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Spectrum Efficiency improvement in 5G Network using NOMA

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Abstract— *Non-Orthogonal Multiple Access (NOMA) achieves optimal spectrum requirements of 5G and future networks. The research work focuses on how to increase the absolute efficiency (SE) of the NOMA energy domain in the 5G network using two new approaches and a smart radio network. These methods use Massive MIMO, Simple-Input and Simple-Output, and Single-Input and Single-Output in a single cellular network. NS2 software was used for situations by distances, power placement coefficients & transmission power to test proposed approaches. Each scenario implies that users are using the Quadrature Phase Shift Keying modulation technique and operating within defined bandwidths. The performance assessment considers frequency selective Rayleigh fading, unstable channel circumstances & successive interference cancellation. Outcomes show that downlink NOMA with a single input and single output achieves the best spectral efficiency performance. Spectral efficiency increases when paired with cooperative cognitive radio network. The results show that SE is greatly increased by using MIMO & M-MIMO techniques.*

Keywords— ***NOMA; MIMO; M-MIMO***

I. INTRODUCTION

Generally, multiple users use following access ways:

- Frequency Division Multiple Access - FDMA
- Time Division Multiple Access - TDMA
- Code Division Multiple Access - CDMA

Figures below shows orthogonal and non-orthogonal multiple access schemes.

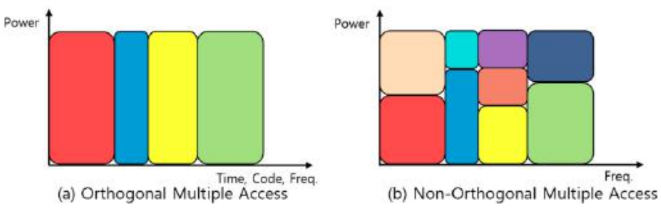


Fig.1: Orthogonal & Non-Orthogonal Multiple Access

According to [3], primary idea of NOMA enables for tolerating many users by segmenting them. NOMA users increases with the availability of orthogonal resources [4-6]. NOMA power/code domain are the two main domains that make up NOMA. Multiple users in the power domain (PD) make use of same frequency (f) or time resource with various power flows.

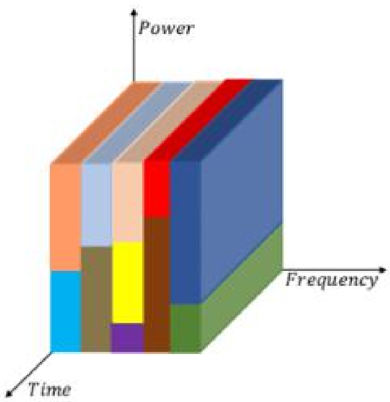


Fig.2: NOMA Power Domain

Every user on the CD has a unique codebook created to match their data [7]. Future systems will therefore need to dramatically increase capacity and SE to manage the anticipated spike in traffic.

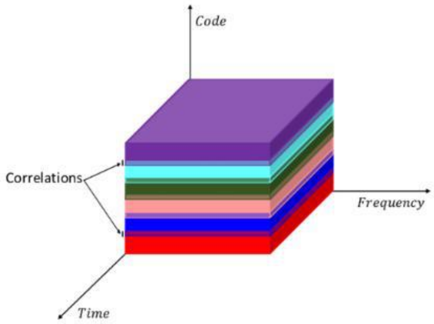


Fig.3: NOMA Code Domain

Future mobile network generations will significantly boost system capacity and resource utilization [8]. Sharing spectrum between several users is one such way. More users can be accommodated by non-orthogonal allocation (NOMA) than by the number of orthogonal resource modules.

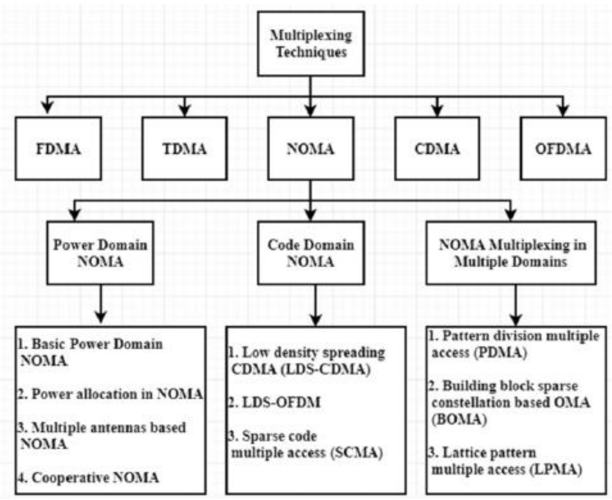


Fig.4: Multiplexing Techniques Comparison

These multiple access strategies are useful for diverse communication circumstances and have varied advantages. They deal with the difficulties of distributing scarce resources among numerous users and make it possible for wireless networks' available communication channels to be used effectively.

Unfortunately, there isn't much spectrum left for wireless applications. In order to fulfil the rising traffic and service needs and avoid potential spectrum scarcity, it is imperative to create innovative techniques [9]. A technique based on cognitive radio (CR) [10] can be helpful to resolve the outlined issues. If interference to PUs is tolerable, SUs may transmit over primary frequency bands.

Cognitive radio technology is used by a wireless network called Cognitive Radio Network (CRN) for improving spectrum use & overall network performance. CRN can automatically perceive, adapt, and dynamically assign spectrum resources based on the shifting wireless environment and the network's communication requirements thanks to cognitive radio technology.

Following are crucial characteristics & elements:

- Spectrum Sensing
- Spectrum Management
- Dynamic Spectrum Access (DSA)
- Interference Mitigation

Context of upcoming wireless communication technologies like 5G and beyond, they have been a focus of active research and development.

The authors of [11] examined a crucial CR procedure and talked about two strategies for spectrum sharing that improve radio frequency utilization. These techniques seek to minimize interference between licenses for conventional and cognitive radio. Various types of spectrum access can be grouped based on [12]'s analysis of spectrum utilization. [13] also examined various spectrum access methods and categorized them into classes. MIMO NOMA technology can be used in a CRN to achieve active cooperative spectrum sensing (CSS) for both primary and secondary users.

