest of the thesis is organized as follows: Chapter 2 presents general concepts of power allocation on power domain on Hetrogenous network review, it explain different autour work , co-tier interference on HetNet scenario finally interference management on the case of one SBS and one MBS. Chapter 3 NOMA HetNet system model, performance evaluation of single carrier NOMA power allocation system, describe on optimal power allocation , Chapter Four: the performance comparsion for power allocation scheme for downlink NOMA and multipath fading channel and see rayleigh faded and rician faded channel and to see multi carrier NOMA system and working principle on successive interference cancelation and finally see performance evaluation metric on power allocation on HetNet related to spaectral efficiency and energy efficiency, quality of servie constrains, bit error rate and sum rate. Chapter Five gives simulation result and discussion related to capacity of HetNet, user paring , Bit error rate vs transmitted power, performance comparsion of three power allocation scheme and computional complexity. Last chapter provides the simulation results and discussion of power allocation scheme on Downlink NOMA over faded channel.

2. Review on Power Doman Heterogeneous 5G Network

2. 1 Power Allocation Heterogeneous Network Review

Heterogeneous Network(HetNet) is one of the most efficient solutions for achieving optimum spectrum , network efficiencies,high demand data rate and low power consumption of mobile terminal or mobile user, in terms of low power consumption of user means when mobile terminal is near to base station power consumption effect is decrease. Non-orthogonal multiple access technology on power domain- NOMA a lot of author made from that am try to review to frame the scope of the thesis and the existing problem [14], power allocation issues in NOMA systems. First they proposed trade-offs based power allocation which was higher power needs to be allocated to the far user and vice versa to improve bit error rate (BER) performance, minimize the interference and perfect SIC at near user. Then it ultimately reduces the overall capacity gain of the pair. Secondly, Conventional Power allocation was proposed which is once the power is allocated to the far user such that its target rate is satisfied; the rest of the power is allocated to the near user. But it's explored at high signal to noise ratio (SNR) the difference between the powers of both users become negligible which increases the mutual interference extremely.

In [15] , power-efficient resource allocation for multicarrier – non-orthogonal multiple access systems with quality of service constraints. A successive interference cancelation policy taking consideration of quality of service constraints requirements is proposed in their report to optimize the performance of Multi carrier- non-orthogonal multiple access systems.

In [16] , Uplink orthogonal frequency multiple access system by using an algorithm that attempts to maximize the sum throughput, with respect to orthogonal frequency multiple access, and power constraints.

In [17] , quality of service aware resource allocation scheme for multi numerology 5G networks. On different kinds of time and frequency domain in the case of scheduling techniques, which allocates packets to resource block to achieve higher spectral efficiency, maintain fairness, and satisfying the quality of service requirements of different users [18].

In [18], Power allocation issues in NOMA systems. First they proposed trade-offs based assign power which was higher power needs to be allocated to the far user and vice versa to enhanced bit error rate (BER) performance [14], minimize the interference and perfect successive interference cancelation at near user. Their investigation does not consider user paring mechanism is channel gain difference of the of pair of users. It affect the SIC of receiver.

Start from the above different autor literature review on power allocation on different technology. power resource allocation on downlink non-orthogonal multiple access on 5G heterogonous network scenario on Rayleigh faded channel and low complexity suboptimal power allocation schemes and to find better power allocation scheme on NOMA downlink scenario.

Heterogeneous network have referred to the deployment of different Base station within the same coverage area, while this paper address the “HetNet” indicates the heterogeneous deployment of 5G network where the regular High Power Cells (Macro cells) are overlaid by Low Power Cells, forming a multi-tier network or the concurrent function of main base station, femato base station, Pico base station termed as HetNet. Such implementation is used to increase network capacity as well as network coverage based on multi-level deployment scenarios. Furthermore, such types of network can improve both average and cell-edge users throughputs [19][27]

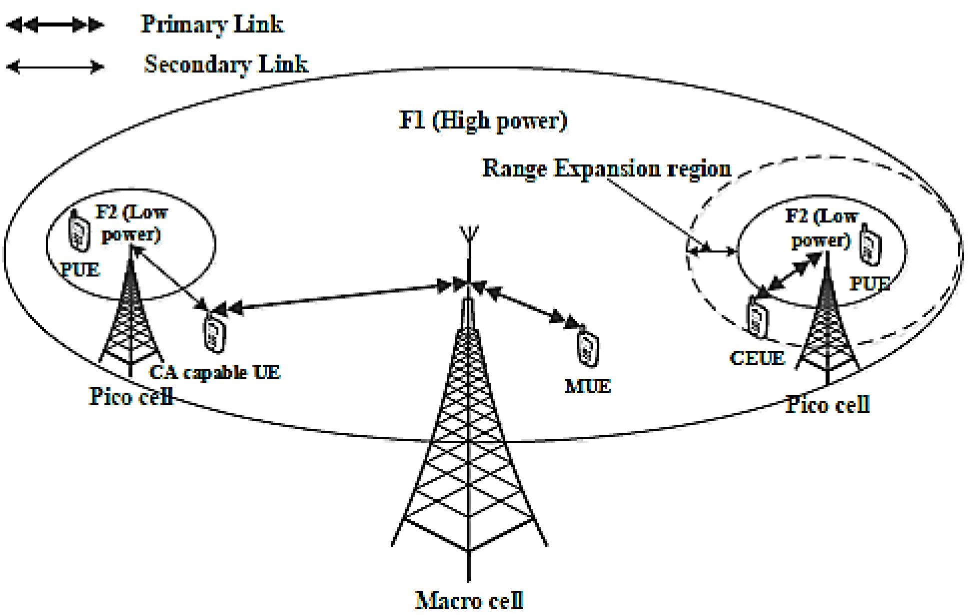

Figure 2. 1 Structure of HetNet

The component of HetNet, it include Micro cells, Pico cells, Femto cells, and Remote Radio Heads (RRHs), where the classification of cells is mainly based on transmit power, coverage area, physical size, and backhaul and radio propagation characteristics [20][28].

Seven types of cells are classified, where cell radius of type A and type B represent a Macro cell and Micro cell respectively.

Characteristics	***Femto cell***	***Pico cell***	***Micro cell***	***Macro cell***
Indoor/outdoor	Indoor	Indoor/outdoor	Outdoor	Outdoer
Number of user	4 to 16	32 to 100	200	200 – 1000+
Max output power	2 to 100mw	2500m W	2 to 100w	4 to 100w
Max cell radius	10 to 15m	200m	2km	10-40KM
Bandwidth	10mhz	20mhz	20 to 40mhz	60 to 75mhz
Technology	3G/4G/WIFI	3G/4G/WIFI	3G/4G/WIFI	3G/4G/5G
Backhaul	DSL,Cable fiber	Microwave	Fiber , microwave	Fiber , microwave

Table 1. 1 over view of HetNet [21]

The main aim of deploying Heterogonous networks are to offload data from the possibly congested Macro cells toward the LPCs, to achieve enhancements for outdoor/ indoor coverage, more spectrum reuse, and to increase the network throughput for cell-edge users. Moreover, it provides better link quality and low power consumption by reducing the path between the transmitter and the receiver [20] [28].

The concept of HetNet is introduced some disadvantage of deploying this network is interference between co-tier base station.

2.2 Co-tier Interference

Intercellular interference mitigation is one of the major challenge in heterogeneous network. Due to the scarcity of licensed spectrum resource, most of telecom vendors tend to reuse frequency on deploying small cell base station over licensed band that lead to severe intercell interference. Interference between main stations with small station is the major challenge of deployment of heterogeneous network, different method to eliminate the interference from different base station mobile user.

- Interferences coordination, the aim of this technique to deduct the effect of user terminals (UE), the base station advance using coordinated radio resource (i.e. frequency, time, power and space) management.

The subcarrier on main base station are licensed spectrum bands, the cross tier base station is scaled in our case is one Pico cell, are introduced. It degrade the signal to interference ratio of different main base station users and small base station users, for special case cell Edge user that have low signal to noise interference ratio to compare with near user, additionally small cells have lower coverage, it support limited number of users can associate with small base station, which is undesirable when macro cell are already overloaded, different mechanism to enhanced the coverages of small coverage on small base station scenario. Nevertheless, does not consider it in this paper. However, different paper propose this problem, the mechanism is called cell range expansion. This method is done by load imbalance this employees a range expansion bias that extends the coverage are of small base station without additional increasing their transmit power [34].Different mitigation technique to minimize co-tier interference Almost Blank Sub frame (ABS).

2.3 Interference Management

Heterogeneous network is the phenomena by which main base station mute some of its sub frames in order to allow user equipment in other base station (specially user equipment in cell range expansion area a) to do the data transmitted in those silenced subcarrier, i.e. by transmitting their data in a different time range than the main base station. Cell center user terminals can do their data transmissions using all the sub frames at any time, which makes the almost blank sub frame method specially targeted for cell – edge user equipment s. Moreover, the usage of for inter cell interference coordination, as time domain mechanism, also solves the cell edge interference problems that could not be addressed by using intercell interference in frequency domain. And since almost blank sub frame works in the time domain, all the neighboring base station which are in the same geographical area should be synchronized in time and phase to a small fraction of one micro second [22][35], as the duration of one sub – frame. In order to assist Pico downlink transmissions, each macro remains silent periods, termed Almost Blank Sub frames, during which a Pico-base station can transmit at reduced interference.

These sub frames are called ”almost blank” because a Main Base station can still transmit some broadcast control signals over these subframes.Since these control signals only occupy a small fraction of the orthogonal frequency multiple access subcarriers, the overall interference caused by Main Base station , in the Pico cell, is much less during these almost blank sub frame periods. Thus, the pico-base station can transmit to its user terminals at a much higher data rate during almost blank sub frame periods. It is important to note, a pico-base station can transmit to its user terminal s during non- almost blank sub frame periods, which can provide good enough performance to users terminal very close to the it [23][30]. The macro cell only need to stop transmission during almost blank sub frame sub frames to protect user terminals connected to the Pico cells that located on its edge.Pico-base station sends data to the type 3 user equipment during almost blank sub frame.

3. NOMA HetNet System Model

3.1 System Model

Downlink NOMA power allocation on 5G heterogeneous network, the concurrent operation of Macro, small, Pico and Femto base station is termed as heterogeneous networks (HetNets). The HetNet consists of a single macro cell overlaid with multiple Pico base stations intended to transmit data to multiple users. assumed that all the devices are equipped with a single antenna and experience independent and identically distributed (i.e.) Rayleigh fading. The channel bandwidth is distributed among main base station (MBS) and PBSs in such a way that MBS and PBSs are non-orthogonal to each other, while each PBS is orthogonal to other PBSs in the HetNet.

Next generation 5G wireless networks will run applications requiring high demand for data rates. One of the solution to solve the data rate requirement is to allow densification of network by deploying small cells.

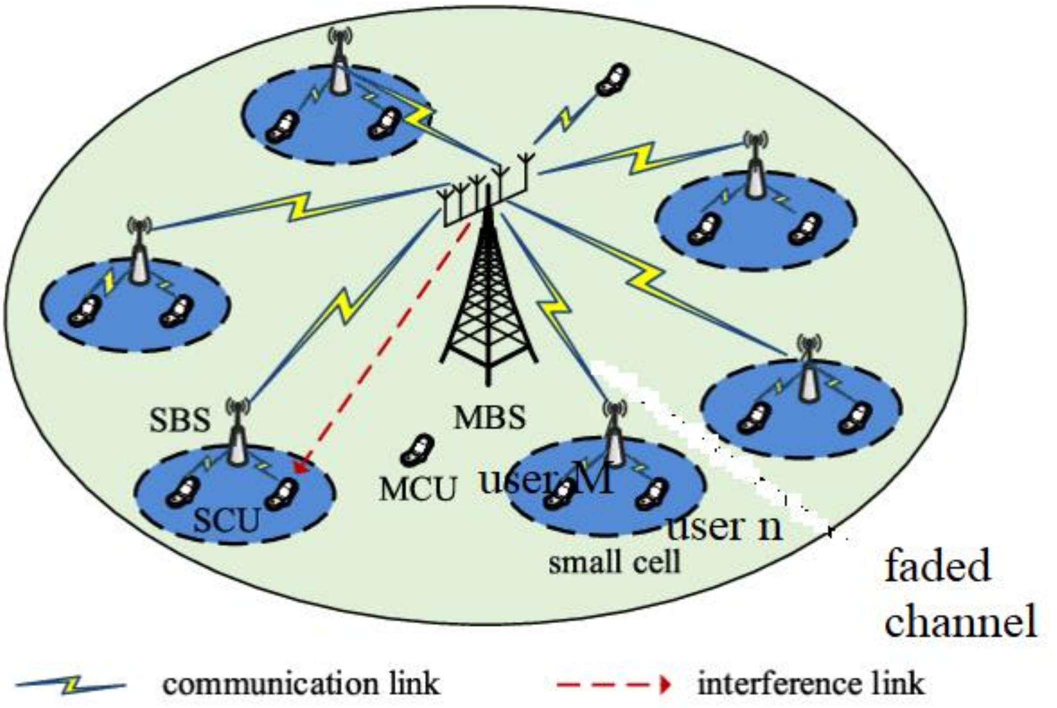

FIGURE 1. System model of a downlink NOMA heterogeneous network.

Figure 3. 1 Downlink NOMA HetNet Network

In this Paper, considering a two tier HetNet consists of one macro base station (MBS), and one small base station (Pico) is considered.

Where the non-orthogonal multiple access based downlink transmission is utilized and all base station are assumed to share the same frequency band, energy can be shared base station through smart grid. Moreover, let MBS and PICO (small base station) is a, b respectively. There is number of allocated users in this network, and each user equipment associated only one base station. All base station and user equipment is under single antenna not multiple input multiple output one.

Let assume that global channel perfect state information (CSI) is available, according to NOMA scheme [24] , [25]

- The superimposed signal transmitted by BS a ,

$$\boldsymbol{X_{a,b}} = \sum_{n=1}^{u_i} \sqrt{\boldsymbol{p_a \rho_{n,a}}} \boldsymbol{s_n} + \sum_{m=1}^{u_j} \sqrt{\boldsymbol{p_b \rho_{m,b}}} \boldsymbol{s_m} \tag{3.1}$$

where

$X_{a,b,n,m} \in \{0,1\}$ Is a binary user a indicator, i.e $X_{a,b,n,m} = 1$ when the m, nth user equipment is associated with the a, b BS and otherwise it is zero,

$p_a -$ Power allocation of MBS a, $p_b -$ power allocation of SBS b

In addition, the received signal can be can be experienced as follow

$$\begin{aligned}\boldsymbol{y_{a,b,n,m}} = &\sum_{mn,ab=1}^{N} \boldsymbol{h_{mn,ab}} \sqrt{\boldsymbol{p_{nm,ab} \rho_{nm,ab}}} \boldsymbol{s_{nm,ab}} + \\ &\boldsymbol{h_{mn,ab}} \sum_{n'm'=1,\ n'm' \neq, mn}^{N} \boldsymbol{x_{n'm',a,b}} \sqrt{\boldsymbol{p_{n'm',ab} \rho_{n'm',ab}}} \boldsymbol{s_{n'm',ab}} + \\ &\sum_{a',b'=1,\ a',b' \neq, a,b}^{N} \boldsymbol{h_{mn,ab}}^{\boldsymbol{a'b'}} \left(\boldsymbol{x_{a',b',n',m'}} \sqrt{\boldsymbol{p_{a',b',n',m',} \rho_{a',b'n',m'}}} \boldsymbol{s_{a'b',n'm',}} \right) + \\ &\boldsymbol{\omega_{a,b}} \quad [26]\end{aligned} \tag{3.2}$$

Inter-cell interference

Intera-cell interference

$\boldsymbol{x_{n'm',a,b}}\ \boldsymbol{x_{a'b',n'm'}} \in \{0,1\}$

Wr.

