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Resource Management in 5G Heterogeneous Network

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Abstract

Due to the explosive growth of mobile data traffic and the shortage of spectral resources, 5G networks are envisioned to have a densified heterogeneous network (HetNet) architecture, combining multiple radio access technologies (multi-RATs) into a single holistic network. Our aim is to address the technical challenges of data traffic management, coordinated spectrum sharing in 5G HetNets through the introduction of a programmable management platform based on Non-Orthogonal Multiple Access (NOMA) and Successive Interference Cancellation (SIC) method. It results in the cancellation of both inter cellular and intra cellular interference. Also, the data rate at the receiver side is obtained without interference and noise by reducing the power consumption and increasing spectral efficiency. Interference has a large power than its desired signal. So, at first, the interference signal is detected and SIC is carried out to avoid interference.

Keywords: NOMA, Successive Interference Cancellation, Power Optimization, **5G.**

I. INTRODUCTION

As the interest for digital substance and administrations over the mobile networks keeps on rising, same as the quantity of users/gadgets coming on the web, the present fourth era (4G) of mobile networks area about or each their capacity limit. By 2022, around 9 billion mobile subscriptions, 8.3 billion mobile broadband memberships, and 6.2 billion interesting mobile supporters are relied upon to be accessible. Mobile data traffic is likewise anticipated to expand with this large amount of memberships, achieving estimations of 71 Exabyte's for every month. The video applications drive the vast majority of this high volume of data.

One of the fundamental upgrades coming about because of deploying the fifth generation of mobile networks (5G) is therefore of high capacity in contrast with 4G. It is normal that 5G networks will deal with traffic multiple times higher than 4G and 10 to multiple times quicker with connections. What's more, there are likewise necessities for energy savings, near-zero latency and reduction in cost. 5G invites, among others, the fast advancement of the shrewd urban areas, Internet of Things (IoT), associated homes, self-governing drive, ultra-high definition video (UHD) and virtual reality. Mobile communication frameworks like WiMAX, LTE (Long Term Evolution) and LTE-Advanced are implemented in the fourth generation (4G), orthogonal multi-access (OFDMA) or single carrier (SC)- FDMA dependent on orthogonal frequency division. Orthogonal access is a sensible decision with a disentangled receiver configuration to accomplish great framework throughput performance. Be that as it may, because of the endlessly expanded requirement for high-volume administrations, such as, video streaming, image transfer and cloud-based administrations, systems past 4G require another mobile communication system with further upgrades in system throughput [1]. Different new innovations like the recent multiple access (MA) technologies, new network designs and recent strategies for use of the spectrum are expected to meet the prerequisites upgrading multiple access (MA) from the orthogonal to the non-orthogonal is relied upon to be an encouraging methodology for the 5G framework among the basic technologies.

To fathom the mobile data traffic, and to expand the capacity multiple times, densification of cells, increment in bandwidth, and high spectral efficiency is required. Because of use of 300 MHz to 3GHz, likewise called millimeter wave (mm wave), the signals are influenced by increment in the loss of free isotropic space, loss through attenuation and penetration during engendering, because of ingestion by downpour, oxygen particles, and so on. Closed networking between macro cells and small cells enables users to have a synchronous connection with small cells access points (APs) and micro cell base station (BSs). A practical option is the wireless backhauling, which gives innovation, augmentation of topographical coverage and extension of capacity to totally utilize the heterogeneity of networks. A wireless self-backhauling utilizes a similar frequency band for access links and backhaul (BH).

Different NOMA solutions can be partitioned fundamentally into two primary methodologies. As opposed to NOMA power - domain multiplexing in the power domain, NOMA code - domain multiplexing in the code domain. The NOMA code - domain shares every single accessible resource (frequency/time, for example, the fundamental division of a multi-access code (CDMA). Code-domain NOMA, then again, utilizes user explicit transferring sequences that are cross sequences - correlation sequences with a small correlation. [14]

In this paper, the NOMA concept for spectrum efficiency upgrades of the future in lower frequency groups for 5G system downlink is depicted. After that, the main component technologies are exhibited. Power allocation and optimization, and receiver design are discussed. Here we are augmenting the spectral efficiency and, in this way, expanding the data rate and diminishing the power consumption. In the receiver design, the interference is dropped by utilizing successive interference cancellation. Finally plotting the channel capacity versus SINR of one antenna and comparing the bit error rate of the proposed and the existing method.