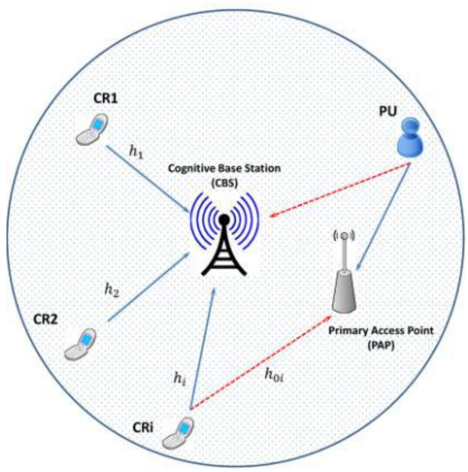


Fig.1.5: Typical Cognitive Radio Network (CNN)

The CRN can still only be accessed through certain channels, and are currently a finite amount of users. The impact of power localization coefficients is not addressed, and the resulting results cannot be extrapolated to a vast network [14].

5G architecture can be a combination of single-input, single-output and MIMO technologies, utilizing massive input (Down Link PD NOMA with CCR) through two distinct methods. It showcases enhanced spectral efficiency compared to conventional SISO DL NOMA modelling.

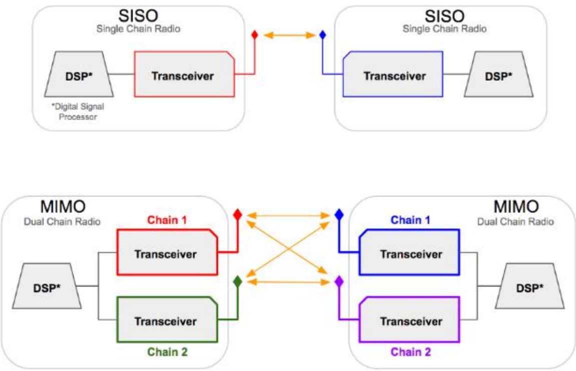


Fig.6: SISO and MIMO Hardware Comparison

(Source: http://docs.arednmesh.org/en/latest/arednHow-toGuides/siso-mimo.html)

Here is a comparison of hardware setups for SISO and MIMO:

SISO (Single Input Single Output): One antenna at broadcaster & one antenna at receiver make up a SISO communication system. In SISO systems, the received signal is received by a single antenna at the receiver after travelling across a single channel during transmission. Simple wireless communication systems, such those found in Bluetooth devices and entry-level wireless routers, frequently employ SISO systems. The key benefits of SISO are its affordability and simplicity, which make it appropriate for applications with low complexity requirements. MIMO uses multiple antennas at transmitter & receiver is referred to as MIMO.

SISO & MIMO comparisons can be summarized as:

- Data Rate and Capacity
- Spatial Diversity and Multiplexing
- System Complexity
- Cost and Power Consumption

Problem Statement

Poor spectral efficiency leads to transmission problems that limit communication performance. There are several important strategies that can be used to improve overall efficiency (SE). Increasing the number of users and implementing multiple input methods (MMIMO) are two of them.

Significance of Research

This study introduces two innovative approaches aimed at enhancing the spectrum efficiency of downlink NOMA power domain in 5G and future networks. NOMA being acknowledged as an effective solution for meeting SE requirements. The proposed techniques involve integrating SISO which is abbreviation for single-input, single-output, MIMO and M-MIMO within the same network. Additionally, these methods combine Down Link NOMA PD with cognitive radio network within single cell.

Research Objectives

Following are summarized research objectives:

- Improving 5G network's downlink (DL) NOMA power domains' (PDs) spectrum efficiency (SE) performance.
- Coming up with strategies to be used to integrate SISO, 64x64 MIMO, and 128x128 M-MIMO technologies with a cooperative cognitive radio network (CCRN).
- Lessen AWGN, interference cancellation (SIC), and unstable channels when Rayleigh fading is present.

Research Questions

- How can 5G network's downlink (DL) NOMA power domains' (PDs) spectrum efficiency (SE) performance be improved?
- Can unique strategies be used to integrate SISO, 64x64 MIMO, and 128x128 M-MIMO technologies with CCRN?
- Is it possible to lessen AWGN, interference cancellation (SIC), and unstable channels when Rayleigh fading is present?

II. LITERATURE REVIEW

Outage probability (OP) & throughput of CR-NOMA system were investigated by author of [15]. Closed-form expressions for OP were developed for assessing performance of secondary network users in event that the primary network interferes. Numerical results suggest that both users can have fair performance when employing the power distribution/energy harvesting parameters. Furthermore, the authors test each framework's spectrum model and compute the MIMO-CR-NOMA framework's overall efficiency and per-user reach for Internet of Things applications [16].

The authors mention the difficulty of creating products in many NOMA systems [17]. Their results show that introducing an information radio network (CRN) foundation for a multi-carrier NOMA network results in an increase in overall throughput with only a slight decrease in first-user (PU) pass-through when below target. In the context of Business 5.0, the authors develop an asymptotic model for a NOMA-based coverage radio network (CRN) using an analytical model of reliability parameters [18].

Effect of phase and voltage distribution upon performance has been investigated through simulation [19]. The authors propose a resource allocation that strikes a balance between power consumption and spectrum efficiency in multi-carrier NOMA, including user fair rules. Simulators were used to validate the results of the corrected performance study, and closed models were used to estimate the chance of outages for primary and secondary users [20].

The research focuses on actively breaking reconfigurable smart surface (RIS) transmitters designed to transmit private signals over IoT networks. In the presence of many eavesdroppers, reflective RIS is used to improve security performance. From the simulation results, the proposed proposal, which is a combination of power dissipation, transmission power dispersion, and phase change of interference and interference RIS, demonstrated its effectiveness in increasing weight [21]. The usefulness and superiority of the suggested strategy over current practices were proven by the simulation findings. The simulations presupposed a homogeneous planar array for the base station and a multi-beam antenna array for the satellite [22]. This study explores stabilization and energy saving beamforming in multi-beam satellite systems, for example, one eavesdropper per beam.