$\boldsymbol{h_{mn,ab}}$ = Channel coefficient on base station base station a, b

$\boldsymbol{h_{mn,ab}}^{\boldsymbol{a'b'}}$ = Interference channel coefficient on base station $a'b'$

$\omega_{a,b}$ = Additive white Gaussian noise

Time and frequency band, In this case the normalized channel gain for this case, corresponding channel to inter-cell interference plus noise ratios, as ordered as. According the successive interference cancelation near user from base station, remove intra-cell interference from data signal user n. On MBS, users m,n have different normalized channel gain, strong user have better normalized channel gain compare from far user, by this case this user satisfy targeted quality of user, but edge user have low normalized channel gain, their fore does not meet over all target QOS, there for power allocation scheme satisfy fair resource allocation

$$\boldsymbol{g_{i,k}} = \frac{|\boldsymbol{h_{ab\,,nm}}|^2}{\sum_{n\in u_b} \boldsymbol{p_{mn}} |\,\boldsymbol{h}_{\mathbf{a,b}\,,\boldsymbol{nm}}|^2 \boldsymbol{\rho_{ab,nm}} + \sigma^2} \tag{3.3}$$

The Power allocation of Users data signal in the a and b cell need to satisfy

$$\sum_{u=1}^{N} p_{nm,ab} = p_u \tag{3.4}$$

Where p_u is total transmit power of the m and n BS, such order is optimal for decoding and guarantee the user fairness. Namely, the data signals of users with weaker downlinks channel and large interface transmit power to achieve more transmit power to achieve the desired quality of service.

$$\mathbf{0} < \boldsymbol{p_n} < \boldsymbol{p_m} \tag{3.5}$$

For special case

The inter cell interference is single base station scenario is zero, and data rate after success interference cancelation at U user terminal is given by

$$\mathrm{R_{ab,nm}} = \mathrm{W}\ \log_2(1 + \mathrm{SINR_{ab,nm}})$$

where: - W is system bandwidth

The overall signal interference noise ratio (SINR)

$$SINR_{nm,ab} = \frac{P_{nm,ab}\left|h_{mn,ab}\right|^2}{\left|h_{mn,ab}\right|^2 \sum_{n'm'=1,}^{N} P_{n'm',ab} + \sum_{a',b'=1,\ a',b'\neq a,b}^{N} \left|h_{mn,ab}{}^{a'b'}\right|^2 P_{a',b'} + \sigma^2} \tag{3.6}$$

Where

$P_{a',b'}$ = total transmit power of a', b' Base station.

SINR for user n on MBS On subcarrier I,

$[\alpha_{b,i}]_{M\times N}$ Is as sub charrier indicator matrix for the small cell where, $\alpha_{b,i} = 1$ denoted that subchannel n is assigned to the small cell s,

$$SINR^{a}{}_{n,i} = \frac{P_{n,i}\left|h^{a}{}_{n,i}\right|^2}{\left|h^{a}{}_{m,i}\right|^2 \sum_{m=1}^{N} p^{a}{}_{m,i} + \sum_{b,=1,\ b\neq a}^{N} \sum_{u=1}^{N} p^{a}{}_{m,i}\ \alpha_{b,i} p^{b}{}_{u,i}\left|h_{m,i}{}^{b}\right|^2 + \sigma^2} \tag{3.7}$$

where

$h^{i}{}_{m,a} -$ channel gain on subcarriers i from Main BS (a) to main UE n

$p^{i}{}_{na} -$ Power allocation user n on MBS on Subcarrier i

$P_{n',a} -$ Power allocation user n' on MBS on subcarrier i

$p^{b}{}_{u,i} -$Assigned power to the uth power in small cell a on ith subcarrier i

$P_{n,i} -$ Transmit power allocation from MBS to MUE n on subcarrier i.

Considering that the main Base station and Small base station knows the perfect channel state information and are connected by wired links [26]. According Shannon capacity, the data rate of small Base stations (b) to small base station users (m, n) on subcarrier i,

$$SINR^{b}{}_{n,i} = \frac{p^{b}{}_{n,i}\left|h^{b}{}_{n,i}\right|^2}{\sum_{u=1}^{N}\left|h^{b}{}_{u,i}\right|^2 p^{b}{}_{m,i} + \sum_{b,=1,\ b\neq a}^{N} \sum_{u=1}^{N} P_{n,i}\ \beta_{b,i} p^{b}{}_{u,i}\left|h_{l,n,i}{}^{b}\right|^2 + \sigma^2} \tag{3.8}$$

where

$\left|\boldsymbol{h_{l,n,i}}^{\boldsymbol{b}}\right| - channel\ gain\ on\ the\ link\ n\ from\ MBS\ to\ SUE\ n\ in\ subarriier\ i$

$[\boldsymbol{\beta_{b,i}}]_{\boldsymbol{M\times N}}$ −As subband indicator matrix for main base station user MUE, where $[\beta_{b,i}]_{M\times N}$ denote that subchannel i is assigned to MUE, HetNet Network the main concern is to maximize the sum rate of macro base station and small base station sum rate. When the sum rate of each base station increase and increase the overall spectral efficiency of the system.

$$EE_{SBS} = \frac{R_S}{P_{SBS}^T + P_{SBS}^C} \tag{3.9}$$

Where

EE_{SBS}, energy efficiency of small base station.

P_{SBS}^T, total power consumption of small base station.

P_{SBS}^C, Total power consumption of a circuit.

In the case of total power consumption on small base station is the sum of total power consumption of users, total power consumption of subcarrier in base station and and power consumption of small base station.

Matimatically

$$P_{SBS}^T = \sum_{u=1}^{U}\sum_{i=1}^{I}\sum_{sub}^{SUB} \alpha_{u,sub} p_{u,i}^{sub} \tag{3.10}$$

In this, case, number of small base station one therefore; the total power consumption of small base station is reduced to

$$P_{SBS}^T = \sum_{i=1}^{I}\sum_{u=1}^{u} \alpha_{u,sub} p_{u,i} \tag{3.11}$$

3.2 Power Allocation in Downlink NOMA

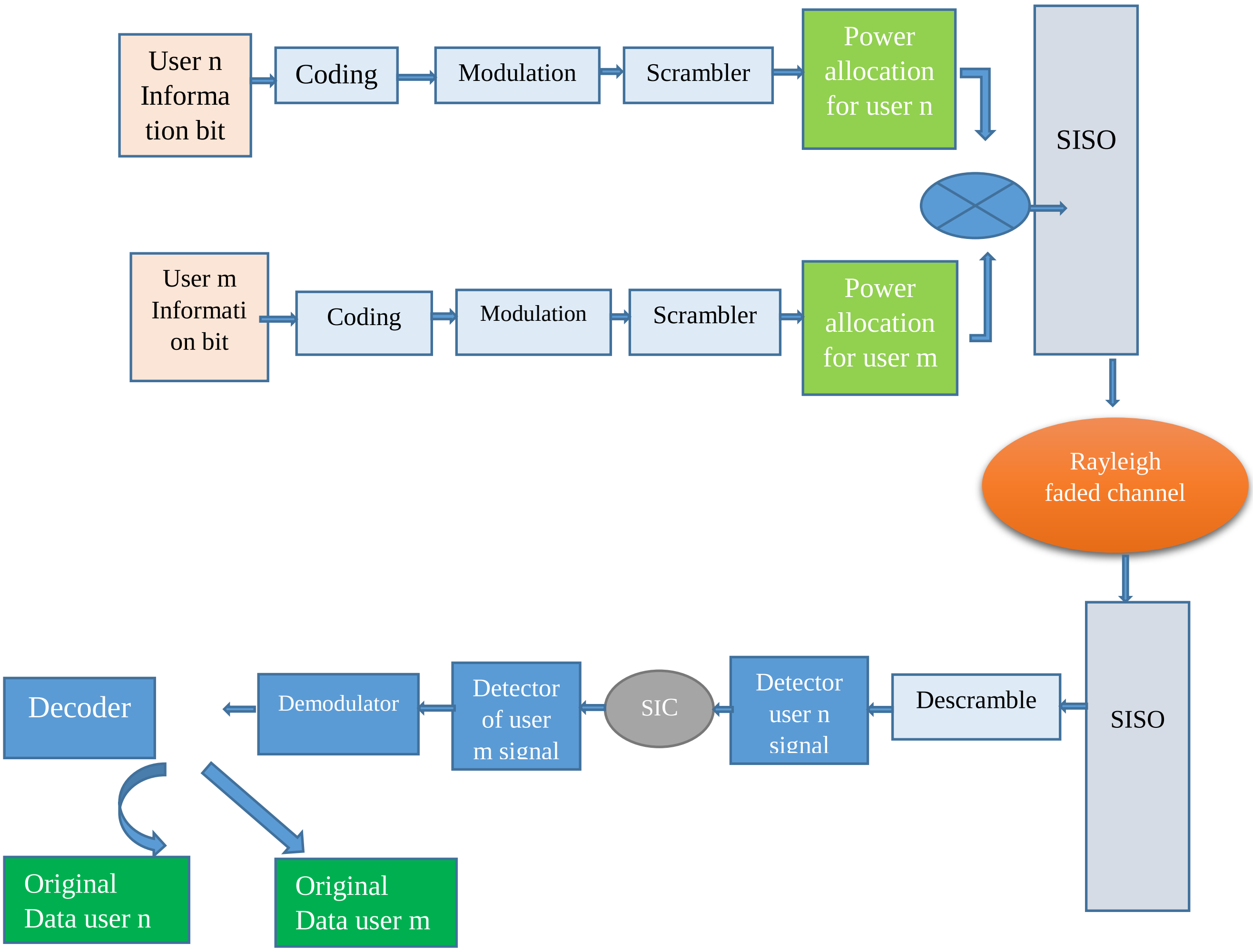

Figure 3. 2 System Design of Downlink NOMA

Power resource allocation in downlink non-orthogonal multiple access communication scenario with one subcarrier with two users are considered. In this part channel state information is ideal, assumed that far user (m) and near users (n) are paired together for non-orthogonal multiple access scheme as an illustration. In this work, there are two users on each subcarrier since the number of paired users are multiplexed on the same subcarrier result in receiver terminal side growth of hardware complexity and processing delay. Therefore,

- The case of two users per subcarrier is studied in the system model.
- User N is closer to the BS compared to User m, which implies User n has a better channel condition comparing to User m.

PD NOMA assign different powers for different users according to the users' channel condition or based on channel gain on the same subcarrier. In order to realize the power domain NOMA system, the user scheduling algorithm at the base station by applying superimposed coding (SC) and perform the signal interference cancellation detection at the receiver or user terminal side to separate the user signals from each other.The total system bandwidth of base station is equally divided in to N sub channel. Where the bandwidth of each sub channel.

$$BW_i = {}^{total\ BW}/_{N} \tag{3.12}$$

Superpose coding is one of type of coding system in 5G wireless network, that perform multiplex number of symbols in power domain [19], where a symbol is an output from a multi-level symbol mapper, such as quadrature amplitude modulation (QAM) [14] or Multiplexing of symbols in power domain make tendency to enhanced capacity of communication system with out of spend additional system bandwidth. At the mobile terminal side or RX side, in one channel, different power level of symbols are required to successfully detect each superimposed symbol with high probability.

An illustration of superposition coding for a two-user system is provided in Fig. where a 16-QAM symbol of the second user is superimposed to a 16-QAM symbol of the first user.

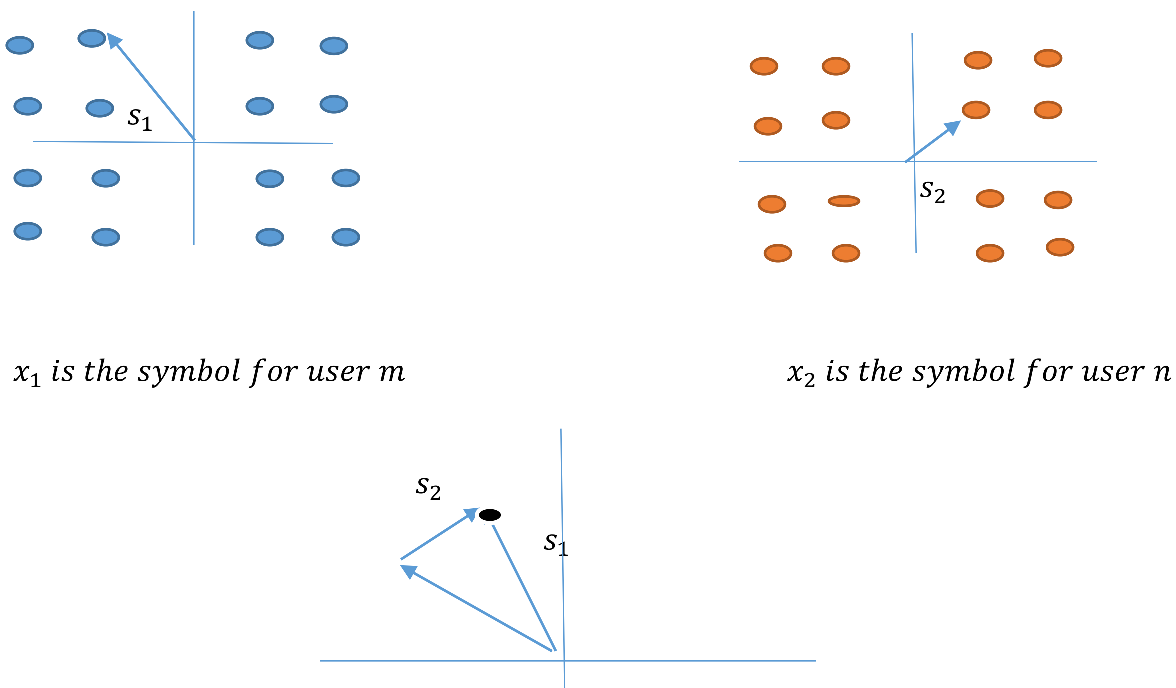

Figure 3.3 Superpose Modulation Technique

For multi-user cellular communication systems, a proper power control can be performed at the transmitter, such The Base Station optimizes the transmit power for each user on each subcarrier. In particular, instead of allocating all the power to one User, User n with stronger channel condition is allocated less transmitted power and more transmit power is allocated to User m. Compared to conventional orthogonal multiple access, User m is allocated with non-zero power which provides certain fairness in resource allocation.

Assigning User 1 with less power leads a small decrease in its capacity but a significantly good effect on two. Therefore, user pairing and power allocation are able to strike a balance between the system performance and resource allocation fairness.

3.3 Single Carrier NOMA Power Allocation System

The superpose coding is a ways of simultaneously communicating information to several receivers by a single source[3] or it allows base station to transmit more than one user on the same subcarrier and time. The base station transpose transmitted users symbol on to make superpose coding practical the transmitter must encode information applicable to each user, In the case of two-user non orthogonal multiple access scenario, Base station will have to contain two encoders that point to point map their respective inputs to complex-valued sequences of the two-user signal. Demonstrates schematic diagram how SC performed, where the quadrature phase-shift keying (QPSK) constellation of user 1 with higher transmitting power superposed on that of user 2 with lower transmitting power. It describe that superpose coding is a recognized non-orthogonal scheme that attains the capacity on a scalar Gaussian broadcast channel.

In this case, two-user assign in one subcarrier is called single carrier NOMA system.

$$x = \sqrt{p_n} s_n + \sqrt{p_m} s_m \tag{3.14}$$

Where

$p_n - transmit\ power\ for\ user\ n\ on\ symbol\ n$

$p_m - transmit\ power\ for\ user\ m\ on\ symbol\ m$

$The\ assigned\ symbol\ is\ restricted\ by\ p_n\ and\ p_m\ is\ not\ greater\ than\ 1$

In addition, the received signal in user terminal side

$$y_i = h_i x + v_i \tag{3.17}$$

where $h_i - channel\ cofficient$

$x - transmitted\ signal$

$v_i - additive\ white\ guassian\ noise$

$v_i - CN(0, \sigma^2)\ guassian\ noise\ zero\ mean\ and\ unit\ variance$

Assume that user m is week user because user m is far from the base station or the cannel gain of user m is worst and user n is close to base station this implies user n have better channel gain, Thus implies user m is more power assign by base station and user n is less power assign by base station $p_m > p_n$ by use of NOMA protocol. Considering that the users' channels between the base station and users are followed the Rayleigh fading channel gain, which are h_1 and h_2 respectively.without loss of generality, we denote the power allocation for user n and user m as ${a_n}^2$and ${a_m}^2$ respectively, Where ${a_m}^2 + {a_n}^2 = 1$. Note that $a_m \geq a_n$ holds since $|h_m|^2 \leq |h_n|^2$ due to the principle of NOMA, Thus, the rates achieved by these two users are given by:

The rate achieved by Edge user (m)

$$R_{\mathrm{m}} = \log\left(1 + \frac{|h_1|^2 {a_{\mathrm{m}}}^2}{|h_1|^2 {a_{\mathrm{n}}}^2 + \frac{1}{\rho}}\right) \quad [19] \tag{3.18}$$

The rate achieved by near user (n)

$$R_{\mathrm{n}} = \log(1 + \rho |h_1|^2 {a_1}^2) \tag{3.19}$$

where $R - rate\ of\ users\ n\ and\ m$

$\rho - transmit\ SNR$

3.4 Optimal Power Allocation

Non-orthogonal multiple access satisfy fairness of resource and in user terminal side successive interference cancelation decoding order is implemented. The decoding order is based on users channel state information. Non-orthogonal multiple access have some limitation in some points.. The power allocation in terms of user's fairness resource allocation, we try to see by two assumptions. 1. base station with perfect channel state information :- In this case the user data rate based on their channel gain, SIC order is work based on channel gain. 2. base station with average channel state information

In this, case the user data rate based on target rate. On the other hand, user fairness is achieve by their achievable data rate. Instantaneous channel state information at the base station cell edge user resource allocation to achievable data rate, resource fairness is main point in this topic.Non-orthogonal multiple access enable an enable management of the users achievable rate and it create best opportunity to create user fairness among different users. Non-orthogonal multiple access optimal power allocation system used to achieve uses fairness among users. It create the best opportunity on Cell Edge user.