II. PRINCIPLE OF NOMA

A. Concepts of NOMA

NOMA is an extremely encouraging methodology for future access to radio and can be utilized for downlink just as uplink. In traditional 4G systems, as regular expansion of OFDM, orthogonal frequency division multiple access (OFDMA) is utilized as a characteristic augmentation of OFDM, orthogonal frequency division multiple access (OFDMA) is utilized in customary 4G networks where data is assigned to a subset of sub-carriers for every user. In NOMA, then again, the majority of the subcarriers may be utilized by every user. Fig.1 shows the sharing of spectrum for OFDMA and NOMA for two users.

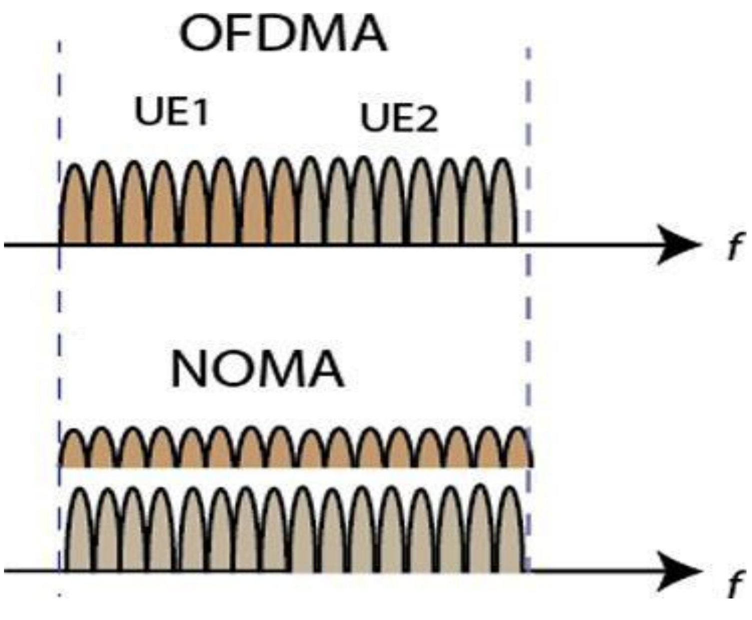

Fig.1. *Spectrum sharing for OFDMA and NOMA for two users. Courtesy [14]*

In this paper, we introduce a transceiver concept. Here if a message is transmitted from microcell to user then microcell is acting as a transmitter and user is acting as a receiver and vice versa.

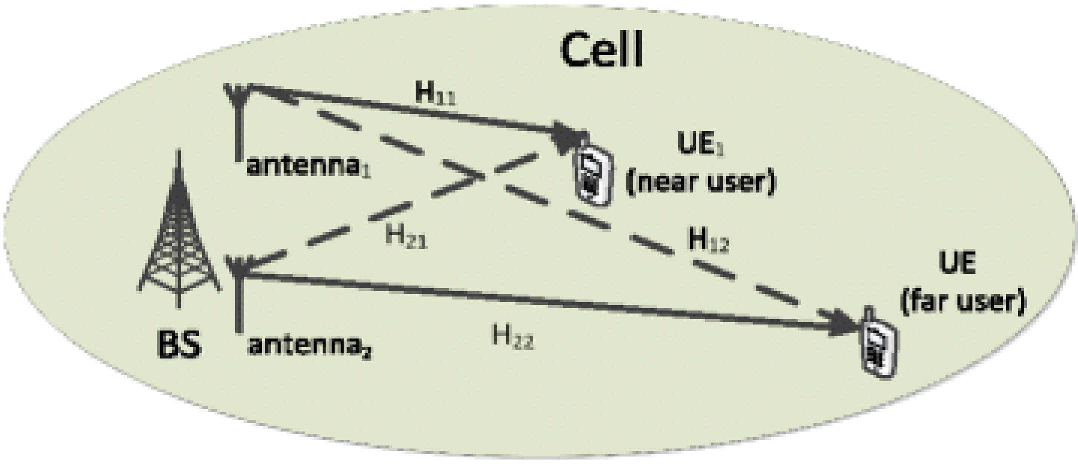

Fig.*2. Transmission scenario for the NOMA-MIMO downlink system of 2-UE. Courtesy [13]*