Another area of focus is the active-breaking Reconfigurable Smart Surface (RIS) as transmitters for personal signaling in IoT networks. Use the RIS hypothesis to improve performance in large audiences. Simulations validated effectiveness of the design optimizing the weight and privacy of common power distribution, power transmission & phase change of associated & related RIS [24].

In [25], authors present a partial collaboration zero interference decoding (PCZF) technique for large, cell-free uplink MIMO systems. The technology includes proximal access points around user equipment to reduce interference via zero-determination state information exchange (CSI).

In order to solve their shortcomings, there is a prevalent trend in modern research to integrate diverse 5G approaches. As an illustration, the authors of reference [26] used cooperative communication to get around the considerable path loss that comes with millimeter-wave (mm-wave) technology. Beyond mm-wave and NOMA, a wide range of innovative methods for enhancing radio spectrum efficiency are projected to have a substantial impact on the development of 5G and subsequent technologies.

Building successes of cooperative non-orthogonal multiple access (NOMA) using conventional radiation and the superior performance of orbital angular momentum (OAM) in increasing system throughput, along with promising findings from reference [27], another study introduces a novel method that combines cooperative NOMA and OAM transmission. Sending messages from all users at various power levels across all the OAM modes is necessary for this integration.

The existence of a large number of mobile devices in a network with a big number of connected devices necessitates the usage of non-orthogonal multiple access (NOMA). NOMA networks enable significant increases in spectral efficiency and low latency, outperforming orthogonal multiple access (OMA) networks [28].

Cognitive radio technology can dynamically change communication channels to enable intelligent access for secondary users when the current channel is congested. In NOMA, multiple simultaneous accesses are possible at the same power level, enabling intelligent multiple access for both primary and secondary users and leading to better spectrum utilization. To enhance the performance of cognitive NOMA in 5G and beyond, several aspects can be improved, leveraging the capabilities of cognitive radio and intelligent spectrum allocation [29-30].

To fulfill future demands, researchers are focusing on the development of fifth generation (5G) and beyond fifth generation (B5G) wireless communication networks. One of the proposed systems is NOMA Non-Orthogonal Multiple Access (NOMA), which is projected to address the needs of the rapidly growing number of users, connectivity requirements, costs, and low bandwidth available in various types of wireless communication networks. However, implementing NOMA in wireless communication networks presents both obstacles and advantages. Previous research studies introduced NOMA concepts, compared them to other approaches, and addressed related concerns [31–32].

The growth of base stations in cellular networks helps to provide larger coverage, but it also causes interference among users at the cell edges, which reduces overall coverage. As a result, ensuring improved coverage becomes a difficult challenge in future cellular networks. Traditional multiple access techniques will not be able to fulfil the future expectations of 5G, which include high data speeds, low latency, huge interconnection, and good spectrum efficiency. As the number of cellular users in 5G networks grows, receiver complexity becomes a major challenge. NOMA approaches, on the other hand, can be used to reduce this complexity. NOMA allows numerous users to be assigned to a single resource block utilizing allocation algorithms that are then decoded at the receiver to reduce system complexity. By taking this method, you can enhance your bit error rate, throughput, and system capacity [33].

As the user base of existing mobile and cellular networks grows, spectrum distribution becomes more difficult. These barriers frequently cause users to transfer to other networks, forcing telecom firms to struggle with providing high-speed services. As a result, the demand for 5G networks is increasing. Given these circumstances, the suggested algorithm seeks to meet the needs of the user. Its main distinguishing characteristic is its capacity to properly detect primary and secondary users inside the 5G network and allot spectrum accordingly, fulfilling the needs of each user category [34].

III. RESEARCH METHODOLOGY

It consists of three study method models: control domain multi-input multiple access, non-orthogonal multiple access (M-MIMO DL PD NOMA), control domain multiple output, multiple non-orthogonal access (MIMO DL PD NOMA), and single access single downlink. Non-Orthogonal Multiple Access (SISO-DL NOMA).

Simulation Design and Setup

Simulations were done using NS2.

Table 1. Simulation Parameters

	Parameters	Values	
1	Total no of users in the network	5	
2	Transmitted power	0 to 30 dBm	
3	Bandwidth	BW	80 MHz
4	Distances	U1	1000 m
		U2	800 m
		U3	500 m
		U4	300 m
		U5	200 m
5	Power coefficients	U1	0.76
		U2	0.184
		U3	0.048
		U4	0.012
		U5	0.008
6	Path loss exponent	5	
7	Single Input Single Output (SISO)	1 x 1	
8	Multiple Input Multiple Output (MIMO)	64 x 64	
9	Massive Multiple Input Multiple Output (M-MIMO)	128 x 128	
10	Modulation Type	Quadrature Phase Shift Keying (QPSK)	

The parameters which will be examined will be:

- NOMA Spectral Efficiency SE (User 1, User 2, User 3, User 4 and User 5)
- Cooperative Cognitive Radio CCR-NOMA Spectral Efficiency Competing Channel C-CH (User 1, User 2, User 3, User 4 and User 5)
- Cooperative Cognitive Radio CCR-NOMA Spectral Efficiency Dedicated Channel D-CH (User 1, User 2, User 3, User 4 and User 5)
- MIMO NOMA Spectral Efficiency (User 1, User 2, User 3, User 4 and User 5)
- MIMO-CCR-NOMA Spectral Efficiency C-CH (User 1, User 2, User 3, User 4 and User 5)
- MIMO-CCR-NOMA Spectral Efficiency D-CH (User 1, User 2, User 3, User 4 and User 5)
- M-MIMO NOMA Spectral Efficiency SE (User 1, User 2, User 3, User 4 and User 5)

- M-MIMO-CCR-NOMA Spectral Efficiency SE C-CH (User 1, User 2, User 3, User 4 and User 5)
- M-MIMO-CCR-NOMA Spectral Efficiency SE D-CH (User 1, User 2, User 3, User 4 and User 5)

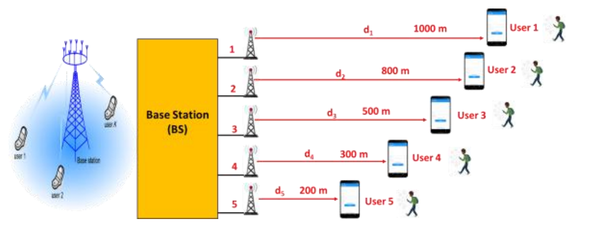
Simulations were done using NS2. The benchmark will be the research paper written by Hassan, Mohamed, (2023).

