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INVESTIGATION OF NON ORTHOGONAL MULTIPLE ACCES OVER FREQUENCY FLAT FADING CHANNEL CONDITONS

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1. INTRODUCTION

Non-orthogonal more than one access (NOMA) has grown to be one of the promising strategies that may be applied for the subsequent technology of wi-fi verbal exchange, i.e., the fifth-technology (5G) [1]. The scheme of non-orthogonality may be applied both at the code or strength domains [2]. In the preceding works on this area, authors have investigated the overall performance of NOMA the use of a cooperative relay scheme (CRS) with inside the amplify-and-forward (AF) mode, wherein the verbal exchange among reasserts and their applicable locations are carried out over the identical frequency concurrently thru a shared AF relay [3]. They first derived a mathematical expression, then the analytical consequences are evaluated inside the excessive signal-to-noise ratio (SNR) region. After validation, the outage possibility is compared among NOMA-AF-CRS and the traditional OMA, displaying that the previous method outperforms the latter inside the variety of low to medium SNR and achieves large throughput at excessive SNR[4-5].

A new NOMA-primarily based totally stable scheme for cognitive radio networks became proposed In this scheme, the secondary customers scavenge the power had to transmit the stable facts from the radio-frequency signals[6]. The paper proposed a two-degree set of rules so as to goal of high-secrecy power performance. A widespread framework for the overall performance evaluation of downlink NOMA transmission in millimeter-wave networks became presented [7]. The article confirmed that dynamically ordering paired with NOMA customers reduces the bad effect of beam guidance errors. A new scheme to enhance spectrum performance and growth mistakes charge detection. The scheme essentially makes use of compressed sensing multiuser detection to gain this intention. The proposed scheme carried out an 86.67 % discount in charge outage possibility. A comparative examination of twin connectivity, electricity area of NOMA, and coordinated multi-factor transmission in 5G cell networks have been proposed[8]. The intention of the examination became to maximize the downlink power performance, wherein the suggested outcomes confirmed the development of 50 %. Furthermore, NOMA making use of a half-duplex, two-manner relay is taken into consideration with best SIC (pSIC) and imperfect SIC (ipSIC), in which expressions internal the appropriate form are derived for the outage opportunity and throughput of the gadget the pair-smart blunders possibility (PEP) is investigated to assess the overall performance of more than one customers running the usage of traditional NOMA. The BER is expressed in a precise-closed shape and the analyses show that the order of attainable range and the consumer's order is proportional[10]. Besides, the precise-closed shape for the downlink NOMA and indispensable expression with one-diploma and closed-shape approximate for the uplink NOMA are taken into consideration with ipSIC. In, energy allocation strategies are proposed, wherein the primary relies upon estimating the channel kingdom information (CSI) for every consumer for the duration of the transmission, even as the second one may be accomplished through making use of them to be had pre-information of the best of a carrier for every consumer. A NOMA transmission situation with direct and indirect, i.e. over relay, communications is proposed, in which the consumer with the susceptible or unavailable channel with the BS can use the relay to finish the transmission[11]. An identical situation is proposed however with a full-duplex relay, wherein self-interference cancellation strategies are required to be carried out beside the SIC. In the latter work, the authors derived precise expressions for the outage possibility and the attainable throughput for every consumer. D2D verbal exchange with NOMA is proposed, wherein the effect of this integration for the 2 strategies is investigated, and exclusive techniques are proposed to acquire the most sum charge with better man or woman costs for every consumer with appreciate to the traditional OMA. Furthermore, the precise-closed expression for the possibility of blunders of quadrature phase-shift keying (QPSK) scheme is derived, in which (AWGN) additive white Gaussian noise channels are assumed for the uplink transmissions of customers. NOMA scheme is investigated, wherein sorts of CSI are taken into consideration, i.e., partial CSI and the second one-order statistics (SOS) of the channel[12].