Fig.2 illustrates the downlink NOMA-MIMO transmission scenario for a 2-UE, where UE1 is a cell- center (near user) user and UE2 is a cell-edge (far user) user. For example, if user (UE) is to communicate with user1 (UE1), the former should sends its data to microcell and then from microcell to user1 rather than direct communication between users.

B. Benefits of NOMA

NOMA technology is utilized for improving spectrum efficiency and many benefits, including but not limited to the following [2]:

- It attains superior spectral efficiency by serving multiple users with the same frequency resource and mitigating SIC interference, simultaneously.
- It increases the number of users served at the same time and can therefore support massive connectivity.
- No need to expand the number of transmitting antennas: from the perspective of expense and space requirements of macro cell and small cell deployments in the practical network, it is very significant.
- Very good backward compatibility with OFDMA and SC-FDMA: it is easy to apply downlink NOMA and uplink SCFDMA on OFDMA.

NOMA have a very good affinity with multi - antenna technology: In order to improve the system performance, NOMA can be effectively joined with beamforming and SU / MU MIMO methods.

III. SYSTEM MODEL

In this paper, we use downlink transmission for a NOMA network of microcell (base stations) where M users and N microcells are present and the downlink bandwidth is split into multiple subbands. Base Station conducts downlink transmission with transmission power that is different for different users to multiple users, simultaneously, in each subband. Different from OFDMA, where only one user is scheduled in a subband, more than one user can be scheduled in a subband in NOMA. Let us consider a subband with M users multiplexed simultaneously in the subband.

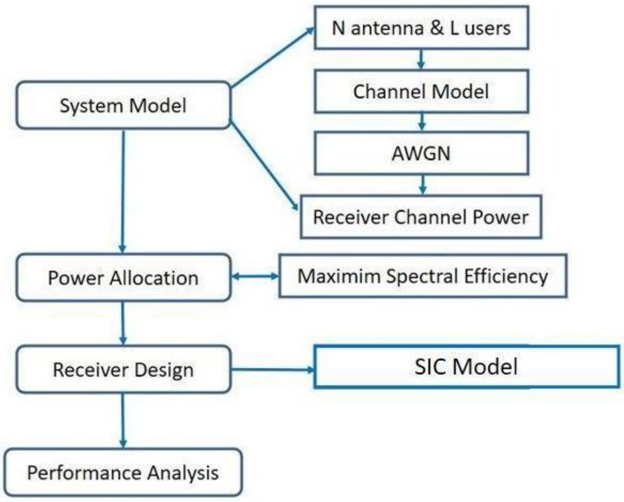

Fig.3. *System Model*

Fig.3 illustrates the system model, where L users and N antenna are used. The Rayleigh channel and AWGN is added to the input data. The signal also consists of intercellular and intracellular interference. Power allocation is done so as to maximize the spectral efficiency. The transmission power for each microcell is decided based on the power assignment ratio.

In the receiver design, SIC is done to remove interference and the channel data is eliminated using Zero Force Equalization. Hard decision decoding is done to remove noise data. Finally, the data is demodulated. The difference between the demodulated data and input data gives the Bit Error Rate (BER). As BER decreases interferences also reduces.

The signal received at the user$n$ can be explained by,

$$y_n = h_n \sum_{k=1}^{N} S_k . \sqrt{P_k} + I_n + n_n \qquad (1)$$

where n, k∈[1, N] represents the user index, h_n represents base station channel response to user$n$ and S_k represents data symbol transmitted for user$k$. The inter- cell interference and additive white Gaussian noise is observed at user$n$, and is denoted by I_n and n_n.

A. Power Allocation and Optimization

The aim of power optimization is to increase the overall spectral efficiency and decrease the power consumption with a constraint that the sum of power assignment ratio should be equal to 1.We are using a BPSK modulated input data. The transmission power of k microcell is determined by,

$$P_k = \beta_k \times P_{BS} \tag{2}$$

where $\beta_k \in (0, 1)$ denotes power assignment ratio of user$_k$, P_{BS} denotes transmission power of BS.