- Maximizing user rate
- Improve quality of service of edge user

In this part different optimization problem related to in the case of average channel state information. The resource allocation optimization problem is formulate to maximize the sum rate of two user ,non-orthogonal multiple access system formulation and the solution then generalized to the multiuser case. if two users are multiplexed over the S- threshold block, using NOMA principles, then the achievable rate by the user with the higher (n) channel conditions is as given in (1) and the user with the low (m) channel conditions is as given in (2), and (3) give their sum rate over that RB.

In the case of partial channel state information, the user is not fully knows channel information, In this case, some error signal add in to a system, to maintentain this issue user target target rate. In order to guarantee each user achievable data rate, different author work on optimization on optimization problem.

Mathematically, the problem of the two-user scenario formulated as

$$\underset{(P_n^{(i)}, P_m^{(i)})}{Maximize} \tag{3.20}$$

$$where\ R = \sum_{i=1}^{i} R_i$$

The sum rate of all resource block is the summation of overall sum rate of each subcarrier. The power allocation on the same two-user case our first assumption power allocation is fixed between users maximize

where $R \rightarrow$ is the sum rate of all resource block?

$$subject\ to\ \sum_{i=1}^{S}(P_n^{(i)}+P_m^{(i)}) \leq p_t \tag{3.21}$$

Power allocation on user n and m on subcarrier i must be less than or equal to total power assigned for base station to subcarrier i.

- ❖ Positive allocated power on both user is $(P_n^{(i)}+P_m^{(i)})$ depend on maximum allowable power p_t

Power allocation on user m or user n on subcarrier i less than or equal to zero.

$$(P_i^{(n)}, P_i^{(m)}) \leq 0, \qquad \forall s \tag{3.22}$$

Minimum rate proportionality constant for users $n\ and\ m$. It helps to maintain proportionality

Between the minimum achievable rates of the users.

$$\sum_{i=1}^{s} R^n : \sum_{i=1}^{S}(R^m) = \quad \emptyset_{min}{}^1 = \ \emptyset_{min}{}^2 \tag{3.23}$$

Where the resource block higher channel level or the user nearest BS is user n and the user far from BS or Edge of cell user m.

where

$$(P_n^{(i)}) - power\ allocation\ user\ n\ on\ subcarrier\ i$$

$$P_m^{(i)} - \ power\ allocation\ user\ m\ on\ subcarrier\ i$$

R: $-$ *Denotes the sum rate over all the RBs, and given by*, , $\sum_{i=1}^{s} R_i$,

Consternate 1 and 2 are to gurante a postive allocated power and limited by Maximum allowable , In addition, the minimum rate proportional fairness constraint (3) is to control the achievable throughput by all users where

$$\emptyset_{min}{}^{\mathrm{m}} = \ \emptyset_{min}{}^{\mathrm{n}} \tag{3.24}$$

Where minimum rate requirement for user m and user n respectively., Constraint helps to maintain proportionality between the min achievable rates of the users. In other words, the proportionality guaranteed for the minimum achievable rates, but the rate obtained in the solution is not restricted to this ratio, as long as the minimum rates for all users are satisfied. It is important to point out that by using the proportional fairness constraint.Once the minimum rates for all users are. Satisfied, the remaining resources will also be allocated in a proportional manner. Such approach is important to maintain fairness in distributing the radio resources among these users and to ensure that the weak users have enough power to decode their own data from the received signal while treating the stronger users as noise, and to ensure that the stronger users have enough power to apply successive interference cancelation and cancel the effect of the weak users and detect their own data. Thus, this constraint is vital especially for power domain non-orthogonal multiple access system to help in maintaining power domain multiplexing of the users (i.e. To establish SC). Without this constraint, the maximum sum rate could easy achieved by allocating all the bandwidth and power to one user or a few users who have the best channel conditions and not all users will be allowed to transmit, and thus no fairness would be established among the users. In addition, another important property of this constraint is that it can utilize the potential advantage of Non-orthogonal multiple access over orthogonal multiple access. The minimum rate requirement is assigned to each user based on the large-scale fading factor (the distance based path loss and the lognormal shadowing factor) experienced by that user in addition to the small-scale fading effects. Since path loss and shadowing is more dominant and vary slowly, the proportionality constraint is therefore effectively more on a long-term basis rather than short-term basis.

4. Performance Comparisons for Power Allocation Scheme in Single NOMA System.

4.1 Downlink Power Domain NOMA

Matimatical model this paper focus on , to assess the performance of Power allocation scheme on downlink NOMA for typical configurations of multi-user on the access on single base station and multiple cell scenario systems without precoding at the base station, which is possible independently of the NOMA power allocation policy, different users are clustered into single subcarrier at different power level used at each terminal to separate the NOMA user’s signals. The interference between paired user in the same sub carrier is called intra cell interference is mitigated by signal interferences cancelation in receiver side.

The total available capacity of base station or bandwidth granted to serve users is divided over a constant number of subcarrier or sum rate of single subcarrier capacity.every subcarrier is then attributed a fraction of the available transmit power that the base station is allowed to use. In transmit side before superpose signal defend power allocation scheme. from this fixed power allocation is the simplest way to divide the power among sub carrier since it minimize the process of scheduling complexity.

Different paper already published regards to dealing with non-orthogonal multiple access consider this repartition [27] [28] , subcarrier frequency scheduling on the case of down link non-orthogonal multiple access under wide area cellular system configuration.Non-orthogonal multiple access power allocation perform the amount of power attributed to a subcarrier is at the same page on all subcarrier under BS and power repartition with in subcarriers, on different paired users is done as a at different level by using different kinds of power allocation scheme.In [29], the overall system performance and throughput improvement using non-orthogonal multiple access at base station the superposition of users on top of an uplink orthogonal multiple access -based system is studied. In [30], a non-orthogonal multiple access in the case of multiuser beamforming system is proposed for improving the system capacity. Degradation in the sum capacity due to inter-cluster interference and inter-user interference is already add to noisy channel in our case the channel is Rayleigh faded channel, leading to a clustering and power allocation algorithm that aims at reducing interference and improving system capacity.

User clustering is by forming select 4 users to be paired in the same subcarrier,beamform based on channel gain & the paired users must have large channel gain difference it become high correlation, In addition, resource is sharing is one of the main function of base station, this resource is subcarrier ,power ,time and bandwidth , power is equally divided between clusters, in addition power allocated among scheduled users in each cluster, in such a way to maximize the sum capacity, while guarantee a minimum capacity for the weakest user.

This paper presents and analyses a downlink non-orthogonal multiple access on single input single output system with users grouped in one clusters and with processing removing the inter-user interference cancellation by signal interference cancelation (SIC) algorithm. Numerical results are presented for two users per one cluster with assumed modulation type binary phase shifted (BPSK) modulation. With non-orthogonal multiple access(NOMA), the limited spectrum resources can be fully utilized to support more users or in single subcarrier different user access in single subcarrier by assigning different power level, therefore the capacity of 5G networks can be improved significantly even though extra interference, assume two users have different channel condition, first user good channel condition or user n and the second user bad channel condition or user m. considering channel coffined matrix $H_1\ and\ H_2$ with $user\ n\ and\ user\ m\ respectively$ and the channel is Rayleigne faded channel and signal interference cancelation algorithm is interpret in reciver side.

Power domain on non-orthogonal multiple access technology assign different power to different user based on the same subcarrier their channel gain, the user-scheduling algorithm at the TX side by superimposed coding (SC) and perform the signal interference cancelation detection at RX side to minimize interference and separate symbol that comes from transmitter side. Proper power control can be performed at transmitter (Base station), The total system capacity or bandwidth is equally divided in available N subcarriers where the bandwidth of each sub channel

$$BW_i = \frac{Total\ BW}{N}\ [22] \qquad (4.1)$$

where

$$BW_i - each\ subcarrier(i)$$

$$N - is\ available\ subcarrie, \qquad U_1 - (n, m \ldots .\ u_n)$$

Non-orthogonal multiple access serve users simultaneously in a same subcarrier, different users are serve a single subcarrier and users placed on variety of distance from base station, How m.uch users support in a single subcarrier on achiving their target rate., How much users support a single subcarrier at fulfill target of quality of service pared users on chapter five. Different user paring mechanism,

- ❖ Near near user and Far far user paring
- ❖ Near user with far user paring.

Near near user and far user paring: - in this case, both near user paired with near user and Far user paired with far user, by this scenario another thing is, the advantage of N-F pairing over N-N-F-F pairing is due to the careful selection of users who will suffer from interference. Clearly, N-F scheme provides interference free reception to both the near users (assuming perfect SIC), in contrast to the N-N-F-F scheme, which provides interference free transmission to one near user and one far user. Therefore, N-F gives better sum rate. Nevertheless, when the noise is dominating the interference power, the choice of users who suffer from interference does not make much of a difference. Both schemes are expected to give the same performance.

Matimatical sum rate on nearest to nearest paired user

The first user paring on a given subcarrier.

$$R_1^{Nf} = \frac{1}{2}\log_2(1 + \frac{P\alpha_1|h_1|^2}{\sigma^2}) \tag{4.2}$$

$$R_2^{NN} = \frac{1}{2}\log_2(1 + \frac{P\alpha_2|h_2|^2}{P\alpha_1|h_2|^2 + \sigma^2}) \tag{4.3}$$

$$R_4^{Nf} = \frac{1}{2}\log_2(1 + \frac{P\alpha_4|h_4|^2}{P\alpha_1|h_4|^2 + \sigma^2})$$

The second user paring, on two different user paring scenario

$$R_3^{NN} = \frac{1}{2}\log_2(1 + \frac{P\alpha_3|h_3|^2}{\sigma^2}) \tag{4.4}$$

$$R_2^{Nf} = \frac{1}{2}\log_2(1 + \frac{P\alpha_2|h_2|^2}{\sigma^2})$$

$$R_4^{NN} = \frac{1}{2}\log_2(1 + \frac{P\alpha_4|h_4|^2}{P\alpha_3|h_4|^2+\sigma^2}) \tag{4.5}$$

$$R_3^{Nf} = \frac{1}{2}\log_2(1 + \frac{P\alpha_3|h_3|^2}{P\alpha_2|h_3|^2+\sigma^2})$$

According to the NOMA protocol, multiple users can be allocated to the same sub carriers with signal interference cancelation technique.a block-fading channel is considered in the system model and it is the same for each user per one sub-carrier but it varies independently across different sub channels.depend on system parameters and limitation of the system, 5G base station needs to assign more than two users in each subcarriers with at different power coefficient on each subcarrier.considering multiple users are allocated on all subcarrier in base station but our focus area assigning two user in the same subcarriers, the symbol transmitted by the BS on each subcarrier can be expressed $X_i = \sum_{u=1}^{u_n} \sqrt{p_{u,n}} S_u$ and the recived signal $y_u = H_u x + n_u$, In our case $u = 2$ user n and user m, and the total recived signal $y_u = H_u(\sum_{u=1}^{2} \sqrt{p_n} S_n + \sqrt{p_m} S_m) + w_u$.

4.2 Power Allocation Strategy

In this section evaluate different power allocation coefficient on the case of downlink non-orthogonal power allocation on transmitter side, the main aim this power allocation to determine edge users quality of service by use of finding best fit power allocation technique, Let have two users on subcarrier on i,these are user m and n and placed on different distance from base station and user m quality of service can still degrade by their poor channel conditions.

1st scenario.

The main target of design of power allocation coefficient are to realize its target data rate for each channel realization. Assuming that the user m meet quality of service requirement, in this case user m target rate is greater than user m normal achievement rate of user m.

$$p_{m,i}^{o} = p\,(\log_2(1 + SINR_i) < R_m) \tag{4.6}$$

where

$p_m^o -$ The outage probability of user m

$R_m -$ over all achievable rate for user m

This implies user m is not satisfy quality of service.

Second scenario:- In this case, assuming user m achieve quality of service requirements instantaneously, then the power allocation coefficient are defined are defined to ensure that the targeted data rate of user m, the target rate of user m is less than the achievement rate of user m on the single subcarrier i**.,** The outage probability occur when the user m target rate less than or equal to the achievement data rate of user m, $p_{m,i}^{o} = p\,(\log_2(1 + SINR_i) \geq R_m)$ **,** The signal to noise to interference ratio on subcarrier me

$$SINR_{k,i} = 2^{R_m} - 1 \tag{4.7}$$

From this formula, can develop power allocation coefficient. ,the power allocation coefficient must be satisfied β_n on multiuser U_N.

$$(U_1\ ) = \begin{cases} \beta_N^i \gamma_1, -\sum_{n=1}^{N-1} \beta_n^i \gamma_1 \geq \min \nabla P \\ \beta_{N-1}^i \gamma_1, -\sum_{n=1}^{N-2} \beta_n^i \gamma_1 \geq \min \nabla P \\ \quad\quad\quad\quad . \\ \quad\quad\quad\quad . \\ \quad\quad\quad\quad . \\ \quad\quad \beta_2^i \gamma_1, -\beta_1^i \gamma_1 \end{cases} \tag{4.8}$$

$\min \nabla P$- is the minimum power difference threshold that can ensure reliable interference cancellation the receiver., For multiple user in the same subcarriers.

$$U_{N-1} = \beta_N^i \gamma_{N-1}, -\sum_{n=1}^{N-1} \beta_n^i \gamma_{N-1} \geq \min \nabla P \tag{ 5}$$

Proposed power allocation scheme on inter carrier allocation scheme

1. Full search power allocation scheme
2. Fractional power allocation scheme
3. Fixed power allocation scheme

4.2.1 Fixed Power Allocation Scheme (FPA)

The power is divided between the users on a certain sub band according to a linearly power is divided between pair of users on subcarrier i based on a fixed threshold.

- A fraction of sub channel power p_i is allocate single user and remaining power allocate on other user.

Power allocation for first or user n is , $\boldsymbol{p_{n,i} = \alpha p_i}$ and Power allocation for second the second user or user m $\boldsymbol{p_{m,i} = (1-\alpha)p_i}$

where

p_i- Fixed ratio remain uniform for all subcarrier.

The value of α should be less than or equal to 0.5 so that the power p_{in} attributed to the user n with the highest channel gain on subcarrier i is always less than or equal to the power p_{im} attributed to the user with the lowest channel gain. α Should be optimized prior to the power allocation process and it is fixed throughout it., signal to interference noise ratio for near user n on subcarrier i. $SINR_{i,n} = \frac{p_{i,n}g_{i,n}}{1+p_{i,m}g_{i,n}}$ and signal to interference noice ration for far user (user m) on subcarrier of i, $SINR_{i,m} = \frac{p_{i,m}g_{i,m}}{1+p_{i,n}g_{i,m}}$. In this case both In this case the power allocation in both users m,n are equal so $p_{m,i}\ and\ p_{n,i}$ are equal so, near user or user n can have better SINR compared to far user, fixed power allocation does not fulfill target rate of far user achiveble rate or throughput.

4.2.2 Fractional Transmit Power Allocation Scheme (FTPA).

It used for the multiplexed pair of users, which provides a suboptimal solution, Power allocation under consideration of channel gain of scheduled user. It is more complex than fixed power allocation scheme.

