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Comparative study of BER with NOMA system in different fading channels

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ABSTRACT

In today's world, cellular communication is rapidly expanding. One of the most common strategies for assigning the spectrum of users in cellular communication is the multiple access strategy. Because the number of people using cellular communication is continually expanding, spectrum allotment is an important factor to consider. To access the channel in fifth-generation mobile communication, a method known as non-orthogonal multiple access (NOMA) is used. NOMA is a promising method for improving sum rate and spectral efficiency. In this research, we used the NOMA approach to compare the bit error rate (BER) versus signal to noise ratio (SNR) of two users in rayleigh, rician, and nakagami fading channels. A single antenna with two users is used in this NOMA system. Two users can tolerate the same frequency with differing power levels in the power domain using 5G NOMA technology. Non-orthogonality ensures that NOMA users are treated equally to OMA users. According to the MATLAB simulation findings, the BER vs. SNR of two user NOMA in the Nakagami channel is substantially better than the rayleigh and rician channels.

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1. INTRODUCTION

Increased data network expansion is one of the primary needs of 5th generation mobile networks. The goal of the advancement is to increase capacity and system throughput. Given the recent sharp growth in the number of mobile traffic, this is a must-have necessity. The recommended multiple access approach should be capable of handling the network's growing traffic. Multiple access strategies, which were used in the previous generation, dispersed users and resources in an orthogonal manner. However, in the fifth generation, researchers have focused their efforts on non-orthogonal multiple access, which is known as non-orthogonal multiple access (NOMA). In the fifth generation, it is critical to offer high connection, high dependability, and low latency, hence a technology known as NOMA is employed to ensure fairness in future radio access resource allocation. NOMA outperforms orthogonal multiple access OMA by 30 percent in this sort of architecture [1]. In NOMA, the base station transmits using superposition coding, with the decoding mechanism being successive interference cancellation (SIC). The capacity improvements will be increased by using this SIC in conjunction with an interference rejection combining receiver [2]. NOMA may be dividedinto two categories. They are the domains of power and code [3]. The user with a bad channel condition is provided high power, while the user with a better channel condition is given low power in the power Domain NOMA. The user with higher power decodes its own signal directly in the receiver, while the user with less power uses SIC to decode its own signal. NOMA is more fair than OMA since both good and poor channel condition users are employed in communication [4]. The intra beam SIC cuts off interference, increasing the throughput of cell edge users relative to other orthogonal users [5].

Enhancement of spectrum allocation is critical when fifth-generation systems link huge devices. NOMA contributes to increased spectrum efficiency. The simulation findings of BER versus SNR in three distinct fading channels are presented in this research. The benefit of this article is that it shows the bit error rate of a system using NOMA in three fading channels [6]. This NOMA aids in the containment of the mobile communication users' sustainability, the problems and requirements of new power domain NOMA have been discovered and produced [7]-[12]. NOMA has been suggested in 5G communications in order to increase spectral efficiency. As the number of users grows, spectrum distribution becomes more important in a variety of ways. Multiple access techniques are used to enhance the total rate, outage probability, and ergodic capacity of a network. As the number of users grows, so does the significance of power allocation in system performance [8]. Calculating the BER of the users is used to evaluate performance. In most circumstances, power domain NOMA is properly evaluated since the performance is acceptable. The best distribution of electricity to NOMA users will improve performance compared to standard NOMA [13]-[17]. NOMA is primarily employed in a variety of applications, including visible light communications. Blockages are the most common difficulty in VLC; the dynamic user pairing approach aids in resource distribution, which immediately improves the system's performance [18]-[21]. For resource allocation, the fractional transmit power that delivers a poor performance as user pairing and power allocation are connected. Subband scheduling and wideband MCS should be addressed for system performance since the NOMA may be paired with any antenna design system [22]-[25].

2. RELATED WORK

In every aspect of wireless communication, NOMA has evolved on its own. The allotment of resources is also taken into account when the number of users grows to take into account the system's performance Table 1 summarizes the results of the NOMA survey in terms of user pairing and power allocation approaches in various wireless communication domains.