While transmitting data through Rayleigh channel, it is affected by both intercellular and intracellular interference as well additive white Gaussian noise. Then the received signal is described as,

$$y_n = h_n \times s_n \sqrt{P_k} + h \sum_{k=n+1}^{N} S_k \sqrt{P_k} + h \sum_{k=n+1}^{N} S_k \sqrt{P_k} + I_n + n_n \tag{3}$$

The power of the received signal is calculated using,

$$\boldsymbol{P_Z} \ \frac{\mathbf{1}}{\boldsymbol{N}} \sum |\, \boldsymbol{x} |^{\mathbf{2}} \tag{4}$$

where N is the length of the signal and x is the input.

The user$_n$ SINR after SIC post-processing can be calculated by

$$\mathrm{SINR}^{\mathrm{Post}} = \frac{P_n}{\sum_{k=1}^{n-1} \beta_K + \frac{1}{SINR_n}} \tag{5}$$

$$SINR_n = |h_n|^2 P_{BS} / (N_{SB} P_{1+N}) \tag{6}$$

$SINR_n$ denotes the SINR of user, when the total transmission power assigned to the user and P_{I+N} represents the total power of inter-cell interference and noise observed at user$_n$[2].

The SINR differs for both the existing and proposed method. For proposed method, the power assignment β∈ (0,1) and the sum should be equal to 1. The channel capacity and spectrum efficiency is calculated by:

$$Channel\ Capacity = B \log(1+SINR) \tag{7}$$

where, B is the bandwidth.

$$\text{Spectrum Efficiency} \ \frac{Channel\ Capacity}{Bandwidth} \tag{8}$$

Algorithm 1 Random Search algorithm

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1. **Initialize:** {i_k=0,eff=0;
2. **Repeat:**

1: evaluate fitness

2: if fitness greater than eff 3: evaluate β,C,P_Z

4: end

3. **Find** optimal power allocation value

B. Successive Interference Cancellation

Due to NOMA's non - orthogonality, the transmitter deliberately adds interference in the power domain. SIC can be used to mitigate this interference. UEi's received signal is as follows:

$$Yi = hiX + Wi \qquad (9)$$

where h_i denotes the complex channel coefficients between UE_i and the base station, and W_i(n) denotes the Gaussian noise including inter-cell interference affected at UE_i. The order that is optimal for decoding the signal received is in the order of the increasing strength of signal (for example, the channel gain that is normalized by the noise and inter- cell interference). In such manner, UEs are sorted out based on their signal strength, with the goal that any UEn will first decode the signal that is the strongest and isolates the desired signal from the combines signal received. To illustrate the outline of SIC better, assume that we have two users, UE1 and UE2, and at first, UE2 comes in the decoding order, so the signal of UE2 is the strongest (more power). In the UE2 receiver, the decoding is as follows [3]:

The M2 message is decoded from Y2, and X1 is treated as noise. The interference brought about by UE1 on UE2 ought not influence the performance of UE2 altogether, as the power from this interference is probably going to be very much lower than the signal desired. Now, this is substantial for the transmitter to be successful in power allocation at the transmitter side.

The decoding method for UE1 is much more complicated and SIC is used here.

1. The message M2 is decoded from Y1, considering X1 as noise. The decoding process for UE1 is more complex and SIC is utilized here. This step is conceivable in light that UE1's channel gain is more than UE2's, so as long as UE2's rate is within its recipient’s Shannon limits, it will likewise be inside the UE1 recipients' limits.

2. Using an encoder, X2 is regenerated and with knowledge of h1 and P2, Y1 is subtracted from h1√P2X2 and obtained:

$$Y'' = Y1 - h1\sqrt{P2X2} = h1\sqrt{P1X1} + Wi \quad (10)$$

3. The message M1 is decoded from Y'.

C. Reconstruction of signal

The received signal is reconstructed by eliminating the channel data and noise. Using Zero Force Equalization the channel data is removed. Hard decision decoding is done to remove noise. The hard decision decoder makes a decision based on the threshold value.