Power allocation far user (m) on subcarrier i, Case one: two users in the same subcarrier i

$$p_{i,m} = \frac{\frac{|h_{i,m}|^{-\alpha}}{N_O B/i}}{\frac{|h_{i,m}|^{-\alpha}}{N_O B/i} \frac{|h_{i,n}|^{-\alpha}}{N_O B/i}} \times p_i \tag{4.10}$$

The simplified form of power allocation user m on subcarrier i is written as,

$$p_{i,m} = \frac{|h_{i,m}|^{-\alpha}}{|h_{i,m}|^{-\alpha} + |h_{i,n}|^{-\alpha}} \times p_i \tag{4.11}$$

Power allocation coefficient on user m on subcarrier i on the case of multiuser scenario. $p_{i,m} = \frac{|h_{i,m}|^{-\alpha}}{\sum_{u=1}^{U} |h_{i,u}|^{-\alpha}} \times p_i$, Power allocation factor $=\frac{|h_{i,m}|^{-\alpha}}{|h_{i,m}|^{-\alpha} * |h_{i,n}|^{-\alpha}}$, when the value of α increase it means channel gain for user it become decrease, α - Fractional quantity of power ranging from zero to 1.it control the amount of power each user

- ❖ Power allocation near user (n) on subcarrier i

$$p_{i,n} = \frac{\frac{|h_{i,n}|^{-\alpha}}{N_O B/s}}{\frac{|h_{i,n}|^{-\alpha}}{N_O B/s} + \frac{|h_{i,m}|^{-\alpha}}{N_O B/s}} \times p_i \tag{4.12}$$

Simplified form of power allocation on near user n on subcarrier i.

$$p_{i,n} = \frac{|h_{i,n}|^{-\alpha}}{|h_{i,n}|^{-\alpha} + |h_{i,m}|^{-\alpha}} \times p_i \tag{4.13}$$

Multi user case on the same subcarrier, and power allocation scheme , $p_{i,n} = \frac{|h_{i,n}|^{-\alpha}}{\sum_{u=1}^{U} |h_{i,u}|^{-\alpha}} \times p_i$ Moreover, signal to noise interference ratio written as

$$SINR_{i,n} = \frac{p_{i,n} g_{i,n}}{1 + p_{i,m} g_{i,n}} \tag{4.14}$$

$$SINR_{i,m} = \frac{p_{i,m} g_{i,m}}{1 + p_{i,n} g_{i,m}} \tag{4.15}$$

In this case near user the amount of $p_{i,n}$ is less than $p_{i,m}$ due to the value of channel gain of $|h_{i,n}|^{-\alpha}$ is high or the distance between user to base station is less.

4.2.3 Full Search Power Allocation Scheme (FSPA)

In the non-orthogonal multiple access in the case of non-orthogonal multiple access downlink system, There are multi users are multiplexed on the same sub carrier i. By this process considering a multiplexed pair in sub channel c, all possible set of power levels regarding the channel conditions of each pair is produced leading to choose the best set of power levels based on the performance gain of the system.

The algorithm of FSPA 1st consider and cheek the amount of user available in that base station, Then listed user is sorted based on their channel gain at a given BS or category the available user in their channel gain.

Let this iteration $N = 1$ listed pair user based on their channel gain, the paring users with better channel condition with bad channel condition users. After paring, the removed pared users removed.

Let this iteration $N = 2$, in this level compare the channel gain for the unpaired user from iteration $n = 1$ and pair bad channel condition user to good channel condition user.

Iteration for $N = 3$, in this in this level compare the channel gain for the remains user or unpaired from iteration $n = 2$ and pair bad channel condition user to good channel condition user.

- A search among all possible power repartitions and chooses the repartition that results in the highest achieved throughput.
    - During searching, process, all possible β are considered.
    - In this paper, considering five possible β , searching process that result better throughput.

Let consider four user in one subcarrier.

1 *Intialized match users* Let $u_s = 4$, let $\forall$ SCi ε 1

2 *Intialized prerefrence* list $\forall\ s_i\ \varepsilon\ 1,\ \ \forall\ U_i\ \varepsilon\ 4$

3 List out user channel gain g_i

4 Find higher channel gain users and less channel gain users, $g_{i1} = V1$, $g_{i2} = V2$, $g_{i3} = V3$, $g_{i4} = V4$.

5 Find user pairing based on their channel gain, when, $g_{i1} > g_{i2} > g_{i3} > g_{i4}$

6 Min difference between g_{i1} and g_{i2} is not less than 0.35.

7 Assign different power allocation factor α_{ui} all users U, p_i on subcarrier i

8 Check and compare all p_i value at specific power allocation factor , and finally chose

9 Better users pairing and power allocation

Power allocation technique how to select user on the same sub carrier or how to pair user in subcarrier i fixed power allocation and full search power allocation work helps us find the best pair of users to be multiplexed by non-orthogonal multiple access, & verify whether the increase in the channel gain difference is always in favor of non-orthogonal multiple access in terms of achieved throughput. In order to carry out this analysis, we consider the case where the channel gain difference between multiplexed users or to select pair of user by channel gain difference.

$$d = h_{i,n}^2 - h_{i,m}^2 \tag{4.16}$$

$$h_{i,n}^2\text{- } Channel\ gain\ on\ subcarrier\ i\ to\ user\ n$$

$$h_{i,m}^2 - \ Channel\ gain\ on\ subcarrier\ i\ to\ user\ m$$

Channel gain difference (d) must be increased. This implies channel gain for far user decrease and channel gain for near user decreased, In the case of fixed power allocation , Its fixed value of power allocation p_i or on the same subcarrier two-paired user $p_{i,m}$ and $p_{i,n}$ are constant on regardless of two users. The rate calculation of near user or have better channel gain. The rate calculation when near user (n) channel gain increase and rate of the user n increased well. In addition, decrease the channel gain rate of the user also decreased. Therefore, in fixed power allocation at different channel gain uses fixed amount of energy this effect the overall performance of cell edge user.

4.3 Multipath fading channel

In wireless communication environment, channel model is one of the the major part of data transmission and our signal is highly affected phase and amplitude of the signal. This affect by rapid fluctuation of wireless communication [26] , Shows that rhea signal propagate from transmitter to receiver passing through free space propagation. During this propagation takes place, transmitted signal is degrade their performance by reflection, refraction and scattering of the signals [31].In wireless communication our system channel mainly affected by faded environment, in this paper we try to focus on Rayleigh faded channel.

4.3.1 Rayleigh fading channel

Rayleigh faded channel is one of major type of fading environment in city areas with many infrastructure related to high building, cars and huge building transmitted signals arrive at the receiver over multiple paths. A Rayleigh fading channel occurs when there are many different signal paths between the base station and mobile terminals. It means all the paths will fluctuate and influence the overall signal at the receiver [32], the impulse response is modeled as a zero-mean, complex valued, Gaussian process, the envelope of $c(\tau;t)$ at any instant t is Rayleigh distributed and the phase is uniformly distributed in the interval (0,2π). In this case, the channel is said to be a Rayleigh fading channel. This is the simplest fading channel from the standpoint of analytical characterization

$$c(\tau;t) = \sum_n \alpha_n(t) j^{-j2\pi f c \tau_n(t)} s_1(t-\tau_n)) \text{ [22] [33]} \tag{4.17}$$

where

$c(\tau;t)$ Is the response of the channel at time t due to an impulse applied at time t – τ.

$\alpha^2 : - a\ chi - squared\ distribution$

The non-line of sight fading channel PDF of the in RX side or user side received signal envelope $p(r_o)$ is given by:

$$p(r_o) = \frac{r_o}{\sigma^2} \exp\left(\frac{{r_o}^2}{2\sigma^2}\right) when\ r_o > 0 \tag{4.18}$$

where

$r_o: - is\ the\ envelope\ amplitude\ of\ the\ received\ signal$

$\sigma^2: -is\ the\ variance\ of\ the\ random\ variable$

$2\sigma^2: -\ is\ the\ average\ power\ of\ the\ multipath\ signal$

In a non-line of sight fading channel, α in equation 2.3 is Rayleigh distributed and α^2 has a chi-squared distribution. Accordingly, γ_b is also a chi-squared distribution [34]. Therefore, the probability density function of the instantaneous signal to noise ratio is given by:

$$p(\gamma_b) = \frac{1}{\overline{\gamma_b}} e^{\frac{-\gamma_b}{\overline{\gamma_b}}} \quad \gamma_b \geq 0 \tag{4.19}$$

$\overline{\gamma_b}$ Is the average signal to noise ratio (SNR) per bit?

$$\overline{\gamma_b} = \frac{E_b}{N_o} E(\alpha^2) \ and \ \ E(\alpha^2) \ is \ the \ avaerage \ value \ of \ \ \alpha^2 \tag{4.20}$$

4.3.2 Rican faded channel

The second type fading channel type is Rican fading one, the main focus parts is line of sight communication between TX and Rx terminals, This path is strongest path compared from Rayleigh faded channel because the signal is transmitted under line of sight., The effect of Rican fading on the transmitted signal will be less than on compared to Rayleigh fading [35]. the impulse response is different from Rayleigh faded with unit variance and zero mean complex value Gaussian process when the signal with In this instance, the envelope of $c(\tau; t)$ has a Rice distribution. Hence, the channel is referred to as a Rican-fading channel. The Rican PDF of the received signal envelope is given by:

$$p(r_o) = \frac{r_o}{\sigma^2} \exp\left[\frac{{r_o}^2 + A^2}{2\sigma^2}\right] \ i_o\left(\frac{r_o A}{\sigma^2}\right) \ f \ or \ r_o \ when \ r_o \geq 0, A \geq 0 \ [32] \tag{4.21}$$

where

A: - $is \ the \ peak \ magnitude \ of \ the \ line \ of \ sight \ signal \ component.$

$i_o(*) - is \ the \ modified \ Bessel \ function \ of \ zero \ order$

In Rican fading channel, the K factor is one of the inputs that defines the ratio of the power of the line of sight component and the multipath components, $k(rician\,factor) = Power \ of \ line \ of \ sight \ \ component \ /Power \ of \ non - line \ of \ sight \ component$,Start when power of line of sight is deceased or reach to zero the Rican K factor is zero or Rican K factor increase also increase line of sight component, In a Rican fading channel, the probability density function of the instantaneous signal to noise ratio is given by

$$p(\gamma_b) = \frac{1 + K}{\overline{\gamma_b}} \left(exp^{\frac{-\gamma_{b(1+k)} + K\overline{\gamma_b}}{\overline{\gamma_b}}} \right) i_o \left(\frac{-\gamma_{b(1+k)} + K\overline{\gamma_b}}{\overline{\gamma_b}} \right) \tag{4.22}$$

This can be represented as the power in the faded envelope that has been produced by the means of X and Y. A Rican-fading channel is described using two parameters: Rican K-factor , The total power of direct (LOS) path & the scattered paths $s^2 + 4\sigma^2$, The above two parameters are used as inputs. The Rican K factor and the total power of the dominant & scatter components are given. Therefore, it is imperative that we must formulate the means and variances of the Gaussian distribution from the given Rican K factor.

Let us define s and σ. Such that they satisfy the equation $s = \frac{K}{K+1} * (s^2 + 4\sigma^2)$ and sigma $\sigma = \frac{total\ power}{\sqrt{2(K+1)}}$

4.4 Multicarrier NOMA system

In this scenario the base station have a lot of resource from that sub carrier are the one, NOMA concept start from our limited resource is available bandwidth without increase available bandwidth increase overall system performance by assigning in the same subcarrier in different user based on their channel gain [36]. In multicarrier NOMA in downlink case, Base station assign resource for different users or K users. M subcarrier in K user

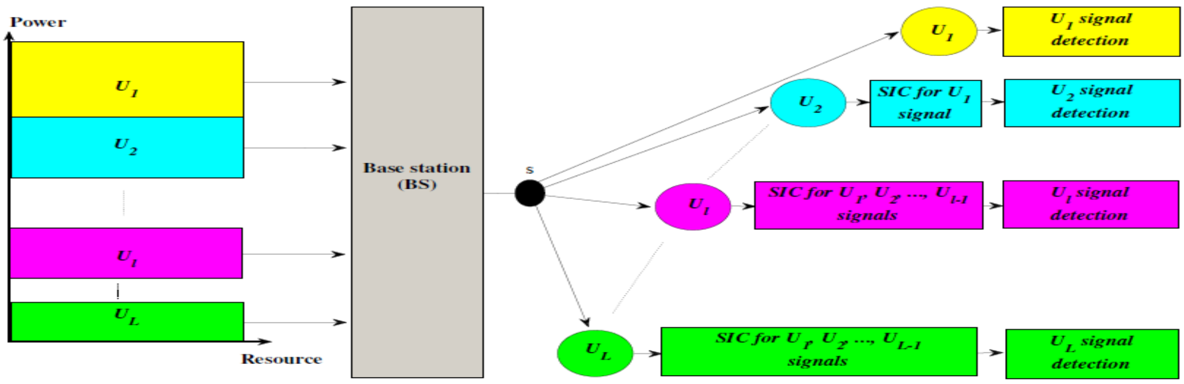

Figure 5.1 1 system model power allocation on downlink NOMA

$$\boldsymbol{x^m = \sqrt{p_m^i}\, s_m^i + \sqrt{p_n^i}\, s_n^i} \tag{4.23}$$

$$where \quad i = subcarrier$$

$$m, n = user \ldots\ldots m, n \in \{1, \ldots k\}$$

$$p_m^i = The\ transmitter\ power\ on\ user\ m\ on\ subcarrier\ i$$

$$p_n^i = The\ transmited\ power\ on\ user\ n\ on\ subcarrier\ i$$

$$s_m^i = modulated\ user\ m\ signal$$

Assume our channel is faded channel is Rayleigh faded channel (non-line of sight), The channel gain is perfectly known on a transmitter and receiver side. The receive signal , $y_m^i = h_m^i x^i + z_m^i$. y_m^i = received signal user m on subcarrier i

$$h_m^i = \frac{G_m^i}{\sqrt{1+d_m^i}} \tag{4.24}$$

where z_m^i- channel coefficient

d_m^i- Distance from base station to user M.

$z_m^i, CN(0,\sigma^2)$ $guassian\ noise\ zero\ mean\ and\ unit\ variance$

4.5 Successive Interference Cancelation

Current scenario users who have higher channel gains or in our case, user n can decode the data that has been successfully decoded by the users who have less channel gains or user m. In this case, since user n has a higher channel gain than user m, then user n can decode the data that has been successfully decoded by user m [37].

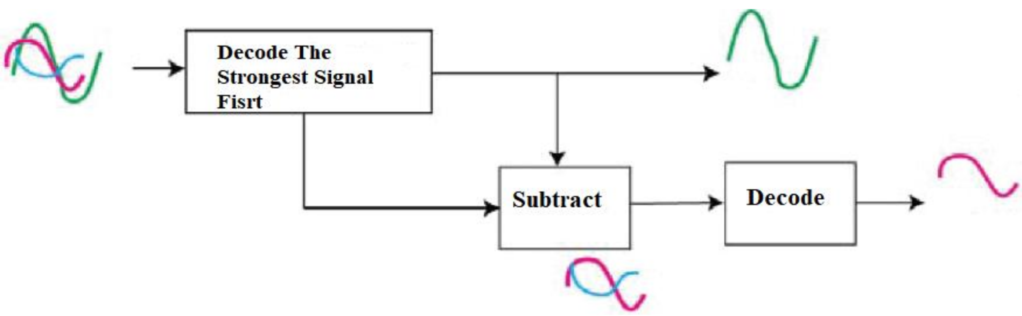

Figure 5.1 2 block diagram for SIC in user terminal side

- It is non-linear multi-user receivers which estimates and cancels multiple access interference successively using feedback.
- The first signal decode by signal interference cancelation is near signal or have better channel gain signal.

$$Y(t) = y(t) - A_n(t)S_n(t)b_n(t) \tag{4.25}$$

$where$

$Y(t)$ = Total receive signal

$S_n(t)$ = spreading code for the strongest power of user one.

$b_n(t)$ = Estimated user symbol for strong user n

$$Y(t) = \sum_{j=1 \; and \; j \neq n}^{M} A_j(t) S_n(t) b_j(t) + A_n(b_n - B_n) S_n(t) + n(t) \qquad (4.26)$$

Successive interference obtain as function in receiver terminal sides its uses to decode the combined information with channel faded channel which transmitted to each receiver non-orthogonal multiple access uses successive interference cancelation. Non-orthogonal multiple access perform multiple access using the power domain [38] [39]. The transmitter realizes power allocation and user scheduling, according to the availability of Channel state information. In addition, some downlink users will exploit successive interference cancelation to remove multi-user interference. In the literature [40], including perfect Channel state information and ignoring quality of service requirements, before strong user, who has better channel quality, decoding itself, they will decode and eliminate signal of weak user, i.e. worse channel quality, first. However, the cell edge user or week user will treat the signal of the strong user as noise and directly decode its own signal. Besides, in order to achieve fairness and to facilitate the successive interference cancelation process, the weak user allocated more power by the base at transmitter.