3.2 System Models

The following three models will be studied.

- SIOS DL NOMA
- MIMO DL PD NOMA
- Massive MIMO DL PD NOMA

The designed/conceptualized model is as under.



Consider a wireless network with four NOMA users: U1, U2, U3, U4, and U5. Each user is represented by d1, d2, d3, d4, and d5 and is located at a certain distance from the base station (BS). It should be noted that because to their relative locations, U1 is expected to get a weaker signal than U5, which is the closest to the BS. Rayleigh fading coefficients are represented by h1, h2, h3, h4, and h5 (corresponding to $|h_1|^2$, $|h_2|^2$, $|h_3|^2$, $|h_4|^2$ and $|h_5|^2$) whereas current power coefficients are represented by α_1, α_2, α_3, α_4 and α_5, correspondingly.

Fig.7: Wireless Network with five users (DL-NOMA PD) System Model

The user who is closer to the base station and has a stronger signal should be given less power, in accordance with the NOMA PD guidelines. On the other hand, greater power should be allocated to the user who is farther away from the base station and has a poorer signal. The letters x1, x2, x3, x4, and x5 stand for the power coefficients. This study uses a reduced set of power coefficients for user-friendliness. There are several dynamic options for changing the power coefficient in order to increase efficiency. Furthermore, the modified power coefficients x1, x2, x3, x4, and x5 ought to perform better than the signals transmitted to the base stations using quadrature phase-shift keying (QPSK). (Note: the equations are taken/adopted from [35]) The base station encoded overlay signal can be stated as follows:

$$x = \sqrt{p}\,(\sqrt{\alpha_1}x_1 + \sqrt{\alpha_2}x_2 + \sqrt{\alpha_3}x_3 + \sqrt{\alpha_4}x_4 + \sqrt{\alpha_5}x_5)$$

Signal received by the ith user are:

$$y_i = h_i x + n_i$$

Where,

n_i = AWGN experienced by ith use U_i.

Strongest signal decodes y_i with maximums as:

$$R_1 = log_2\left(1 + \frac{\alpha_1 P\,|h_1|^2}{\alpha_2 P|h_1|^2 + \alpha_3 P|h_1|^2 + \alpha_4 P|h_1|^2 + \alpha_5 P|h_1|^2 + \sigma^2}\right)$$

The above equation can be written as:

$$R_1 = log_2\left(1 + \frac{\alpha_1 P\,|h_1|^2}{(\alpha_2 + \alpha_3 + \alpha_4 + \alpha_5)P|h_1|^2 + \sigma^2}\right)$$

Given that denominator is total of power coefficients of other three users ($\alpha_2 + \alpha_3 + \alpha_4 + \alpha_5$), power coefficient of targeted user α_1 must satisfy: $\alpha_1 > \alpha_2 + \alpha_3 + \alpha_4 + \alpha_5$. As a result, U1 power is controlled by both sent signal x & received signal y_1. U1s data was removed & considered interference, $\alpha_2 < \alpha_1$, and $\alpha_2 > \alpha_3 > \alpha_4 > \alpha_5$ through the use of SIC [36].

$$R_3 = log_2\left(1 + \frac{\alpha_3 P\,|h_3|^2}{\alpha_4 P|h_3|^2 + \sigma^2}\right)$$

Moving on, y_3, with the exception of U1, U2, U3, U4 and U5 (where $\alpha_3 < \alpha_1$, $\alpha_3 < \alpha_2$) is included in the denominator's overlapping term. To eliminate cancelled data y_3, three sequential interference cancellation (SIC) operations must be performed. Because α_1 is the most important, it must be eliminated first. As a result, the phrase α_3 is dropped. As a result, the possible rate can be represented using the equation:

$$R_3 = log_2\left(1 + \frac{\alpha_3 P\,|h_3|^2}{\alpha_4 P|h_3|^2 + \sigma^2}\right)$$

The resulting y_4, involving U1, U2, U3, U4, and U5 (where $\alpha_3 < \alpha_1$, $\alpha_3 < \alpha_2$, $\alpha_3 < \alpha_4$) is found in the denominator's intersecting term. As a result, removing cancelled data y_4 necessitates the execution of two sequential interference cancellation (SIC) operations [37]. Given that α_1 has the highest priority, it must be removed first, followed by the phrase α_3. The attainable rate is expressed as:

$$R_4 = log_2\left(1 + \frac{\alpha_4 P\,|h_4|^2}{\sigma^2}\right)$$

For CCRN-Based Free Channels, the figure is shown below.

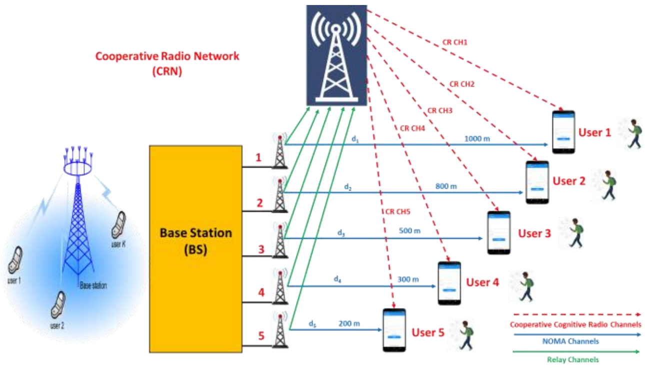


Fig.8: DL-NOMA PD with the CCR Network with four users System Model

Consider a wireless network having 4 NOMA users: U1, U2, U3, U4, and U5. In this case, U1 symbolizes weaker/far user, whereas U5 represents stronger/near user. These users' distances from their respective base stations are designated as d_1, d_2, d_3, d_4, and d_5. This scenario depicts a cooperative cognitive radio network. We may use the formula $|h_1|^2$, $|h_2|^2$, $|h_3|^2$, $|h_4|^2$ and $|h_5|^2$ to express Rayleigh fading values [38].