Table 1. Literature survey of NOMA in user pairing and power allocation

References	Methodologies used
Reddy in 2021 [1]	The model of the experiment is endorsed with software defined Radio testbed.
Kim *et al.* in 2019 [2]	Partial overlapping of user equipment signals which reduces the interference thereby increases the performance of the system.
Hsiung *et al.* in 2019 [4]	Packet level scheduling scheme is proposed to maximize the throughput aggregate
Hendraningrat *et al.* in 2020 [6]	Ergodic sum capacity is increased by combining virtual pairing NOMA and JT-CoMP to reduce the inter cell interference.
Wang *et al.* in 2019 [9]	User problems are formulated by user based time slot allocation and cluster-based time slot allocation
Obeed *et al.* in 2020 [13]	Inspite of blockages in visible light communication, user pairing, power allocation is employed to increase the sum-rate in the network
Choi *et al.* in 2019 [15]	By suitable user pairing and power allocation, queuing delays are reduced by reducing the queue blockages
Alghasmari *et al.* in 2020 [18]	Resource allocation of FPA, FTPA, FSPA algorithms are used and compared
Xiao *et al.*in 2019 [20]	Provides a sub optimal solution for mm wave communication in beamforming
Yin *et al.* in 2019 [21]	Dynamic user grouping method is used to calculate the increase the system accuracy

3. PROPOSED WORK

The notion of downlink non-orthogonal multiple access and its possible characteristics have been presented in this part. The two-user downlink NOMA is taken into account here. Superposition coding is used to relay the signal from the base station to users 1 and 2. Two users are assumed, each with a separate broadcast and receive antenna. The base station emits a signal with transmit power for user i(i=1,2) in the downlink is shown in Figure 1. The transmitter in NOMA superimposes the two signals, and the broadcast signal is determined by:

$$x = \sqrt{p_1}s_1 + \sqrt{p_2}s_2 \quad (1)$$

Where s_1 is the signal of user 1 and s_2 is the signal of user 2.

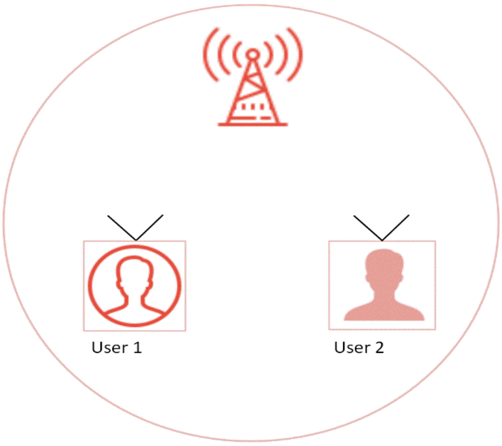

Figure 1. Basic architecture of NOMA

The received signal at the user i is represented as

$$y_i = h_i x + \omega_i \tag{2}$$

The Gaussian noise with zero mean and unit variance at the receiver is represented by the complex channel coefficient between user I and the base station. The example of NOMA systems is shown in Figure 2.

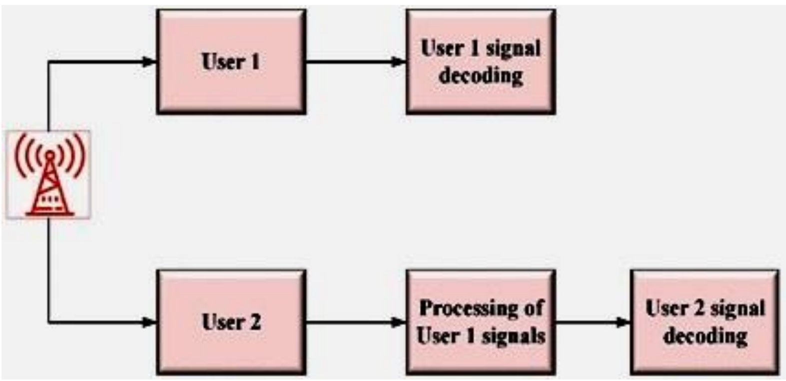

Figure 2. NOMA systems

NOMA decoding at the far user (user 1) is given by

$$y_1 = h_1 x + w_1 \tag{3}$$

Where h_1 is the complex channel coefficient of user 1 w_1 is the additive white Gaussian noise of the user 1.

$$y_1 = h_1\left(\sqrt{p_1} s_1 + \sqrt{p_2} s_2\right) + w_1 \tag{4}$$

Where p_1 and p_2 are the power allocated to user 1 and user 2.