In the case of non-orthogonal multiple access, successive interference cancelation interpretation ways similar to other wireless transmission. Based on ordering channel gain information, the Transmitter cannot decide the signal interference cancelation decode order without perfect channel state information. , the distance between Base station and user terminal can be determined as a metric to determine average channel condition. However, this metric does not take the considering quality of service. Which also influence of the signal interference cancelation decoding order and then change of performance power allocation. For example the near user , this user require a lower outage probability the other user, choosing this user to perform Signal interference cancelation require more transmission power than choosing than other user, this is opposed to conventional non orthogonal multiple access regardless of quality of service requirement [38] [39]. Furthermore, it can be seen that the situation non orthogonal multiple access system with quality of service requirement and perfect channel state information, only choosing the strong user to exploit the signal interference cancelation will require less transmit power.

The total required target rate for given user m isR_m, which allocated subcarrier only statical channel state information is achived at the base stations. Thus the target rate of user m on its assigned subcarrier I is represent by

$$\widetilde{R_m^i} = \frac{R_m}{L} \tag{4.27}$$

Correspond target SINR rate

$$\widetilde{Y_m^i} = 2^{\widetilde{R_m^i}} - 1 \tag{4.28}$$

Considering subcarrier m, successive interference cancelation at near user or user n is successful when the decoding rate of the signal for Edge user is not less than the target rate of Edge user, i.e.,

$$\widetilde{Y_m^i} = 2^{\widetilde{R_m^i}} - 1 \tag{4.29}$$

where $R_{n\rightarrow m}^{i}$ represents the achievable rate for user n which decodes the signal of user m on subcarrier I, and it is represent.

4.6 Performance Evaluation Metric on Power Allocation On HetNet

Performance evaluation is essential part of any thesis that distinguish overall system performance and evaluate different power allocation scheme on the case on downlink non-orthogonal multiple access in the case of single subcarrier scenario will be investigate. The following performance metric will be considered, I will focus on power allocation on single subcarrier due to full fill specific objective this thesis, and the distance from base station to active user is considered, and considered, and the thesis evaluation metric based on achievable rate on different users at a given transmit power at multi users on the same subcarriers.

4.6.1 Spectral and Energy Efficiency

The overall power usage or consumption of the system can be represented as sum of information signal power on subcarrier and total power consumption used by system circuit. In this paper is considering non-orthogonal multiple access, focus area on downlink NOMA scenario. In the case of NOMA Downlink, total power consumption on Base station is the sum of total power of the signal and total power consumption on the process or system.

$$P_{Total\ power\ consumption\ BS} = P_{total\ of\ assigned\ signal\ power} + P_{total\ power\ consumption\ on\ sys}$$

Energy efficiency (EE) is one of key performance measurement of 5G wireless communication, it defined as total power the sum rate over total consumed power on base station.

In our case considering on single subcarrier,

$$EE_{subcarrier} = \frac{R_{total\ on\ subcarrier}}{P_{total\ power\ consumption\ on\ the\ case\ of\ subcarrier}} \quad (4.30)$$

Moreover, Energy efficiency defined in the case of Base station is the sum of all rate on subcarriers divided by total power consumption BS.

$$EE_{BS} = \frac{R_{total\ BS}}{P_{total\ power\ consumption\ BS}} \quad (4.31)$$

Spectral efficiency consider the achievable rate on different users on the same subcarriers, on different system level performance indicators.

- The achieved system capacity
- The amount of used system bandwidth
- The edge users throughput

The achievable system capacity and the amount of used system bandwidth is merge and try to see the effect under spectral efficiency scenario,

$$spectral\ efficency = achivable\ sum\ rate/total\ amount\ of\ system\ bandwidth$$

4.6.2 Quality of Service Constraints

To satisfy diverse quality of service requirement for users on near and far or edge user on the case of main base station and small base station scenario. Different types of quality of service constraints on the case of single subcarrier.

- min data rate requirement of defend users, it implies user perform defend activities on communication process on the case of users m and user n on different base station and achieving cell edge user fairness of resource allocation applying defend power allocation Scheme.

4.6.3 Bit Error Rate

BER is one of key performance metric parameter transmit digital data from transmit from transmitter or base station to receiver to user terminal, there is channel, this channel is noisy or faded channel, the channel possibility with error is introduced to the system, to measure the amount of error rate is added to the signal, there is the integrity of the system is compressed. To determine the performance of the system and bit error rate provide an ideal way in which can be achieved [41]. In wireless communication the amount of bit error is the number of bit we get in receiver side or received bits through faded communication channel, this received signal is not the same as transmit signal due to noise, bit synchronization error and noise.

$$bit\ error\ rate = \frac{amount\ of\ transmited\ bit\ error}{transmited\ bit\ signal}$$

4.6.4 Sum Rate

The main aim of future wireless communication is maximizing sum rate, enhancement of throughput**,** to achieve sum rate maximization for multiple usurers and avoiding the resource of occupied by one user, the weight or quality of service of edge user.

- ❖ Total sum rate for SBS(Pico cell)

$$R^s = \sum_{b=1}^{N}\sum_{u=1}^{N}\sum_{i=1}^{N} R_{U,i}^{s} \tag{4.31}$$

Total sum rate for MBS

$$R^m = \sum_{a=1}^{N}\sum_{u=1}^{N}\sum_{i=1}^{N} R_{U,i}^{m} \tag{4.32}$$

In the case of HetNet network over all sum rate is the summation of sum rate for SBS and sum rate on MBS, Matimatically described as follows.

$$R = R^s + R^m \tag{4.33}$$

Finally sum rate for users on individual subcarrier is the summation for individual users on the same subcarrier. $R^i = \sum_{u=1}^{U} R^s$

4.7 Suboptimal Solution

In the case of statically channel state information, different users have different channel estimation error, so individual user throughput affected a lot, different paper working on this problem. the resource allocation optimization problem is formulate to maximize the sum rate or user through put of multi users scenario. Non-orthogonal multiple access system formulation and the solution then generalized to the multiuser case.

If two users are multiplexed over the $on\ i\ subcarriers$, using non- orthogonal multiple access principles, then the achievable rate by the user with the $higher\ (n)$ channel conditions is as given in(1) and the user with the low (m) channel conditions is as given in (2), and (3) give their sum rate over that resource block [42]. In order to guarantee that each user is able to achieve its target rate, the optimization will include nonlinear constraints of proportional rate.

$$Mathematically\ equation\ 4.48, the\ problem\ of\ the\ two\ - user\ scenario\ formulated\ as$$

sum rate of all resource block is the summation of overall sum rate of each subcarrier. Power allocation is first proposed the allocation factor of different users in a cell are the same,Power allocation on user n and m on subcarrier i must be less than or equal to total power assigned for base station to subcarrier i.

$$\underset{(P_n^{(i)}, P_m^{(i)})}{Maximize} \quad R \tag{4.34}$$

$$\sum_{i=1}^{S}(P_n^{(i)} + P_m^{(i)}) \leq p_t \tag{4.35}$$

$$(\mathrm{P_i^{(n)}}, \mathrm{P_i^{(m)}}) \leq 0 \tag{4.36}$$

To find minimum achievable rate of users on different users at the same subcarrier that means user m and user n on subcarrier i [43], Minimum rate proportionality constant for users n and m. It helps to maintain proportionality b/n the minimum achievable rates of the users.

Achievable rate of two users, user n,m , *on subcarrier* i

$$\sum_{i=1}^{s} R^n : \sum_{i=1}^{S} (R^m) = \quad \emptyset_{min}{}^1 = \emptyset_{min}{}^2 \tag{4.37}$$

$$R = R_i^{(n)} + R_i^{(m)}$$

$$= \mathrm{B_i} \log_2\left(1 + \frac{\mathrm{P_i^n |H_i^n|^2}}{\mathrm{B_i N_O}}\right) + \mathrm{B_i} \log_2\left(1 + \frac{\mathrm{P_i^m |H_i^m|^2}}{\mathrm{p_S^n |H_S^n|^2 B_i N_O}}\right) [36] \tag{4.38}$$

After the first derivative in terms of $\frac{dR}{dP_i^{(H)}}$ and second derivative in terms $\frac{d^2R}{dP_i^{(n)}}$, Now after first derivative we get this value ,This result shows concave; due to both power allocation have negative value. Power allocation solution for statically channel state information, the result of power allocation error.pwer allocation solution for statically channel state information, successive interference cancelation is give the exact figure due to channel uncertainty

The outage probablity of user n $P_n^{out} = Pr\{R_{n\to m}^i \geq \hat{R}_2^m, R_{n,n} < \hat{R}_n\} + Pr\{R_{n\to m}^i < \hat{R}_2^m, R_{n,m} < \hat{R}_n\}$, The outage probablity of user m $P_m^{out} = Pr\{\, R_{m,n} < \hat{R}_m\}$

Now substitute the value in equation 4.38 to the outage probablity of user n

$$P_n^{out} = Pr\left\{\log_2(1 + \frac{|\, h_\mathrm{n}{}^i|^2\, p_\mathrm{m}{}^\mathrm{i}}{|\, h_\mathrm{n}|^2\, p_\mathrm{n}{}^\mathrm{i} + \sigma^2}) \geq \log_2\left(\widehat{SINR}_m + 1\right), \log_2(1 + \frac{|\, h_\mathrm{n}{}^i|^2\, p_\mathrm{m}{}^\mathrm{i}}{\sigma^2}) < \log_2(\widehat{SINR}_m + 1)\right\}$$

$$+ Pr\left\{\log_2(1 + \frac{|\, h_\mathrm{n}{}^i|^2\, p_\mathrm{m}{}^\mathrm{i}}{|\, h_\mathrm{n}|^2\, p_\mathrm{n}{}^\mathrm{i} + \sigma^2} < \log_2\left(\widehat{SINR}_m + 1\right), \log_2(1 + \frac{|\, h_\mathrm{n}{}^i|^2\, p_\mathrm{m}{}^\mathrm{i}}{\sigma^2}) < \log_2\left(\widehat{SINR}_m + 1\right)\right\}$$

Now far user or user m

$P_m^{out} = Pr\left\{\log_2(1 + \frac{|\, h_\mathrm{m}{}^i|^2\, p_\mathrm{m}{}^\mathrm{i}}{|\, h_\mathrm{n}|^2\, p_\mathrm{m}{}^\mathrm{i} + \sigma^2}) < \log_2\left(\widehat{SINR}_m + 1\right)\right\}$, Now in the case of outage probability of near user rate 1 canceled by one. , $P_n^{out} = Pr\left\{log_2(\frac{|\, h_n{}^i|^2\, p_m{}^i}{|\, h_n|^2\, p_n{}^i + \sigma^2}) \geq\right.$

$$log_2(\widehat{SINR}_m), log_2(\frac{\left|h_n{}^i\right|^2 p_m{}^i}{\sigma^2}) < log_2(\widehat{SINR}_m)\Bigg\} + Pr\Bigg\{log_2(\frac{\left|h_n{}^i\right|^2 p_m{}^i}{\left|h_n\right|^2 p_n{}^i + \sigma^2} <$$

$$log_2(\widehat{SINR}_m), log_2(\frac{\left|h_n{}^i\right|^2 p_m{}^i}{\sigma^2}) < log_2(\widehat{SINR}_m)\Bigg\} \text{ [28]}$$

$$P_m^{out} = Pr\left\{log_2(\frac{\left|h_m{}^i\right|^2 p_m{}^i}{\left|h_n\right|^2 p_m{}^i + \sigma^2}) < log_2(\widehat{SINR}_m)\right\}$$

Now simplified usern power output

$$P_n^{out} = Pr\left\{\left|h_n{}^i\right|^2 \geq \frac{(\widehat{SINR}_m)\sigma^2}{p_m{}^i - p_n{}^i(\widehat{SINR}_m)}), \left|h_n{}^i\right|^2 < \frac{\sigma^2(\widehat{SINR}_n)}{p_n{}^i})\right\} + Pr\left\{\left|h_n{}^i\right|^2 < \right.$$

$$\left.\frac{(\widehat{SINR}_m)\sigma^2}{p_m{}^i - p_n{}^i(\widehat{SINR}_m)}), \left|h_n{}^i\right|^2 < \frac{\sigma^2(\widehat{SINR}_n)}{p_m{}^i - p_n{}^i(\widehat{SINR}_n)})\right\}$$

$$P_n^{out} = Pr\left\{\left|h_n{}^i\right|^2 < max\frac{(\widehat{SINR}_m)\sigma^2}{p_n{}^i}, < \frac{\sigma^2(\widehat{SINR}_n)}{p_m{}^i - p_n{}^i(\widehat{SINR}_m)}\right\} \text{ [14]} \tag{4.39}$$

$$P_n^{out} = Pr\left\{\left|h_n{}^i\right|^2 < \frac{\sigma^2(\widehat{SINR}_n)}{p_m{}^i - p_n{}^i(\widehat{SINR}_m)}\right\} \tag{4.40}$$

The cumulative distribution function for channel gain for users on subcarrier i, in this case two users these are user n and user m on subcarrier of i.

Considering the probability of strong user channel gain $\frac{\sigma^2(\widehat{SINR}_n)}{p_m{}^i - p_n{}^i(\widehat{SINR}_m)}$

$$= \frac{\sigma^2(\widehat{SINR}_n)}{p_m{}^i - p_n{}^i(\widehat{SINR}_m)} > \frac{(\widehat{SINR}_m)\sigma^2}{p_n{}^i} \rightarrow\rightarrow\rightarrow\rightarrow\rightarrow pr\left\{\left|h_n{}^i\right|^2 < \frac{(\widehat{SINR}_m)\sigma^2}{p_n{}^i}\right\}$$

$$F_{\left|h_n{}^i\right|^2 \frac{(\widehat{SINR}_n)\sigma^2}{p_n{}^i}}$$

- Now replace result to CDF equation

$$F_{\left|h_n{}^i\right|^2 \frac{(\widehat{SINR}_n)\sigma^2}{p_n{}^i}} = 1 - e^{-(1+d_1{}^\alpha)\frac{(\widehat{SINR}_n)\sigma^2}{p_n{}^i}} < \delta_1$$

Equivalent equation

$-(1+{d_1}^{\alpha})\frac{(\widehat{SINR}_n)\sigma^2}{{p_n}^{i}} = ln(1-\delta_1)$, $\frac{(\widehat{SINR}_n)}{{p_n}^{i}} \le -\frac{ln(1-\delta_1)}{(1+{d_1}^{\alpha})\sigma^2}$. Now the value of user 1 power allocation, is $\beta_1 = -\frac{ln(1-\delta_1)}{(1+{d_1}^{\alpha})\sigma^2}$, now changing this value to $\frac{(\widehat{SINR}_n)}{{p_n}^{i}} \le \beta_1$

2nd scenarios

$$\frac{(\widehat{SINR}_n)\sigma^2}{{p_n}^{i}} \ge \frac{\sigma^2\,(\widehat{SINR}_m)}{{p_m}^{i} - {p_n}^{i}(\widehat{SINR}_m)}$$

$$P_n^{out}\left(\frac{(\widehat{SINR}_n)\sigma^2}{{p_n}^{i}} \ge \frac{\sigma^2\,(\widehat{SINR}_m)}{{p_m}^{i} - {p_n}^{i}(\widehat{SINR}_m)}\right)$$

$$= Pr\left\{|\,{h_n}^{i}|^2 < \frac{\sigma^2\,(\widehat{SINR}_n)}{{p_m}^{i} - {p_n}^{i}(\widehat{SINR}_m)}\right\}$$

CDF function , $F_{\left|\,{h_n}^{i}\right|^2 \frac{\sigma^2\,(\widehat{SINR}_m)}{{p_m}^{i} - {p_n}^{i}(\widehat{SINR}_m)} \le \delta_1}$

$$\frac{(\widehat{SINR}_m)}{{p_m}^{i}} \le -\frac{ln(1-\delta_1)}{(1+{d_1}^{\alpha})\sigma^2}$$

$$\frac{(\widehat{SINR}_n)}{\beta_1} \le \; {p_m}^{i} - {p_n}^{i}(\widehat{SINR}_m)$$

$$When\ \beta_1 > \beta_2 \begin{cases} {p_n}^{i} \ge \dfrac{(\widehat{SINR}_n)}{\beta_1} \\ {p_n}^{i} \ge \dfrac{\widehat{SINR}_m}{\beta_2} + \dfrac{(\widehat{SINR}_n)(\widehat{SINR}_m)}{\beta_1} \end{cases}$$

$$\beta_2 > \beta_1 \begin{cases} {p_n}^{i} \ge \dfrac{(\widehat{SINR}_n)}{\beta_1} \\ {p_n}^{i} \ge \dfrac{\widehat{SINR}_m}{\beta_2} + \dfrac{(\widehat{SINR}_n)(\widehat{SINR}_m)}{\beta_1} \end{cases}$$

From general assumption power allocation is greater than power factor, to minimize the assigned users power on subcarrier i. ${p_m}^{1i} = \frac{1}{\beta_1}$, ${p_n}^{1i} = \frac{(\widehat{SINR}_n)}{\beta_1}$

$$p_m{}^{1i} = max\left(\frac{(\widehat{SINR}_n)(\widehat{SINR}_m)}{\beta_1} + \frac{\widehat{SINR}_m}{\beta_2}, \frac{(\widehat{SINR}_n)(\widehat{SINR}_m)}{\beta_1} + \frac{\widehat{SINR}_m}{\beta_2}, \frac{1}{\beta_1}\right)$$

Power allocation factor for different users on the same subcarrier , in this case $\beta_u = -\frac{\boldsymbol{ln}(1-\boldsymbol{\delta_1})}{(1+\boldsymbol{d_1}{}^{\alpha})\boldsymbol{\sigma^2}}$, where u is different pared user on subcarrier I, $u \in \{1,2\}$, near user have better channel gain, it uses Successive user cancelation, $\frac{1}{\beta_u}$ in this case the value of increase, it means power allocation factor deacrease, it state that near user use small amount of power compaired to far user to achive QOS or users far from base station express this statement by other when user far from base station it need small amount of outage probability, this means far user achieve user throughput or quality of service it need additional amount of power. Non-orthogonal multiple access, perfect channel state information, power allocation factor β_u is already fulfill quality of service, the other user need additional power allocation factor to ful fill quality of service.