A cognitive radio network monitors channel status and communication accuracy. Assuming the channel is unstable and has poor communication, the Cooperative Cognitive Radio Network channel can be either available or unavailable.

- Spectrum Sensing

The cognitive radio uses entire spectrum window for packet transmission (s). Assume T_{window} depicts length of this spectral window period. It is obvious that:

$$T_{window} \geq T_{sense} + T_{CR} - Transmission + T_{ramp} - up + T_{ramp} - down$$

The figure depicts CR (i.e. transmission opportunity window) in context of beacon signals with fixed separation. T_{sense} denotes minimal time required for sensing & gathering communication parameters required to ensure CR transmission opportunity. T_{CR} Transmission defines transmission duration i.e. CR packets, whereas T_{ramp} up/down is transmission ramping.

$$PD = \frac{Number\ of\ acquisitions}{Total\ number\ of\ opportunities} = \frac{Over\_Num}{NOP}$$

In order to choose b/w 2 possibilities, spectrum sensing on link-level targets in single primary system is used.

$$y[n] = \{\ w[n]\ h\ s[n] + w[n]\ n = 1 \ldots N\ \frac{H_0}{H_1}$$

Complex signal received by mental radio is y[n], signal sent by first user being s[n], AWGN is signal w[n], h is the reception signal difficulty of good channel, denoted N. Specifies the observation distance at a position. If the channel is not good, the inversion of h and s[n] is used instead of simple multiplication. The null hypothesis, H0, states that there is no primary user signal, while the alternative hypothesis, H1, states that there is a primary user signal. There are two types of intelligence methods:

- Energy Detection

A binary choice is made in the following manner:

$$\begin{cases} H_0, \text{i f} \sum_{n=1}^{N} /y[n]^2/ \leq \lambda \\ H_1,\ otherwise \end{cases}$$

The noise in the receiver influences the threshold, represented as λ.

$$PF = P\left(\frac{H_1}{H_0}\right) = P\left(\frac{PU}{H_0}\right) = P\left(\frac{y_n}{H_0}\right) = 1 - F_{H_0}(Th)$$

The false alarm probability is represented by the cumulative distribution function (CDF), which is indicated by F_{H0}.

$$PD = \frac{Number\ of\ acquisitions}{Total\ number\ of\ opportunities} = \frac{Over\_Num}{NOP}$$

$$PD = 1 - P_m = 1 - P\left(\frac{H_0}{H_1}\right)$$

$$PD = \left[e^{\frac{-Th}{2}} * \frac{1}{n!}\left(\frac{Th}{2}\right)^n\right] + \left[e^{\frac{-Th}{2(1+L)}} * \left(\frac{1+L}{L}\right)\right] - \left[e^{\frac{-Th}{2}} * \frac{1}{n!} * \frac{Th * L}{2(1+L)}\right]$$

$$P_m = 1 - PD$$

In this context, PD symbolizes detection probability, Th the threshold, L the signal-to-noise ratio (SNR), P_M the chance of missed detection & P_{FA} false-alarm probability.

Error probability is calculated by:

$$P_e = P_F * P_{(H_0)} + P_M ri P_{(H_1)}$$

In the presence of a primary communication system, the Cooperative Cognitive Radio (CCR) system evaluated the channel conditions and its suitability for communication. When the communication quality was poor or the channel state was unstable, this evaluation was carried out. In these situations, the CCR channel is only accessible under a single, highly prioritized condition, which enables NOMA users to make use of it.

For MIMO DL PD NOMA, consider three scenarios in 5G network telephony:

1. 64 x 64 MIMO DL NOMA PD
2. 64 x 64 MIMO DL NOMA PD with Cooperative Cognitive Radio Network (CCRN) C-CH
3. 64 x 64 MIMO DL NOMA- CHPD and MIMO DL NOMA-CHPD.

These positions are based on the presence of N users, namely U1, U2, U3,... UN and the strength of users α_2 < α_1, α_3 < α_2, α_4 < α_2.

$$x = \sqrt{P}\left(\sqrt{\alpha_1 x_1} + \sqrt{\alpha_2 x_2} + \sqrt{\alpha_3 x_3} + \sqrt{\alpha_4 x_4} + \sqrt{\alpha_5 x_5}\right)$$

The NOMA power allocation coefficients, abbreviated as " α," govern power distribution among users. The transmit antennas simultaneously broadcast the signal "x." We can deduce what signal U_N is detecting based on this information.

$$y_N = xh_{N1} + xh_{N2} + \cdots + xh_{NN}$$

We may calculate the Rayleigh fading channel for each user if n_N represents total no of samples from Additive White Gaussian Noise with zero mean & variance of σ^2 & N represents number of users.

$$h_{ik} = \sum_{i=1}^{k} h_{ik}$$

The entire number of users, defined by i = 1, 2, 3, 4 & 5, represented by no of users. Furthermore, k = 64 channels are available in total. Furthermore, signal is received by base station.

$$y = \sqrt{P_{x1}}h_{1N} + \sqrt{P_{x2}}h_{2N} + \sqrt{P_{x3}}h_{3N} + \sqrt{P_{x4}}h_{4N} + \sqrt{P_{x5}}h_{5N}$$

We used an identical model that includes the CCR spectrum to assess the channel's condition and communication capacity. If channel state is unreliable & communication is poor, CCR channel state offers 2 choices: C-CH or D-CH.

For Large MIMO DL PD NOMA, we investigate three scenarios using the same wireless network configuration:

- 128 x 128 M-MIMO DL NOMA PD
- 128 x 128 M-MIMO DL NOMA PD with one competitive channel (C-CH)
- 128 x 128 M-MIMO DL NOMA PD MIMO DL NOMA PD with dedicated channel (D-CH).