The SIC operation is performed at the user terminal with minimal power in the downlink NOMA. The ascending order of the channel's gain, which is normalised by the inter cell interference power [8], determines the order in which the original signal is decoded. Every user decodes its own signal by eliminating interference signals from other users in this ascending order of channel gain. The value of |h2|2

/N 0,2 is bigger than the value of |h1|2 /N 0,1. User 1 will not participate in the SIC process. When the term carrying the desired and dominant signal is substituted for the term representing interference and low power in (4), the attainable rate of user 1 is given by

$$R_1 = log_2(1 + snr_1) \tag{5}$$

$$R_1 = log_2(1 + \frac{|h_1|^2 p_1}{|h_1|^2 p_2 + N_0}) \tag{6}$$

NOMA decoding at the near user (user 2) is given by

$$y_2 = h_2 x + w_2 \tag{7}$$

$$y_2 = h_2 \left(\sqrt{p}_1 s_1 + \sqrt{p}_2 s_2\right) + w_2 \tag{8}$$

User 2 must first perform SIC before decoding his own signal. SIC is carried out as:
- $y_2$is directly decoded to obtain s_1
- $y_{2'}$=$y_2 - \sqrt{}\alpha_1 s_1$ is computed.
- $y_{2'}$ is decoded to obtain an estimate of x_2.

The SNR at the user 2 for decoding the user 1 signal (before SIC) is,

$$snr_{12} = \frac{|h_1|^2 p_1}{|h_1|^2 p_2 + N_0} \tag{9}$$

The corresponding achievable data rate is given by

$$R_{1,2} = log_2(1 + snr_{12}) \tag{10}$$

$$=log_2 \left(1 + \frac{|h_1|^2 p_1}{|h_1|^2 p_2 + N_0}\right) \tag{11}$$

After subtracting of user 1's signal using SIC, the SNR at the user 2 for decoding its own signal is,

$$snr_{12} = \frac{|h_1|^2 p_1}{|h_1|^2 p_2 + N_0} \tag{12}$$

The corresponding achievable data rate is

$$R_2 = log_2(1 + snr_2) = log_2(1 + \frac{|h_2|^2 p_2}{N_0}) \tag{13}$$

NOMA's sequential interference cancellation approach outperforms orthogonal multiple access in terms of spectral efficiency. The power is shared between user 1 and user 2. The power distribution of power to users in the NOMA domain plays a significant role in the users' throughput. The users' fairness and throughput are mostly determined by power allocation [10]. The capacity of sum-rate in NOMA is given by:

$$total\ rate = R_1 + R_2 \tag{14}$$

$$= log_2 \left(1 + \frac{|h_1|^2 p_1}{|h_1|^2 p_2 + N_0}\right) + log_2(1 + \frac{|h_2|^2 p_2}{N_0}) \tag{15}$$

$$= (1 + F(x)) \tag{16}$$

The function F(x) actually represents F ($p, h_{1,} h_2, N_0$), as F is a function of all these parameters.

4. RESULTS AND DISCUSSION

This section displays the BER vs SNR of two user NOMAs in several fading channels, including rayleigh, rician, and nakagami. Table 2 lists the assumptions that were evaluated in the NOMA study. The simulation results for BER assessment of two user NOMAs using BPSK modulation across rayleigh, rician, and nakagamifading channels are shown in this section. Figure 3 depicts the BER vs. SNR for a two-user NOMA in a rayleigh channel. In the rayleigh channel, it can be shown that the BER lowers as the SNR rises. User 1's BER is 10-2 at 20 dB SNR, whereas user 2's BER is larger than 10-2, indicating that user 1 has a superior BER in the Rayleigh channel is shown in Figure 3. This is due to the user being provided a lot of power with terrible channel conditions in order to offer fairness.

The BER analysis of two user NOMA in the rician channel is shown in Figure 4. Because the Rician channel has a line-of-sight component, it produces superior results than the Rayleigh channel. Figure 4 clearly depicts the influence of the line-of-sight factor on system performance. The BER of the system with K=10 is bigger than the BER of the system with K=1 for 20 dB. This is due to the fact that line of sight allows for improved receiver detection. The BER analysis of two user NOMA in the nakagami channel is shown in Figure 5. This is the broadest definition of fading channels. When m=3 is used in the Nakagami fading with rayleigh and rician fading channels, the results are better. When m=1, the Nakagami channel performs similarly to the Rayleigh channel. In the nakagami channel, user 1's BER is better than user 2's at 20 dB SNR. The parameter m is known as the nakagami or gamma distribution's'shape factor. Figure 6 compares the bit error rate analysis of two user NOMAs using various fading channels such as Rayleigh, Rician, and Nakagami. User 1 and user 2 of the nakagami channels outperform the other fading channels, as seen in Figure 6. This is due to the nakagami channel's shaping factor is shown in Table 2.