Fig.6 shows the Bit Error Rate plot. The Bit Error Rate is calculated by counting the number of errors. If the error is minimum, then we can know that the signal received is free of interference. By subtracting the reconstructed signal from the input signal, we can determine the number of errors.

IV. PERFORMACE ANALYSIS AND SIMULATION PARAMETERS

A. Simulation parameters

The simulation parameters are listed below:

Table I . Simulation parameters

Parameters	**Value**
Number of base antennas	4
Channel	Rayleigh
Noise	AWGN
Modulation	BPSK
Bandwidth	10MHz
Power of the base band	60W

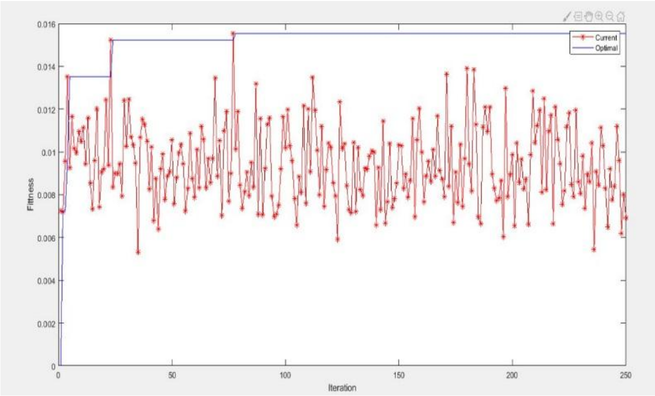

Fig.4 *Optimal Power Allocation Value*

Fig.4 depicts the power points that is optimal, which is obtained after power optimization using random search algorithm with a constraint that the power assignment ratio (β) lies within the range (0,1) and the sum of β should be equal to 1.

B. Performance analysis

In this paper, we compare the BER of the existing method and proposed method. Next, we plotted the graph of channel capacity versus SINR for a single antenna.

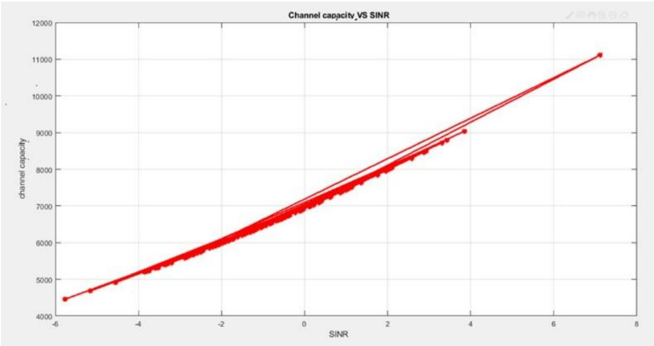

Fig.5 Graph of Channel Capacity versus SINR

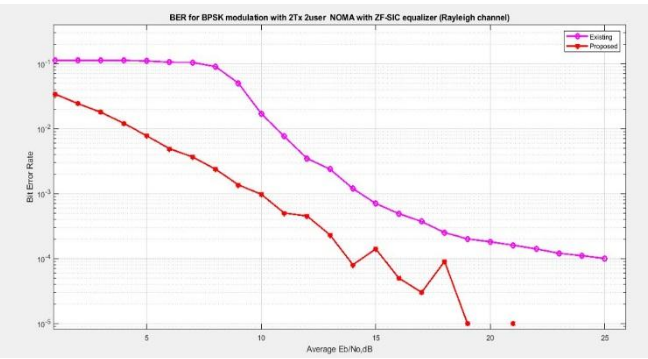

Fig.6 Bit Error Rate

V. CONCLUSION

Users are more concerned about efficient usage of available data and its usage without outside interference. Using a SIC module, 5 G interference is eliminated. A new user will not interfere with the normal connectivity here. It prevents intercellular interference and intracellular interference. Therefore, the non - orthogonal multi - access system can achieve significantly high cell output and cell edge output performance gains. This increases the data rate by reducing energy consumption and increasing spectral efficiency. Increased spectrum efficiency and system output therefore lead to a difference in the channel between users, which is translated by non - orthogonal multiplexing into multiplexing gain.

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