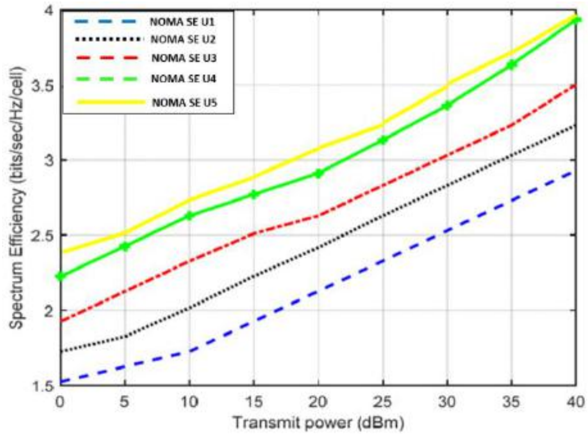
There are 4 users in this network called U1, U2, U3, U4 and U5 with different distances from each other α_2 < α_1, α_3 < α_2, α_4 < α_3. We assume that these users are using M-MIMO DL NOMA PD 128x128 under same configuration. Using same methods to evaluate the credibility and authority of a news channel. If the CR channel enabled, NOMA users can use it. As previously thought, NOMA users have access to the CCR frequency. We can calculate the weakest channel for each user.

$$h_{jM} = \sum_{j=1}^{M} h_{jM}$$

Data Simulations

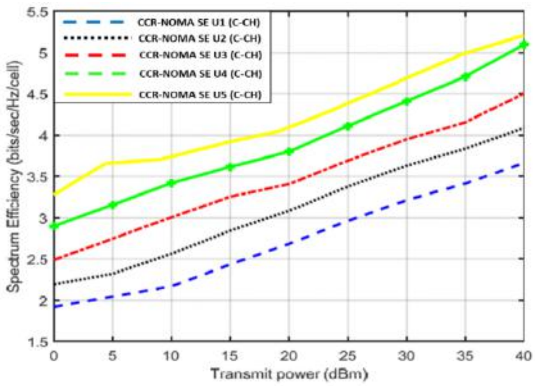
- Simulation Design and Setup

According to the findings, boosting the transmit power resulted in an increase in spectral efficiency (SE). The highest SE value obtained among the users was 3.95 bps/Hz/cell, which occurred when U5 i.e. user physically closest to BS (200m), transmitted at a power level of 30 dBm. The users listed in terms of SE performance after U5 were U4, U3, U2, and ultimately U1.



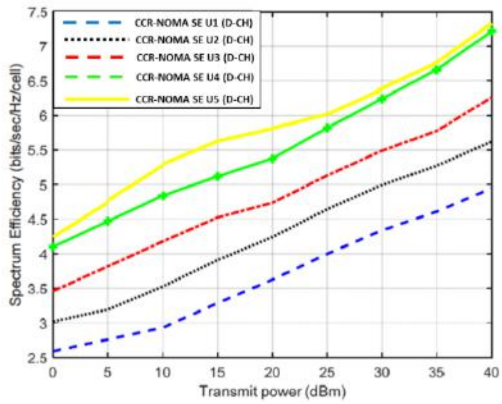
The image depicts the relationship between spectral efficiency (SE) and transmit power for five users named U1, U2, U3, U4, and U5 in the context of a single-input single-output (SISO) downlink non-orthogonal multiple access (NOMA) system with an unstable channel state. These users are separated from the base station (BS) by 1000m, 800m, 500m, 300m, and 200m, respectively. These users' power location coefficients are 0.76, 0.184, 0.048, 0.012, and 0.008, respectively.

Fig.9: Spectrum Efficiency Vs Transmit Power for 5 users SSISO DL NOMA PD



Graph shows the relationship between spectral efficiency (SE) and transmit power for five users in a single-input single-output (SISO) downlink non-orthogonal multiple access (NOMA) power-domain (PD) system combined with a CCR network, specifically the model using a C-CH free channel (referred to as the first model). The users' distances from the base station vary, as do their power location coefficients. According to the graph, the greatest SE attained is 5.11 bps/Hz/cell for user U5. This maximum SE is achieved at a transmit power of 30 dBm.

Fig.10: Spectrum Efficiency Vs Transmit Power for 5 users SSISO DL NOMA PD WITH C-CH CCRN



Graph depicts the relationship between spectral efficiency (SE) and transmit power in a downlink NOMA power-domain (PD) system linked with the CCRN. The figure depicts the second model, which employs a dedicated channel (D-CH). The graph depicts the SE vs transmit power for five users at differing distances from the base station and power location coefficients. The greatest SE attained by these users is 7.3 bps/Hz/cell. This extraordinary SE value is obtained for user U5 at a transmit power level of 30 dBm.

Fig.11: Spectrum Efficiency Vs Transmit Power for 5 users SSISO DL NOMA PD WITH D-CH CCRN

The relevant power location coefficients for these users are 0.0811, 0.01875, 0.3, 0.075, and 0.06. The results show that spectral efficiency (SE) rises in proportion to transmit power increases. With a SE of 12.22 bps/Hz/cell, U5, the user closest to the base station, has the highest. Following U5, users U4, U3, U2, and U1 observe decreasing SE levels. We obtained these SE results at 40 dBm transmit power. Best user, U5, improves the SE by 8.36 bps/Hz/cell when 64x64 MIMO technology is paired with NOMA as opposed to SISO DL NOMA PD. This enhancement happens at 40 dBm of transmission level.