The difference between assigned power allocations for user n to user m times target signal to interference noise ration on different users on the same subcarrier(i) is grater than zero, matimatically described as follows $\mathrm{p_n}{}^{\mathrm{i}} - \mathrm{p_m}{}^{\mathrm{i}}(\widehat{\mathrm{SINR}}_\mathrm{n}) > 0$, and the difference btween user m power allocation to user n times target rate of user m power allocation $\mathrm{p_m}{}^{\mathrm{i}} - \mathrm{p_n}{}^{\mathrm{i}}(\widehat{\mathrm{SINR}}_\mathrm{m}) \leq 0$, $p_m{}^{2i} = max\left(\frac{(\widehat{SINR}_n)(\widehat{SINR}_m)}{\beta_2} + \frac{\widehat{SINR}_n}{\beta_2}, \frac{(\widehat{SINR}_n)(\widehat{SINR}_m)}{\beta_2} + \frac{\widehat{SINR}_n}{\beta_1}, \frac{1}{\beta_2}\right)$

Power allocation problem is can be deduced

$$p_m{}^{2i} = \frac{(\widehat{SINR}_m)}{\beta_2}$$

The suboptimal power allocation for two users on the same subbcheenea is state as follows.

$$(p_n, p_m) = \begin{cases} (p_n^{1i}, p_m^{1i}) .If\ p_n^{1i} + p_m^{1i} \leq p_n^{2i} + p_m^{2i} \\ (p_n^{2i}, p_m^{2i}), \qquad orherwise \end{cases} \qquad ($$

Base station will massage user$U$, exploit successive interference cancelation and prevent other user to do $(p_n^{1i}, p_m^{1i})\ and\ (p_n^{2i}, p_m^{2i})$

5. Simulation Result and Discussion

5.1 Introduction

In this chapter, power allocation is one of the major impact on 5G Heterogeneous Network it is in terms of maximizing sum rate of edge user and maximizing energy efficiency. In this chapter, compare performance power allocation scheme on the case of single subcarrier on melt-user on the case of heterogeneous 5G network the result will be shown by mat lab simulation.

First, discuss the result of performance

- HetNet capacity or achievable rate perspective
- Orthogonal and Non-orthogonal multiple access in terms of system capacity perspective
- BER vs transmit power in terms of statically channel state information, but the paper focus on perfect channel state information.
- Capacity of subcarrier, how much user support single subcarrier to achieve user achievable rate.
- Computational complexity on power allocation scheme
- Finally, performance comparison for power allocation scheme, on the case of single subcarrier downlink NOMA HetNet scenario.

Simulation result related to power allocation on HetNet and focus area is power allocation on downlink non orthogonal multiple access, the effect of different power allocation scheme on system performance to validate the choices of different comparative parameters within framework in this chapter, in terms of user pairing, multi-user power allocation on single subcarrier on downlink NOMA on heterogeneous network scenario.

In this simulator considering the following points, Two Base Station. These are main base station (MBS) and small base station (SBS) is called Pico cell. MBS users randomly distributed in the max cell radius range of 100m to 1000m respectively and the small base station in the cell range from 50m to 200m.NB: max cell radius is 200m, we choose max one, and the system channel model is Rayleigh faded channel with zero mean and unit variance. In order to carry out this analysis, we consider the case where the channel gain difference between multiplexed users, the bandwidth and carrier, the difference between channel gain between 2 multiplexed user is increased,

$d =$ channel gain for edge user $-$ channel gain for near end user,

Considering d, the value $\geq$ 0.35 value best pared user are considered, to minimize SIC complexity and system through put.

- The total available bandwidth and carrier frequency for mid band for the system are 0.5 MHz and 3.5 GHz respectively.

5.2 Capacity of HetNet

HetNet consists of one central main base station and different small base station, in this paper focus on single MBS and a single Pico cell, the achiveble sum rate for Heterogeneous network is the addition of sum rate of small base station and sum rate of main base station. The energy efficiency of MBS is defined as the ratio of the achiveble sum rate to the total power consumption on the macro cell $R^m = \sum_{a=1}^{N} \sum_{u=1}^{U} \sum_{i=1}^{N} R_{U,i}^{m}$, a single base station let a, number of max users in MBS is U and there for in this case our achiveble rate in the case of MBS is higher compare to SBS or PICO cell or matimatically$R^s = \sum_{b=1}^{N} \sum_{u=1}^{U} \sum_{i=1}^{N} R_{U,i}^{s}$, wr. In this case, number of small base station is one and number of users in a single subcarriers U and number of subcarrier in a single small base station is N.

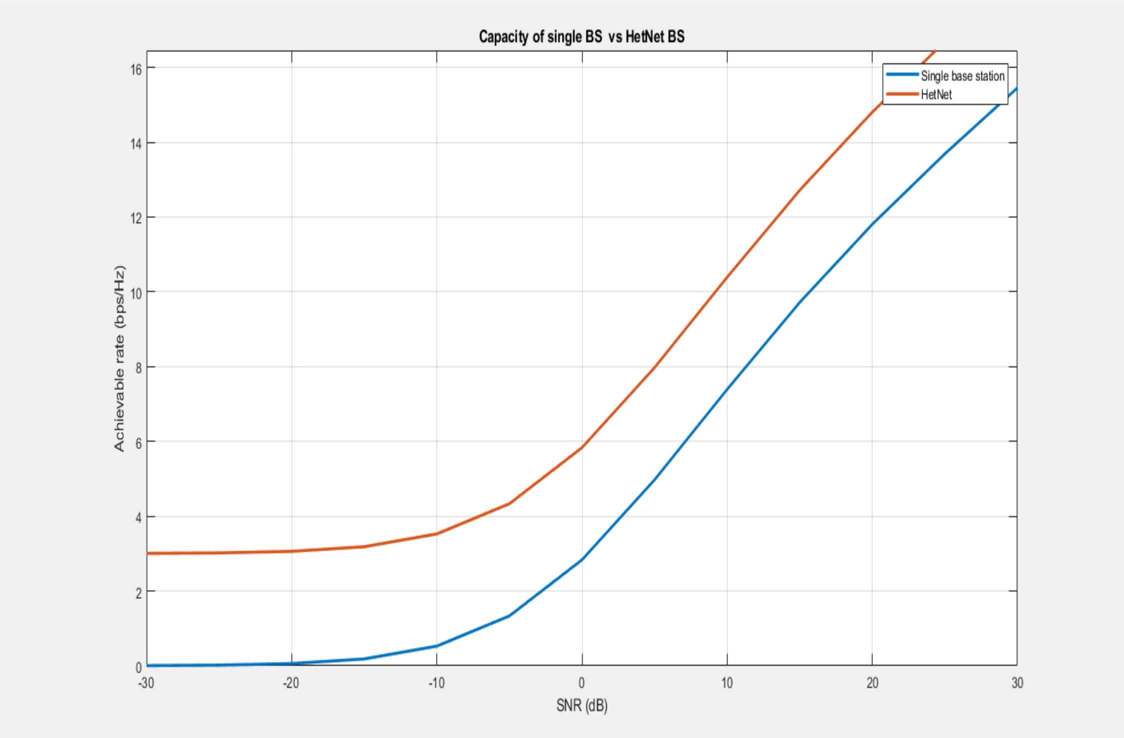

Figure 5. 1 Achievable sum rate for HetNet capacity

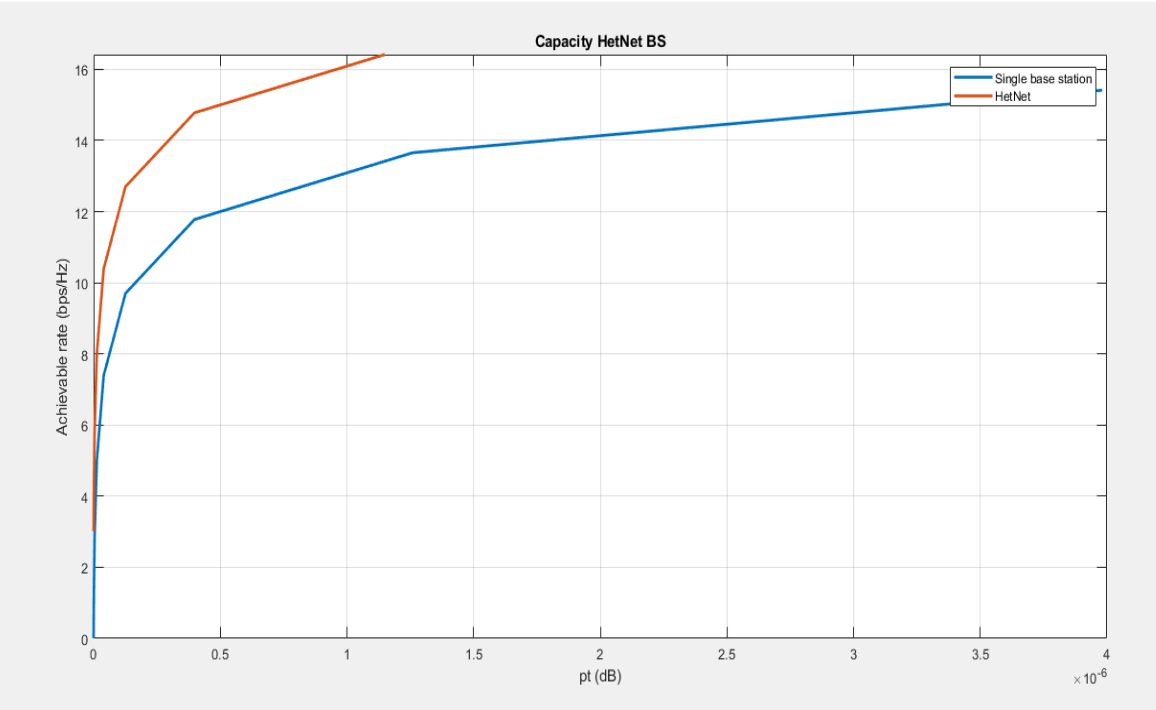

Figure 5. 2 HetNet Capacity 1

From fig one simulation result the case of single base station, by SNR value by 10dB rate is 7bps/hz and in the case of HetNet by the same amount of SNR value, it gives 11bps/hz.

Single base station, by SNR value by 20dB rate is 12bps/hz and in the case of HetNet by the same amount of SNR value, it gives 17bps/hz.

Over all achievable rate and coverage is increased in HetNet.

SNR	-20dB	-10	10dB	20
Sum Rate single Base station (mbps)	0.1	0.2	7	12
Sum rate on HetNet	3	3.6	11	17

Table 5. 1- Comparison between SNR Vs sum Rate on the case of BS and HetNet. Moreover, we try to see the spectral efficiency on NOMA HetNet.

Second scenario

Performance metric is transmit power Vs achievable rate, When transmit power start to increase from 0.5 to 4dB, the capacity or achievable rate is increase dramatically in both case., Spectral efficiency vs energy efficiency at a given bandwidth $\text{total bandwidth } 5 \times 10^7$ and at a given noise power 1×10^{-21} and the users placed on at difference distance from base station user 1 is near to base station station that means it have better channel gain,

channel gain for three users at MBS$-120dB, -140dB, -160dB$ respectively and $SBS\ -60dB, -70dB, -80dB$ respectively. Moreover, the power allocation is considering channel gain of users, user have better channel gain, and user 2 is better channel gain compare from user 3 and user 3 is edge user or it have worst channel gain, For user one is allocate less power compared to user 2 and user 2 is allocate less power compare to user 3 and edge user locate better power compared from both user one and user 2.

Spectrum efficiency describes the amount of data transmitted over a given spectrum or bandwidthwith minimum transmission errors, a cellular network's spectral efficiency is equivalent to the maximum number of bits of data that can be transmitted to a specified number of users per second while maintaining an acceptable quality of service, on the case of NOMA HetNet increase transmit power 1dB to 80dB the spectral efficiency increase(bps/Hz) dynamatically.

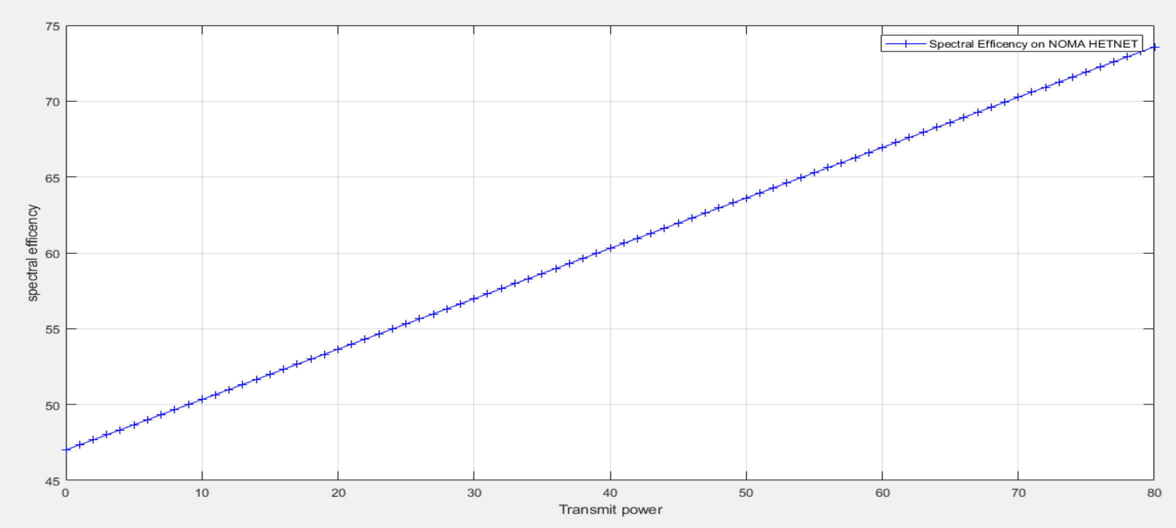

Figure 5. 3 Spectral efficiency 1

5.3 User Paring

Non-orthogonal multiple access serves multiple user simultaneously in the same subcarriers in different power level. To determine how many users assign on a single subcarrier.