There exist lessons of NOMA solutions: code vicinity NOMA (CD-NOMA) and power vicinity NOMA (PD-NOMA) [13]. CD-NOMA achieves a couple of getting proper access through the manner of assigning clients precise spreading codes with which the signal is unfolding, and absolutely everyone can be identified. The code words are sparse in format to allow for a higher variety of precise codes to avoid IUI.PD-NOMA operates through a manner of allowing clients to percent transmission reasserts to allow for advanced spectral efficiency. This scheme's power levels are special in keeping with the NOMA principle [14]. Therefore, the character with a worse channel advantage is allocated higher power as compared to the character with a higher channel advantage. The direct give-up end result of the sort of device is an increased receiver complexity, on the equal time as signal detection is required [15]. The complexity of the reception approach is mainly due to the implementation of successive interference cancellations (SIC). The SIC approach is a vital part of signal reception in a NOMA device as it permits clients with lower power levels to get preserved in their messages.

SIC operates through manner of first detecting the signal of the higher power character, through manner of treating the opportunity clients withinside the signal as noise, then subtracting that signal from the received, superposed, signal, thereby extracting the signal of the low power character [16].

2. SYSTEM MODEL

The BS contains two distinct messages a_1 to user 1 (far user), and a_2 to user 2 (near the user). β_1 and β_2 are the two power allocation factors for both far and the near users (β_1 + β_2 = 1). In NOMA, more power is given to the far user and less power to the near user just to promote the user fairness. That is, $\beta_1 > \beta_2$. In this post, we will use β_1=0.75 and β_2 =0.25. This will be an arbitrary choice. Let g_1 and g_2 denote the channel from the BS to the near and the far user respectively.

Look at to see the various choices of β_1 and β_2 to find the performance of NOMA. Now we can learn how to optimize β_1 and β_2 , see this post

NOMA encoding and transmission

$$a = \sqrt{q}\left(\sqrt{\beta_1}a_1 + \sqrt{\beta_2}a_2\right)$$

where, PP is the transmit power. Below is the copy of received near user after propagating through channel g_1 is,

$$b_1 = g_1 a + u_1$$

Similarly, the copy of a received at the far user after propagating through the channel g_2 is,

$$b_2 = g_2 a + u_2$$

1) NOMA decoding at User 1 (far user)

Expanding the received signal at user 1,

$$b_1 = g_1 a + u_1$$

$$b_1 = g_1\sqrt{q}\left(\sqrt{\beta_1}a_1 + \sqrt{\beta_2}a_2\right) + u_1$$

$$b_1 = g_1\sqrt{q}\sqrt{\beta_1}a_1 + g_1\sqrt{q}\sqrt{\beta_2}a_2 + u_1$$

Since $\beta_1 > \beta_2$, direct decoding of b_1 would yield a_1. The term containing the a_2 component will be treated as interference. The signal to interference noise ratio for the far user is,

$$\delta_1 = \frac{|g_1|^2 q\beta_1}{|g_1|^2 q\beta_2 + \tau^2}$$

and his achievable data rate is,

$$S_1 = \log_2(1+\delta_1) = \log_2\left(1 + \frac{|g_1|^2 q\beta_1}{|g_1|^2 q\beta_2 + \tau^2}\right)$$

2) NOMA decoding at User 2 (near user)

Expanding the received signal at user 2,

$$b_2 = g_2 a + u_2$$

$$= g_2\sqrt{q}\sqrt{\beta_1 a_1} + \sqrt{\beta_2} a_2 + u_2$$

$$= g_2\sqrt{q}\sqrt{\beta_1} a_1 + g_2\sqrt{q}\sqrt{\beta_2} a_2 + u_2$$

1. b_2 is directly decoded to obtain or rather, an estimate of a_1, that is a
2. $b'_2 = b_2 - \sqrt{\beta_1}\tilde{a}_1$ is computed.
3. b'_2 is decoded to obtain an estimate of a_2

$$\delta_{1,2} = \log_2\left(1+\delta_{1,2}\right) = \log_2\left(1+\frac{|g_2|^2 q\beta_1}{|g_2|^2 q\beta_2 + \tau^2}\right)$$

The corresponding achievable data rate is,

$$S_{1,2} = \log_2\left(1+\delta_{1,2}\right) = \log\left(1+\frac{|g_2|^2 q\beta_1}{|g_2|^2 q\beta_2 + \tau^2}\right)$$

After after cancellation of user 1's signal using SIC, the signal to noise ratio at the user 2 for decoding its own signal is,

$$\delta_2 = \frac{|g_2|^2 q\beta_2}{\tau^2}$$

The corresponding achievable data rate is,

$$S_2 = \log_2\left(1+\delta_2\right) = \log_2\left(1+\frac{|g_2|^2 q\beta_2}{\tau^2}\right)$$

3. SIMULATION

We have seen the mathematical details of NOMA we can go ahead and write a MATLAB code to simulate it. We will write two codes. One is to study the BER performance and another one is to study the capacity and outage performance of NOMA. So, let's get started.