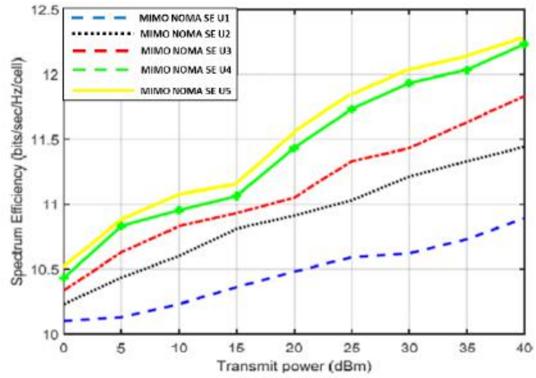
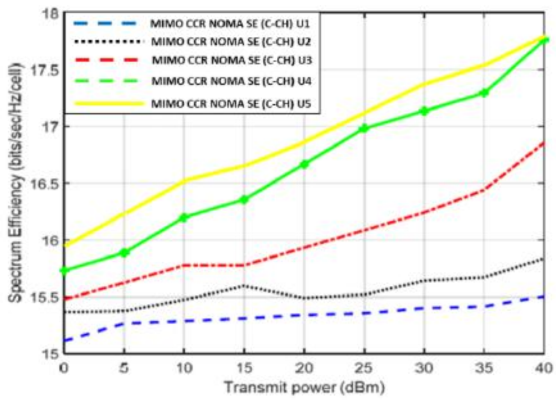


Figure displays results of a 64x64 Multiple-Input Multiple-Output (MIMO) downlink non-orthogonal multiple access (NOMA) power-domain (PD) system with an unstable channel condition. For five users (U1, U2, U3, U4, and U5), the spectral efficiency (SE) vs transmit power is displayed at 100, 800, 500, 300, and 200 meters, respectively.

Fig.12: Spectrum Efficiency Vs Transmit Power for 5 users 64 x 64 MIMO DL NOMA PD

Out of all users, the one nearest to the base station (BS), or U5, has best SE performance. Using 40 dBm of transmit power, U5 achieves a remarkable SE value of 17.83 bps/Hz/cell. The use of 64x64 MIMO with CCRN NOMA utilizing C-CH is quite advantageous for U5. In comparison to SISO, DL CCR-NOMA PD employing C-CH, U5 attains a 12.69 bps/Hz/cell increase SE @ 40 dBm transmission power.

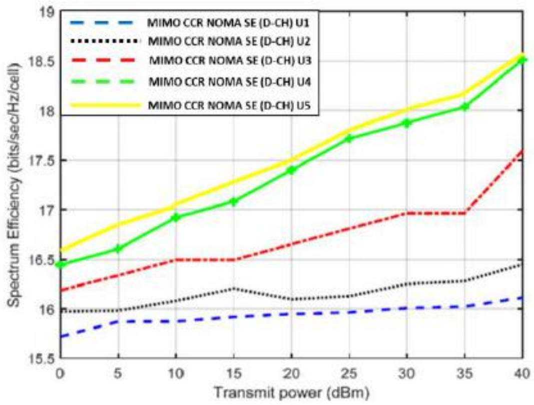


For four users in a 64x64 MIMO downlink non-orthogonal multiple access (NOMA) power-domain (PD) system connected to the Coordinated Cyclic Reuse Network (CCRN), the relationship between spectral efficiency (SE) and transmit power is shown. This configuration makes advantage of the C-CH (common channel).

Fig.13: Spectrum Efficiency Vs Transmit Power for 5 users 64 x 64 MIMO DL NOMA PD WITH C-CH CCRN

At a 40 dBm power level, U5 achieves an exceptional

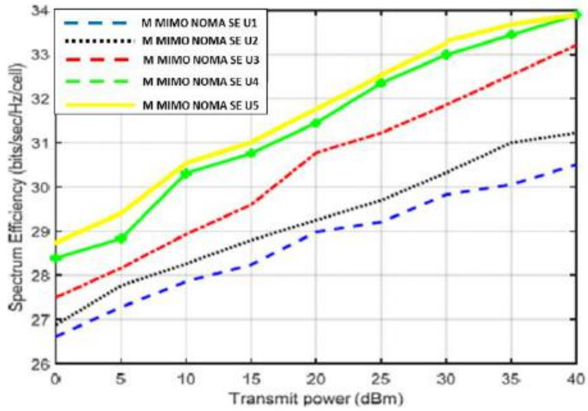
SE value of 18.62 bps/Hz/cell. After examining the best user's (U5) performance & utilizing 64 x 64 MIMO technology, with CCRN NOMA employing D-CH, SE is significantly enhanced. SE improvement is 11.37 bps/Hz/cell when compared to Single-Input Single-Output DL CCR-NOMA PD using the D-CH. These improvements show how the suggested system configuration leads to notable improvements in SE.



The plot shows the relationship between transmit power and spectral efficiency (SE) for a 64x64 MIMO downlink power-domain (PD) system that is connected to the Coordinated Cyclic Reuse Network (CCRN) via non-orthogonal multiple access (NOMA). The system interacts via the dedicated channel (D-CH).

Fig.14: Spectrum Efficiency Vs Transmit Power for 5 users 64 x 64 MIMO DL NOMA PD WITH D-CH CCRN

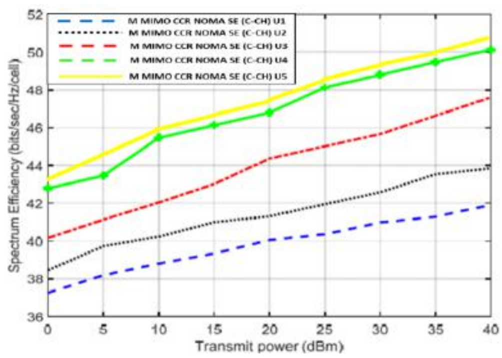
Larger SE values are associated with higher transmission power levels. With transmission power 40 dBm, U5, user close to the base station, has good SE performance. In particular, the U5 achieves a unique SE value of 33.97 bps/Hz/cell. SE values for users U4, U3, U2 and U1 decrease after U5. When the 128 x 128 M-MIMO is combined with NOMA, top user, U5, will see improvement over the SE. At transmission power of 40 dBm, U5 provides gain of 30.01 bps/Hz/cell in SE over single input DL NOMA PD (SISO) scheme. Compared to SISO DL NOMA PD configuration, these tests show benefits & performance gains achieved by combining 128 x 128 M-MIMO & NOMA technology.