- Considering K users share a single subcarrier.
- By SIC working principle, strong user need SIC, so when increase number of user in the same subcarrier, become higher receiver complexity.
- Let channel gain of Edge user to near user $|h_1|^2 < |h_2|^2 < |h_3|^2 < - - - < |h_n|^2$at the same time the power allocation factor is inversely relation with channel gain is $\alpha_1 > \alpha_2 > \alpha_3 > \alpha_4 \ldots \ldots \ldots > \alpha_n$
- Power allocation factor say that in the case of two user$\alpha_1 + \alpha_2 = 1$, in the case of three user$\alpha_1 + \alpha_2 + \alpha_3 = 1$, where$\alpha_1 > \alpha_2 + \alpha_3 = 1$, In the case of K user$\alpha_1 > \alpha_2 + \alpha_3 + \cdots + \alpha_n$.
- In receiver side, SIC operate on k user, process in continuous in k-1 times decode its own data, this process is not saying only its computationally complex, but also consume much time leading to processing delay.

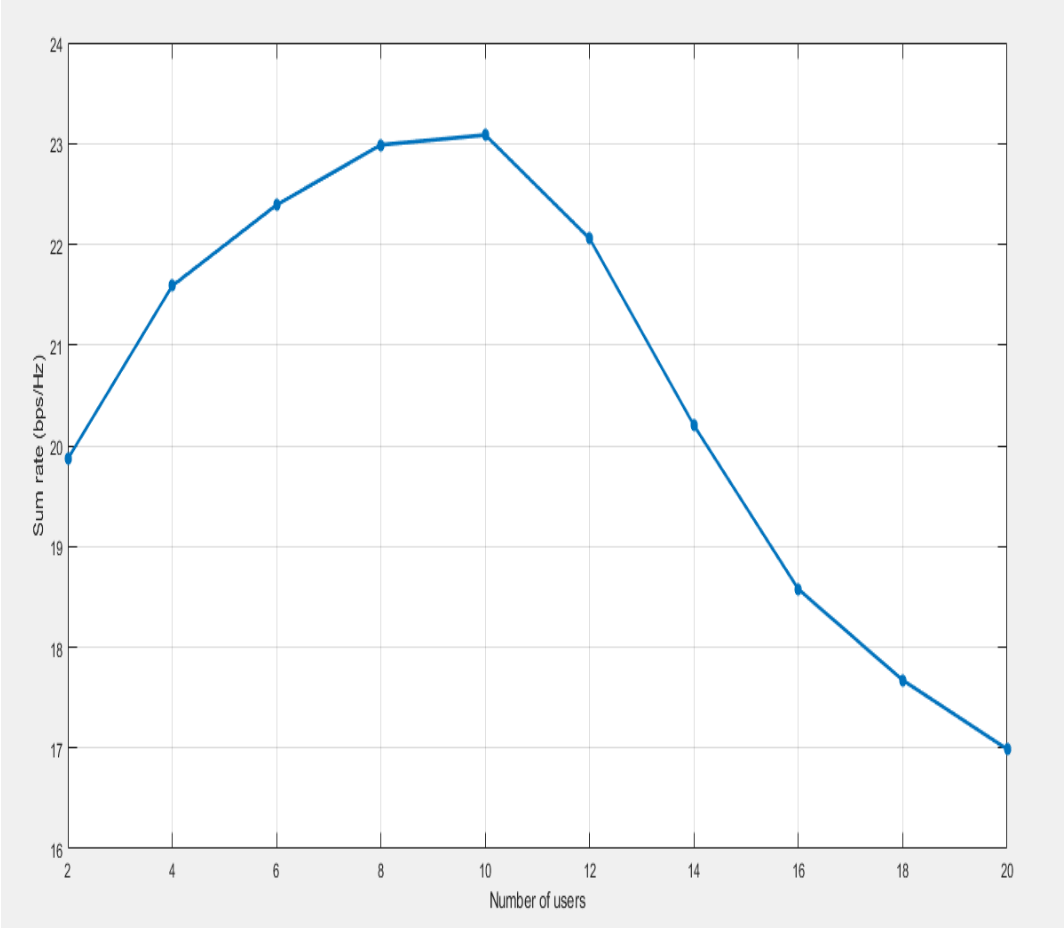

Figure 5. 4 Number of User Vs Sum Rate

Number of user	2	4	6	8	10	12	14	16
Sun rate	20bps	21.5bps	22.5bps	23bps	23.1bps	22bps	20.2bps`	18.6bps

Table 5. 2 Number of users VS sum rate

Start from the above simulation

- As the number of users of single carrier -NOMA is increased, the sum capacity of the network initially increases and then after 10 user per subcarrier automatically drop off point and sum rate or system capacity is decreased.

5.4 Bit Error Rate VS Transmitted Power

Consider an extreme case of Rayleigh fading where each transmitted bit undergoes a different attenuation and phase shift due to multipath transmission. In other words, the channel changes for every bit. To simulate the bit error rate (BER), capacity Bit error rate means number of bit transmitted to number of error signal received, Let us set paper simulation parameters: Distances from high power base station are set as $d_1 = 700m$, $d_2 = 500m$, $d_3 = 300m$, $d_4 = 100m$. The power allocation coefficients are set as $\alpha_1 = 0.7$, $\alpha_2 = 0.2$, $\alpha_3 = 0.06$ and $\alpha_1 = 0.04$. Moreover, generate Rayleigh faded channel, on different channel gain, Here, N is the no. of transmitted signal (bit), to be transmitted. Since we are using QPSK modulation, each symbol has 2 bits. Therefore, going to transmit N/2 symbols. For each symbol generating a Rayleigh fading coefficient. super position coding x to creat NOMA transmit signal.

From simulation the effect of distance on different users on case of time varying channel, far from BS.

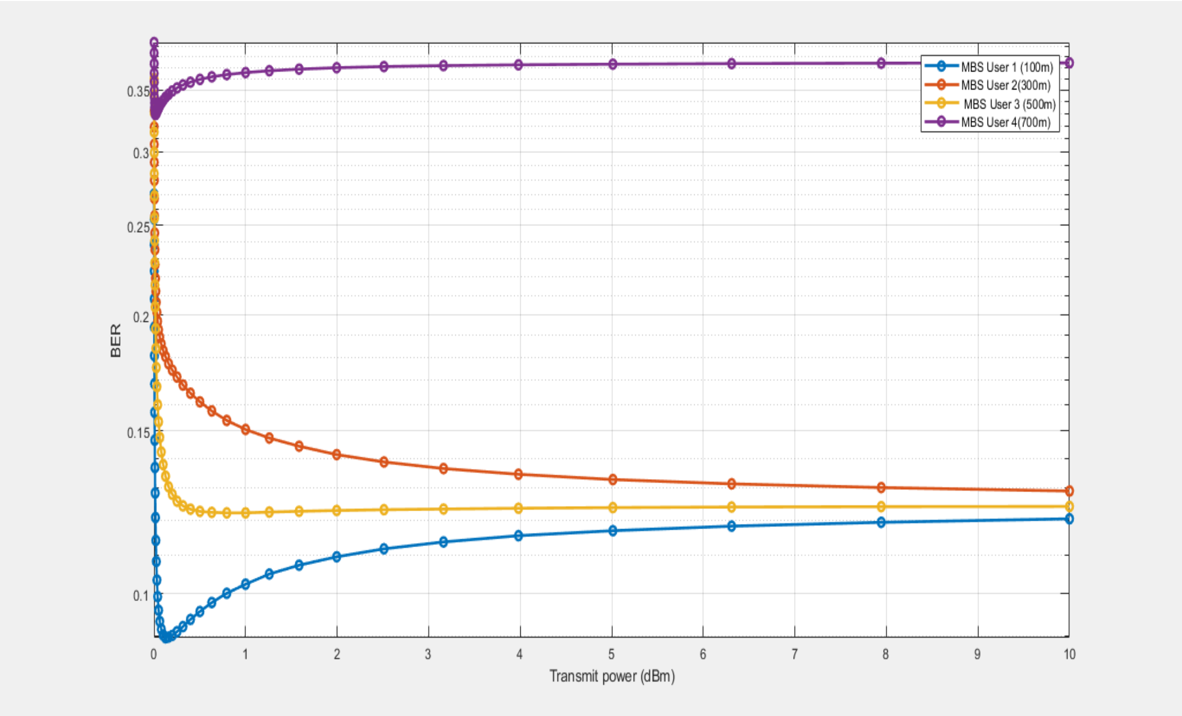

Figure 5. 5 Transmit Power vs Bit Error Rate

	BER user 1(700m)	BER user 2(500m)	BER user 3 (300m)	BER user 4 (100m)
Transmit power 1dB	0.37	0.11	0.15	0.3
Transmit power 3dB	0.38	0.12	0.11	0.8
Transmit power 8dB	0.39	0.125	0.10	0.9
Transmit power 10dB	0.40	0.13	0.13	0.1

Table 5. 3 BER performance users at differed user on different distance from base station.

Start from above simulation result BER increase by user far from main base station, The first user distance from MBS is 700m or bad channel gain, the power allocation factor for this user $\alpha_1 = 0.7$, this is due to when user far from base station target rate for user is affected, and transmit power increase the BER for received signal is increased, the second user distance from main base station is, 500m and power allocation factor is α_2 =0.2 by this amount of power allocation, power transmit for this user is increase by this effect the user BER mitigated and transmit power, from as the same as increasing transmit power, and user is close to BS with increase the amount of transmitted power, bit error rate is decreased, conclude that near user achieve target rate but edge user is not achieve target rate, and to full fill Edge user target throughput evaluate different power allocation scheme. Over SIC process in receiver side, user 4 has the highest BER among the remaining three users, user 3 is less BER compared to user 3, User 2 less BER compared to user 1. SIC process is as follows

- Direct demodulation to get U1's data
- Demodulation of U1's data
- SIC to remove U1's data
- Direct demodulation of remaining signal to get U2's data
- Demodulation of U2's data
- SIC to remove U1's data….the process is continued based on number user in subcarrier.

Finally, User 4 is free from interference and has the lowest BER in the group.

In this paper considering four number of user base station is used in order to reduce the considering demodulating complexity of the successive interference cancelation under receiver side.

5.5 Performance Comparison Power allocation scheme on Single Subcarrier.

In this case assuming two users the an single base station and on single subcarrier their distance from the base station is edge user is 1000m and near user distance 500m, and transmit power is 30dB, and channel is SISO antenna type and our channel is rayleigne channel. Moreover, power allocation coefficient for two users are$\alpha_1 = 0.25$, $\alpha_2 = 0.75$ respectively and transmit power $p_n^i = \alpha p_{\boldsymbol{i}}$ for the first user and the second user $p_m^i = (1 - \alpha)p_i$ for fixed power allocation scenario.

Mechanism fixed power allocation $\boldsymbol{p_i}$; power allocation to users in subcarriers is equal not considering resource farness, edge user throughput. Performance metric is sum rate vs achievable rate for increase channel gain for near user as a result increase the over of rate of user n, and decrease channel gain for edge user as a result decrease over all rate of user m. In the case of fractional power allocation scheme, $channel\ gain\ for\ near\ user\ (\boldsymbol{h_{i,n}}^{\boldsymbol{2}})$ increase as a result channel gain for edge user $h_{i,m}{}^2$ decrease by this power allocation scheme power allocation is based on channel gain , and the assigned power for user m $p_{i,m} = \frac{|h_{i,m}|^{-\alpha}}{\sum_{u\epsilon U}|h_{i,U}|^{-\alpha}} \times p_i$ and near user or higher channel gain user power allocation on user n on subcarrier I, $p_{i,n} = \frac{|h_{i,n}|^{-\alpha}}{\sum_{u\epsilon U}|h_{i,U}|^{-\alpha}} \times p_i$, when near user more close to base station, it assign less power. Moreover, in the case of edge user scenario more power is assigned. It uses edge user achievable target rate.

In the case of full search power allocation, searching different power allocation cofficent to be exthansive search power allocation coefficient to maximize achievable rate for different user.

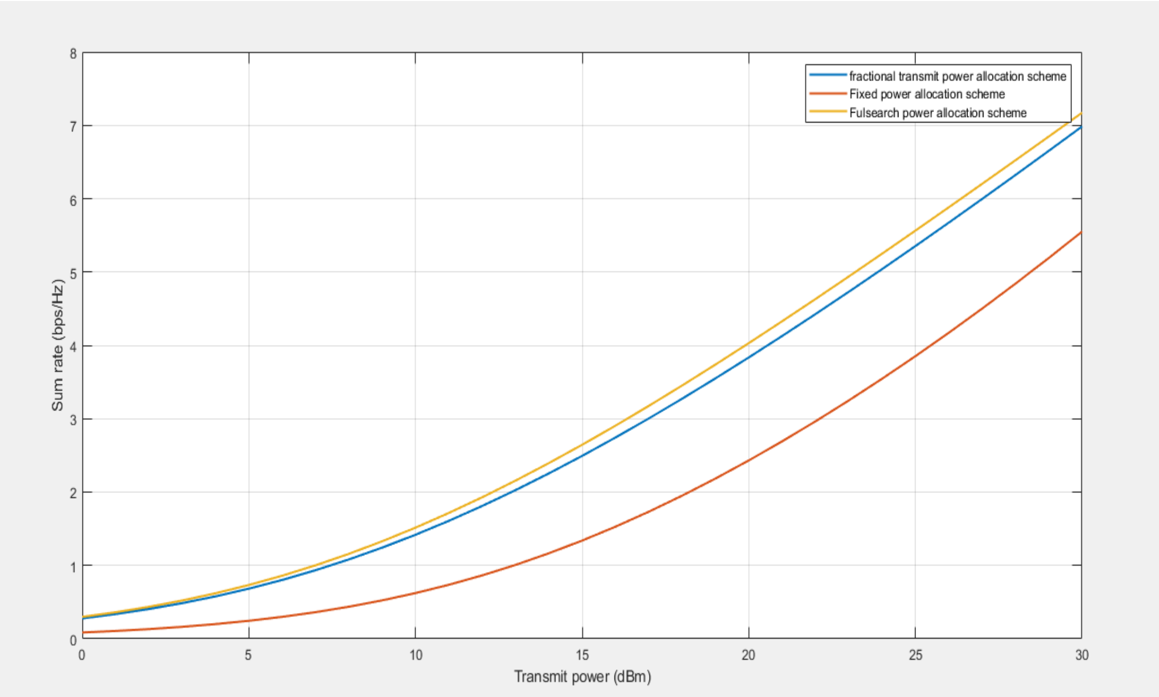

Figure 5. 6 Transmit Power vs Sum rate On Different Power Allocation Scheme,

Start from above simulation result shown, increase transmit power all power allocation scheme performance is boosted, but at different level. at transmit power at 5dB, sum rare for fixed power allocation scheme, fractional power allocation scheme and full search power allocation scheme 0.3mbps, 0.7mbps and 0.8mbps.

	Transmit power	*Transmit power*	*Transmit power*
	5dB	*15dB*	*25dB*
Sum rate for fixed power allocation scheme	*0.3mbps*	*1.3mbps*	*3.9mbps*
Sum rate for fractional transmit power allocation scheme	*0.7mbps*	*2.5mbps*	*5.3mbps*
Sum rate for full search power allocation scheme	*0.8mbps*	*2.7mbps*	*5.6mbps*

Table 5.4 Performance comparison for power allocation scheme, sum rate vs transmit power

5.6 Computational Complexity

In the aim of assessing the implementation feasibility of the different proposed power allocation techniques, measured the computational load of the main allocation techniques to be integrated at the BS, computational complexity scenario, proposed power allocation scheme compare from fixed power allocation and fractional transmit power allocation have more computational complexity. when increase power search interval or granularity for FSPA to achieve better user sum rate on different channel gain

- ❖ For the proposed power allocation algorithm, computational complexity of the power allocation algorithm is related to the number of multiplexed users *N*, the search interval granularity *O*.
- ❖ The computational complexity increases with, internal granularity *O* increase

When the number of multi-users is *N*, the computational complexity of the proposed power allocation algorithm is = O^{N-1} where O stands for power allocation search interval, when O increae the overall system computational complexity is increased.