Table 2. Simulation parameters

Cell layout	Hexagonal cell model
Distance between the cells	0.5 km
Modulation used for centered cell user	BPSK
Modulation used for edge cell user	BPSK
Type of receiver used	SIC
Fading channel	Rayleigh, Rician and Nakagami

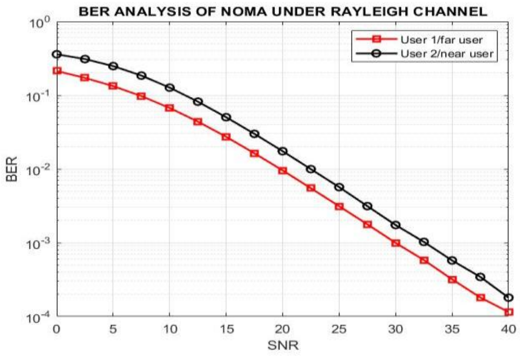

Figure3. BER vs SNR of rayleigh channel

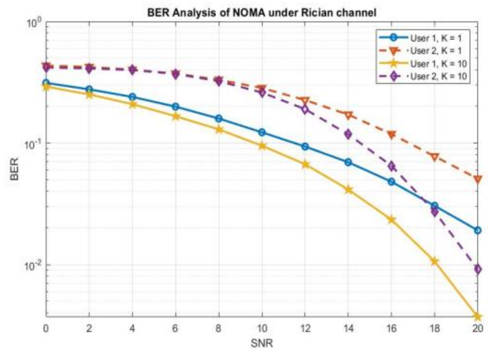

Figure 4. BER vs SNR of rician channel at K=1,10

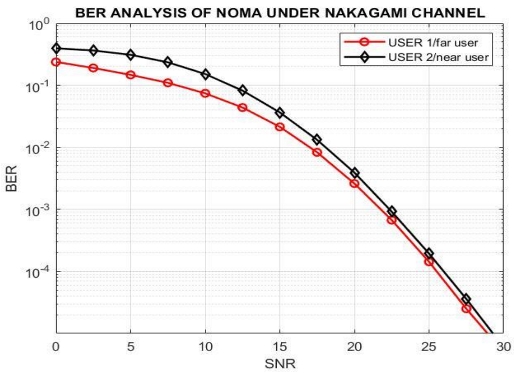

Figure 5. BER vs SNR of nakagami channel at m=3

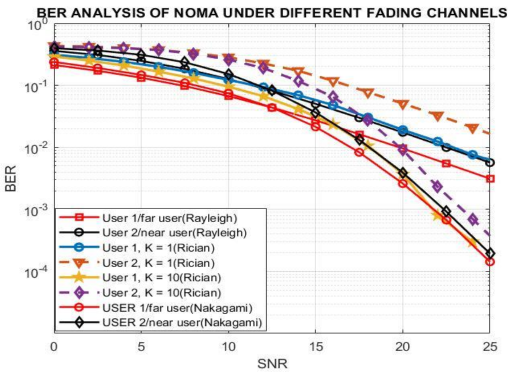

Figure 6. Comparison of bit error analysis of three different fading channels

When the m value varies in increasing order, such as m=0.5,1,2, the 2 user NOMA system delivers superior results, as seen in the graph. Because m determines the number of multipath clusters, as m grows, n separate signals are received, resulting in a drop in BER is shown in Figure 7.

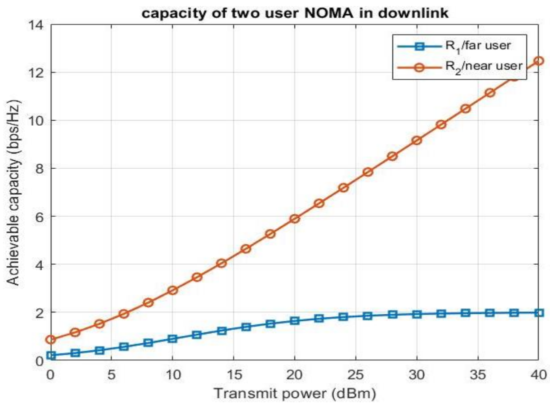

Figure 7. Capacity of two user NOMA in downlink

5. CONCLUSION

The performance of three distinct fading channels, rayleigh, rician, and nakagami, is evaluated in this paper for wireless NOMA communication. Rayleigh and rician channel BER performances are same. For 5G communications, NOMA is preferred because it provides high connection, dependability, and low latency. This NOMA aids huge networking with higher spectrum efficiency. In comparison to Rayleigh and Rician channels, the BER of the Nakagami channel is better. The use of multiple coding algorithms or diversity approaches may compensate for an increase in BER.

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