For four users (U1, U2, U3, U4, and U5) in a 128x128 Massive Multiple-Input Multiple-Output (M-MIMO) non-orthogonal multiple access (NOMA) power-domain (PD) system, the graph shows the relationship between spectral efficiency (SE) and transmit power. The SE performance at different distances and power location coefficients is shown on the graph.

Fig.15: Spectrum Efficiency Vs Transmit Power for 5 users 128 x 128 MIMO DL NOMA PD

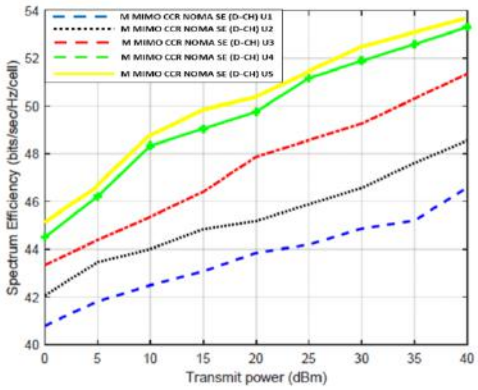
At 40 dBm, user U5, which is very close to the base station (BS), achieves the best SE performance. In particular, the U5 achieves a unique SE value of 50.23 bps/Hz/cell. By using C-CH, this SE exceeds DL CCR-NOMA single input (SISO) PD. In addition, SE can be significantly improved when using the 128 x 128 Multiple Input Multiple Output technology & NOMA. In comparison to SISO DL CCR-NOMA PD, SE of C-CH using this technology increases by 45.06 bits / s / Hz / cell. These results show the significant gains and benefits in SE performance achieved by combining 128 x 128 M-MIMO with NOMA, especially when combined with SISO DL CCR-NOMA PD through use C-CH which is slow to resist.



The graph demonstrates the link between spectral efficiency (SE) and transmit power for a 128x128 non-orthogonal multiple access (NOMA) and power-domain (PD) integration system. The SE performance using the Common Channel (C-CH) and Coordinated Cyclic Reuse Network (CCRN).

Fig.16: Spectrum Efficiency Vs Transmit Power for 5 users 128 x 128 MIMO DL NOMA PD with C-CH CCRN

With an impressive SE value of 53.31 bps/Hz/cell, the U5 stands out. After implementing 128x128 M-MIMO and NOMA technology, the SE U5 can achieve 46.1 bps / Hz / cell at 40 dBm compared to DL CCR-NOMA PD single input setup (SISO) by use D-CH. These results indicate greater gains in SE performance compared to previously published studies. In the CCRN D-CH configuration, the use of 128 x 128 M-MIMO and NOMA technology leads to a significant increase in SE performance, especially for the user close to the BS, which is than the findings of previous experiments.



The graph shows the relationship between transmit power and spectral efficiency (SE) for an M-MIMO (massive multiple-input multiple-output) downlink non-orthogonal multiple access (NOMA) power-domain (PD) system that uses the dedicated channel (D-CH) and the Coordinated Cyclic Reuse Network (CCRN). It shows the SE performance for five users with different power placement coefficients and at different distances from the base station (BS). At a transmit power level of 40 dBm, the user U5, who is closest to the BS, achieves the best SE performance.

Fig.17: Spectrum Efficiency Vs Transmit Power for 5 users 128 x 128 MIMO DL NOMA PD with D-CH CCRN

IV. CONCLUSIONS AND FUTURE WORK

- **Conclusions**

The objective of this study is to evaluate the performance (SE) of a NOMA Power Domain (PD) downlink (DL) system in 5G networks. The study focuses on integrating three technologies with CCRN in two novel ways: Single Input Output (SISO), 64 x 64 Multiple Input Output (MIMO), and 128 x 128 Massive MIMO (M-MIMO). The first strategy allowed customers to access the CCRN channels over competing channels (C-CHs), while the second strategy used dedicated channels (D-CHs) to balance the channel demands. Independent from the user.

This review considered a number of factors including user distance, power placement coefficient (PLC) and transmission power levels, including serial interference cancellation (SIC), redundant channels and add Gaussian noise (AWGN) during fading. DL NOMA system significantly improved SE performance when 64x64 MIMO and 128x128 M-MIMO technologies were combined in addition to CCRN in a single network and single cell. At 40dBm transmit power, user U5 achieved high SE of 3.9bps/Hz/cell for SISO DL NOMA, 5.1bps/Hz/cell for SISO DL NOMA, high SE of CCRN using C-CH & high SE of 7.2bps/Hz/cell for SISO DL NOMA & CCRN using C-CH. Cells for SISO DL NOMA & CCRN using D-CH.

The researcher also evaluated SE performance in various configurations and discovered that DL 64 x 64 MIMO NOMA enhances SE performance for User U5 by 51%. Compared to SE SISO DL NOMA, 64 x 64 MIMO DL NOMA with CCRN using C-CH outperforms 64 x 64 MIMO DL NOMA with CCRN using D-CH at 40 dBm. Power transmission through the DL NOMA performance improves by 79% when using 128 x 128 M-MIMO User U5 SE. Compared to performance of SE SISO DL NOMA, 128 x 128 M-MIMO DL NOMA with CCRN using C-CH improves by 85%, while 128 x 128 M-MIMO DL NOMA with CCRN using D-CH improves by 86%, with transmit power of 40 dBm. SISO, 64 x 64 MIMO, and 128 x 128 M-MIMO DL NOMA and CCRN systems had highest SE performance.

- **Future Work**

Based on the findings, there are several key strategies to increase perceived effectiveness (SE). Some of these include increasing the number of users, using multiple input multiplexing (M-MIMO) technology, using better channel coding techniques, implementing better bandwidth building techniques, and using multiple input methods. These strategies have shown potential in increasing SE in the learning environment. Future research should seek to combine the two developing technologies, which are, Massive MIMO Cooperative NOMA & Cognitive Radio.

Investigating the synergistic potential of these approaches can provide insights into how to improve SE while addressing the unique problems of uplink transmission. It is expected that significant gains in SE can be realized by combining the benefits of cooperative NOMA, which allows for efficient resource allocation and power control, with cognitive radio, which enables dynamic spectrum access and interference management.

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