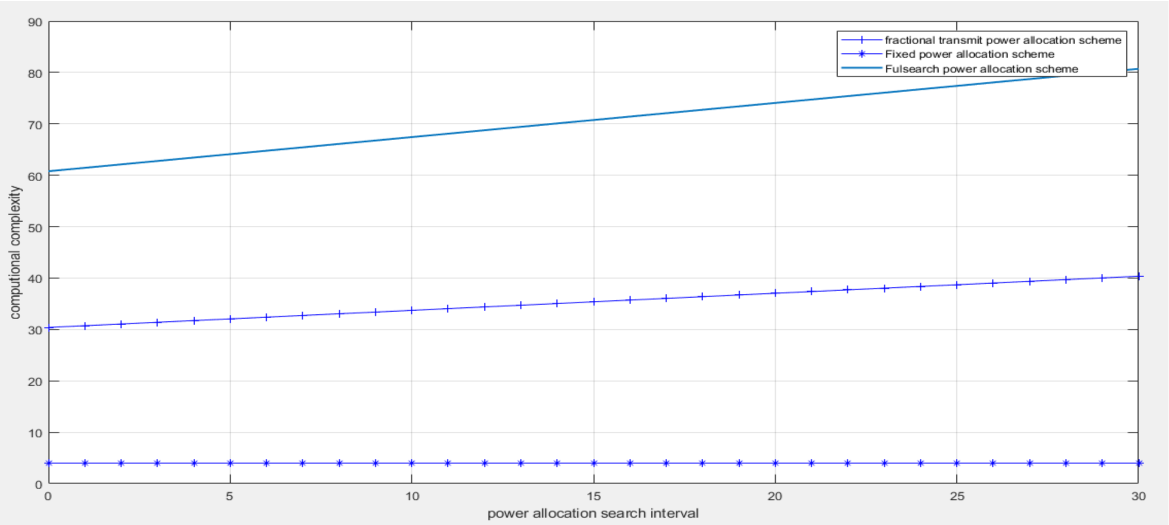

Figure 5.7 Computational complexity for power allocation scheme.

Fig 5.7 shows compares the computational complexity of the proposed power allocation algorithm with the FTPA and FPA algorithm. when the number of multi-users is *N* = 2, *N* = 3, or *N* = 4, the proposed algorithm produces a number of all possible power allocation coefficients is increase , it creat a possibility of internal granuality increase by this effect FSP,FTPA and FPA allocation algorithm produces 62,31 and 4 power allocation coefficients respectively

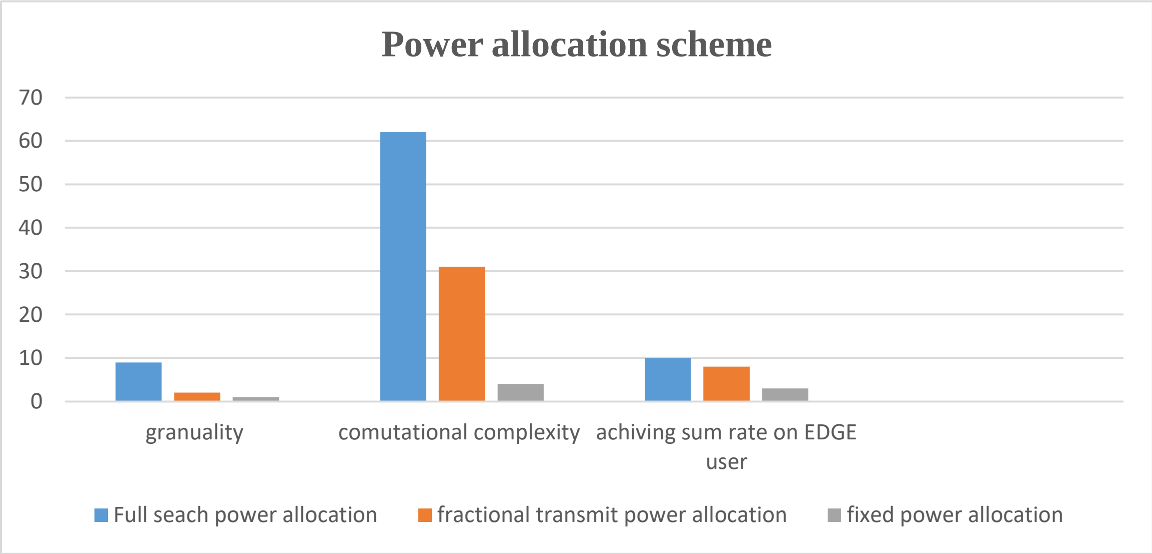

Figure 5. 8 computation complexity on power allocation scheme

6. Conclusion and Recommendation for Future Work

6.1 Conclusion

I have mainly investigated for the optimal power allocation solutions for the downlink non-orthogonal multiple access system in the target of cell through put maximization. In this thesis, compare the performance of dynamic power allocation for downlink Comp-NOMA into two-tier HetNet in considering the interference of other small cell. In this case when increase transmit power of HetNet network the capacity or Achievable sum rate is increase dramatically increase compare from single base station.

From above simulation result,

- Improving the user capacity in the case of cell edge user, thus enhancing the total achieved user throughput.
- Improving the convergence time towards required fairness performance, thus QoE,
- Enhancing fairness among users on both small and macro base station.

Intera-power allocation scenario the cell edge user doesn’t fulfill target rate in the case of fixed power allocation, in the case of fractional power allocation scheme, have cell edge user maximize the sum rate of all users while satisfying the target threshold in the case of full search power allocation scheme find all possible combination considering channel gain have better., the spectral efficiency increases as the transmitted power grow; the best performance of the three-power allocation schemes reached with the transmitted power is 30dBm. Full search power allocation scheme outperforms the other power allocation schemes due to choosing the best pair of power levels that provide the best performance among the other solutions. Moreover, fractional transmit power allocation performs better than the fixed power allocation which can be related to the dynamic nature of power allocation in fractional transmit power allocation.

- First scenario consider computational complexity, compare from other power allocation scheme FTPA have better performance of capability on computational complexity
- Considering over all achieving Edge user achieving target rate, full search have good capability of achieving target rate for edge user.

6.2 Recommendation for Future Work

Performance evaluated in this thesis is under intra subcarrier scenario on Rayleigh faded environment under perfect channel state information.

- This paper focus on user non effect on frequency offset or TX frequency and RX frequency are the same, better to show power allocation user different frequency or add effect on frequency off set in future work.
- Paper focus on non-line of sight environment for future work better to consider the effect of power allocation on different faded environment.
- Non-convex optimization problem in the case of HetNet problem better to show future work.
- Performance of NOMA compering with other multiple access technique and Implementing NOMA in real time platform in order to evaluate the performance over a practical medium is also future work.
- In heterogeneous network, a lot of small cell in underlay on a single MBS, where in SBS side users is not treated as comp users, its challenging concept on HetNet. And error mitigation technique in small base station non-comp users intercell interference is high, better to work on future work.

References

[1] Z. Wei, J. Yuan, D. W. K. Ng, M. Elkashlan, and Z. Ding, , “A Survey of Downlink Non-Orthogonal Multiple Access for 5G Wireless Communication Networks,”, accepted by ZTE Communications, Sep. 2016. .

[2] L. Dai, B. Wang, Y. Yuan, S. Han, C. I. I, Z. Wang, , "Non-orthogonal multiple access for 5g: solutions challenge opportunities and future research trends,", IEEE Communications Magazine, vol. 53, no. 9, pp. 74-81,, Sep. 2015. .

[3] J. Choi, , "Non-orthogonal multiple access in downlink coordinated two-point systems, ," IEEE Communications Letters, vol. 18, pp. 313-316, , Feb. 2014. .

[4] G. Y. L. W. C. D. W. K. N. R. S. Q. Wu, ", “An Overview of Sustainable Green 5G Networks,”," IEEE Communications Society,, Aug. 2017., pp. vol. 24, no. 4, pp. 72-80,.

[5] X. C. W. G. a. D. W. K. N. J. Chen, ", "Resource Allocation for a Massive MIMO Relay Aided Secure Communication," on Inf.," in *Forensics & Security*,, IEEE Trans., , Aug. 2016. , pp. vol. 11, pp. 1700-1711.

[6] D. W. K. N. a. J. Y.] L. Zhao, "Multi-user Precoding and Channel Estimation for Hybrid Millimeter Wave Systems,"Special Issue on Millimeter Wave Communications for Future Mobile Networks,, IEEE Journal of Selected Areas in Communications (IEEE JSAC) , 2019.

[7] P. W. C. C. D. W. K. N. E. S. L. a. S. S. J. Liu, , "Hybrid Visible Light Communications in Intelligent Transportation Systems with Position Based Services," i, n Proceedings of the IEEE Global Communications Conference (Globecom) , 2012 Workshop.

[8] E. S. L. a. R. S. D. W. K. Ng, " "Wireless Information and Power Transfer: Energy Efficiency Optimization in OFDMA Systems,"," IEEE Trans. , Dec. 2018., pp. Wireless Commun., vol. 12, pp. 6352 - 6370,.

[9] E. S. L. a. R. S. D. W. K. Ng, ", "Energy-Efficient Resource Allocation in OFDMA Systems with Hybrid Energy Harvesting Base Station,"," in *Wireless Commun.*, ,, IEEE Trans., Jul. 2013. , pp. vol. 12, pp. 3412 - 3427.

[10] E. J. S. S. P. Cao, ""Pareto boundary of the rate region for single-stream MIMO interference channels:," in *linear transceiver design,"* , IEEE Trans. on Signal Processing, , Oct. 2016. , pp. vol. 60, no. 20, pp. 4907-4922, .

[11] E. S. L. a. R. S. D. W. K. Ng, ""Energy-Efficient Resource Allocation in Multi-Cell OFDMA Systems with Limited Backhaul Capacity,"," IEEE Trans. Wireless Commun.,, Oct. 2017. , pp. vol. 11. pp. 3618 - 3631, .

[12] E. S. L. a. R. S. D. W. K. Ng, ", "Energy-Efficient Resource Allocation in OFDMA Systems with Large Numbers of Base Station Antennas," I., ,," EEE Trans. Wireless Commun, Sep. 2016. , pp. vol. 11. pp. 3292 - 3304.

[13] E. S. L. a. R. S. D. W. K. Ng, ""Energy-Efficient Resource Allocation for Secure OFDMA Systems," ,," IEEE Trans. on Veh. Technol,, Jul. 2017. , pp. vol. 61, pp. 2572 - 2585.

[14] al., M. Basit et, "“On the Power Allocation of Non orthogonal Multiple Access for 5G Wireless Networks ”, Kumoh National Institute of Technology (KIT) , Dec 2016," *On the Power Allocation of Non orthogonal Multiple Access for 5G Wireless Networks,* Dec 2016.

[15] Z. Wei, D. W. K. Ng and J. Yuan, I, IEEE Global Communications Conference (GLOBECOM),,, Washington, DC,,: "Power-Efficient Resource Allocation for MC-NOMA with Statistical Channel State Information, 2016, pp. pp. 1-7..

[16] P. X. M. I. R. T. M. Al-Imari, "Uplink Non-Orthogonal Multiple Access for 5G Wireless Networks,, " Wireless Communications Systems, 11th International Symposium on, pp 781-785, , August 2014. .

[17] G. Y. L. W. C. D. W. K. N. R. S. Q. Wu, “An Overview of Sustainable Green 5G Networks,” vol. 24, no. 4, pp. 72-80,, IEEE Communications Society,, Aug. 2017. .

[18] G. Y. L. W. C. D. W. K. N. R. S. Q. Wu, “An Overview of Sustainable Green 5G Networks,, Aug. 2017.: ” IEEE Communications Society, vol. 24, no. 4, pp. 72-80, Aug. 2017., [4].

[19] I. G. G. R. a. M. K. D. Lopez, “Enhanced intercell interference coordination challenges in heterogeneous networks,” IEEE Wirel. Commun., vol. 18, no. 3, pp. 22–30, 2011., IEEE Wirel. Commun, 2011.

[20] S. Brueck, , “Heterogeneous networks in LTE-Advanced,”, IEEE Int. Symp, 2011..

[21] Glaucio H.S. Carvalho,, eHandbook of Green Information and Communication Systems, Alagan Anpalagan, 2016.

[22] A. Daeinabi, “Intercell interference mitigation in long term evolution (lte) and lte-advanced,” Ph.D. dissertation,, 2015..

[23] S. Brueck, [30] S. Brueck, “Heterogeneous networks in lte-advanced,” in Wireless Communication Systems (ISWCS), 2011 8th International Symposium,, IEEE, , 2011 pp. 171–175..

[24] Y. K. A. B. T. N. A. L. K. H. . Saito, [24] Y Non-orthogonal multiple access (NOMA) for cellular future radio access, i, Dresden, Germany: n Proceedings of IEEE VTC (Spring), June 2013) pp. 1–5,.

[25] Z. Ding, F. Adachi, H.V. Poor, The application of MIMO to non-orthogonal multiple access . Wirel. Commun. 15(1),, IEEE Trans, 537–552 (2016).

[26] I. G. G. d. l. R. M. K. T. Q. S. Q. D. Lopez-Perez, Enhanced Intercell Interference Coordination Challenges in Heterogeneous, IEEE Wireless Communications, , vol. 18, no. 3, pp. 22–30, June 2017..

[27] A. Benjebbour, A. Li, Y. Saito, Y. Kishiyama, A. Harada, and T. Nakamura., "Concept and Practical Considerations of Non-orthogonal Multiple Access (NOMA) for Future Radio Access. Intelligent Signal Processing and Communications Systems (ISPACS),," in *ntelligent Signal Processing and Communications Systems (ISPACS),*.

[28] N. Otao, Y. Kishiyama, and K. Higushi. , "Performance of non-orthogonal access with SIC in cellular downlink using proportional fair-based resource allocation. I),," nternational Symposium on Wireless Communication Systems (ISWSC, pp. . 476-480, 2017..

[29] T. Cover, “Broadcast channels,”, IEEE Trans nf. Theory, vol. 18, no. 1, pp. 2-14, Jan 1972., Jan 1972..

[30] Saito, Y. K. (June 2013) pp. 1–5, Non-orthogonal multiple access (NOMA) for cellular future radio access,, Dresden, Germany:: Proceedings of IEEE (Spring)..

[31] S. T. a. I. Krikidis, , “Fairness for non-orthogonal multiple access in 5G systems,, ” Lett., vol. 22, no. 10, pp. 1647–1651, Oct. 2019.: IEEE Signal Process..

[32] L. S. Emil Björnson, Rayleigh Fading Modeling and Channel Hardening for Reconfigurable Intelligent Surfaces, IEEE Wireless Communications Letters, 10 Sep 2020 (.

[33] P. Tang, Analysis of Multipath Fading and Doppler Effect with Multiple Reconfigurable Intelligent Surfaces in Mobile Wireless Networks, 31 Jul 2021.

[34] C. O. Bruno Clerckx, Rayleigh Fading Channel, Cognitive Radio Communications and Networks, 2010.

[35] M. A. Haowei Bai, Error modeling schemes for fading channels in wireless communications., IEEE Comm. Surveys and Tutorials, v5,, 2003, pp.2-9..

[36] 2. m. I. T. L. (. m. I. R. P. L. JIE ZENG1, Investigation on Evolving Single-carrier NOMA into Multi-carrier NOMA in 5G, EEE Access 6:1-1, August 2018.

[37] M. M. F. S. Andrea Abrardo, Power and subcarrier allocation in multicarrier NOMA-FD systems, 21 Apr 2020].

[38] Z. D. M. E. a. J. Y. Y. Liu, "Non-orthogonal multiple access in large-scale underlay cognitive radio networks,", EEE Trans. Veh. Techno Il., vol. PP, no. 42 .

[39] Z. Y. P. F. a. H. P. Z. Ding, "On the performance of nonorthogonal multiple access in

5G systems with randomly deployed users", EEE Signal Process. Lett., vol. 21, no. 12, pp. 1501–1505, , Dec. 2019..

[40] A. B. Y. K. T. N. Y. Saito, "System-level performance evaluation of downlink non-orthogonal multiple access (NOMA)", Proc. pp. 611-615,, : IEEE Annu. Symp. Pers. Indoor Mobile Radio Commun. (PIMRC),, Sep. 2018..

[41] T. A. e. al, ., "Performance Analysis of Zero Forcing Equalizer in 2×2 and 3×3 MIMO Wireless Channel",, Global Journal of Researches in Engineering (F) Volume XIV Issue IX Version I, , December 2014. .

[42] A. Daeinabi, "Intercell interference mitigation in long term evolution (lte) and lte-advanced,", Ph.D. dissertation, , 2015..

[43] A. Daeinabi, , "Intercell interference mitigation in long term evolution (lte) and lte-advanced,, Ph.D. dissertation, 2015., 2015..