Capacity and outage probability of NOMA -MATLAB simulation

You can download the MATLAB code to plot capacity and outage probability of NOMA here. Capacity and Outage probability for NOMA – MATLAB code

1. First, let's declare the values of some parameters. Let's say the distances are, d_1 =1000 meters and d_2 =500 meters. Let's set the power allocation factors as β_1 =0.75 and β_2 =0.25. You can set any values for these parameters but make sure that the far user is given the higher fraction of power.
2. We want a plot of capacity and outage probability as a function of transmit power. So, let's initialize a range of transmit power from 0 dBm to 40 dBm
3. Let's set our system bandwidth as B=1MHz. Let's calculate the thermal noise power as M_0 =kTB, where k= 1.38×10^{-23} ,T=300K
4. Next, we have to generate the Rayleigh fading coefficients g_1 and g_2 to simulate the channel between the two users. This can be done using the following MATLAB command $g_j = \sqrt{e_j^{-\omega}}\left(randn(1,M) + 1j * random(1,M)\right)/\sqrt{2}$. Here, ω is called the path loss exponent. Typically we set ω =4
5. To plot capacity, we need to calculate

$$S_1 = \log_2\left(1 + \frac{|g_1|^2 q\beta_1}{|g_1|^2 q\beta_2 + \tau^2}\right)$$

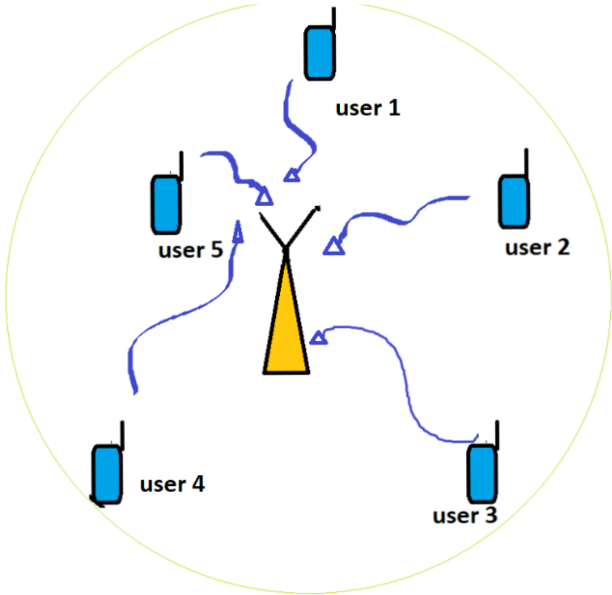
$$S_{1,2} = \log_2\left(1 + \frac{|g_2|^2 q\beta_1}{|g_2|^2 q\beta_2 + \tau^2}\right)$$ and

$$S_2 = \log_2\left(1 + \frac{|g_2|^2 q\beta_2}{\tau^2}\right)$$

1. Find the average value of each of the above quantities for every transmit power
2. Calculating the above quantities for different power levels (for eg., from 0 to 40 dBm), we get a plot as shown below:
3. Next, we will plot the outage probabilities. Set target rate for each user. For example, for user 1, we set the target rate as 1 bps/Hz and for user 2, we set the target rate as 2 bps/Hz.
4. Count the number of times the values calculated in step 5 fall below the target rates and take the average. In other words, set a counter for user 1, which is incremented every time R1<1bps/HzR1<1bps/Hz and another counter for user 2 which increments every time R1,2<1bps/Hz or R2<2bps/Hz
5. Plot the outage probabilities as a function of transmit power and the graph would look like this:

BER of NOMA- MATLAB Simulation

You can download the MATLAB code to plot BER of NOMA here. BER of NOMA -MATLAB code.



REFERENCES

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