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RESEARCH ARTICLE

Performance of Relaying System with NOMA over Symmetric α-Stable Noise Channels

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Abstract

Objectives: This paper investigates the performance of a candidate 5G transmission system technique that is Non-Orthogonal Multiple Access (NOMA) over α-stable channels. This type of channel gets more attention in the research community because of its ability to model new IoT scenarios. However, there is a research gap in applying this type of channel to different wireless communications scenarios. In this work, we envision a scenario where users employ NOMA communications in the presence of an obstacle. As our mathematical analysis and simulation results show, there is a significant difference in performance when considering α-stable channels. **Methods:** To characterize the performance of the proposed noise channel, performance metrics such as outage probability and achievable rate are discussed. More particularly, we derive expressions for both outage probability and achievable rate for three NOMA users, considering the near user as a relay. In this paper, we consider additive symmetric α-stable noise channels with alpha $\alpha \in (1, 2)$. We present expressions for achievable rate and outage probability for each user (near, middle, and far) and investigate its behavior for different values of alpha (α). **Findings:** Based on the simulation results, it is shown that the high achievable rate observed for low alpha values while reduced as alpha is increased. Also, due to the influence of alpha, the outage probability is highly affected by α for small rate thresholds (R_o). In an envisioned scenario of three users with only one user forwarding the transmission to the other two, our results show that the near and middle users' outage probability decreases as alpha α increases. **Novelty:** Despite this extensive study of the NOMA on individual channels, transmission under α-stable channel is not considered to the best of the authors' knowledge.

Keywords: NOMA; relaying; Cooperative Non-Orthogonal Multiple Access; Symmetric α-Stable Noise Channels; Achievable rate

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1 Introduction

The rapid growth of mobile internet devices is immense and will supplementary increase over the next few decades, which will certainly pose a massive traffic demand for persistent communications[1]. The fifth generation (5G) mobile communication networks have raised concerns due to their ability to support diverse applications and communication needs. As cellular communication improves, the number of mobile users continues to grow [2] on a daily basis, resulting in robust traffic. Mobile users in 5G are estimated to be 100 times more than in 4G. The 5G network faces high demand; one of the future solutions is the use of Nonorthogonal multiple access (NOMA).

Radio access technologies for cellular mobile communications are typically characterized by multiple access schemes, e.g., frequency division multiple access (FDMA), time division multiple access (TDMA), and code division multiple access (CDMA), where signals are transmitted at different frequency, time, and codes. However, NOMA is a promising radio access strategy for 5G wireless networks due to its considerable spectral efficiency and capacity to service a large number of users [3]. The key characteristic behind NOMA is that multiuser signals are superimposed at the base station (BS) with different power allocation coefficients but at the same frequency/time/code at the transmitter side. On the receiver side, successive interference cancellation (SIC) is applied to the user with a better channel condition, in order to remove the other users' signals before detecting its own signal [4].

Cooperative communications schemes have received a considerable recommendation for 5G implementation due to their ability to offer many advantages, such as minimizing fading, while addressing the problem of implementing more antennas on small communications terminals, such as spatial diversity [5]· On the other hand, the combination of NOMA with cooperative relaying has been considered recently to improve reliability and system capacity [6]· Meaning that users with better channel conditions need to decode the messages for the others, and therefore these users can be used as relays to improve the reception reliability for the users with poor connections to the base station. The key advantage of exploiting cooperative communications in NOMA is that it can enhance system performance, including efficiency and reliability, which are both key challenges in wireless communication· For instance, the authors in [2] suggested a relay-to-relay (R2R) scheme to provide a greater sum rate because it employs a relay based on the power available to it. They consider a total of 500 users at any given moment, with random arrivals and departures. The user's arrival and departure processes are random using a Poisson distribution. The performance of NOMA-based cooperative relay transmission CRS over Rician-shadowed fading channels has been analyzed in [5] and provided specific analytical formulations for achievable rates. Furthermore, in [7] authors studied a cooperative relaying system with NOMA (CRS-NOMA) system's performance over $\kappa - \mu$ fading channels, namely outage probability and achievable rate as performance metrics. Analytical formulas for outage probability and average achievable rates were developed for two symbols. In [3], the authors have considered a performance of a bidirectional relaying system that utilizes non-orthogonal multiple access BR-NOMA in terms of ergodic sum capacity, outage probability, and outage sum capacity. Analytical equations for ESC, OP, and OSC are offered for optimal information exchange under perfect and imperfect consecutive interference cancellation. In [8] the author's study examines the performance of a cooperative relaying full duplex Non Orthogonal Multiple Access (CR-FD-NOMA) system in downlink and uplink scenarios over Nakagami-m fading distribution by deriving an approximated closed form BER expression of both the users in downlink and uplink systems.

In wireless networks controlled by the α-μ generalized fading model, the author's [9] examines the average achievable rate and outage probability of a cooperative relaying system (CRS) based on NOMA (CRS-NOMA). The average achievable rate is represented in closed form using Meijer's G-function and the extended generalized bivariate Fox's H-function (EGBFHF), and the outage probability is denoted using the lower incomplete Gamma function.

The performance of a two-user downlink NOMA network has been considered by assuming perfect and imperfect channel state information (CSI) in [10]. They derived a closed-form expression for the outage probability over $\eta - \mu$ fading channels. The outage performance of two cooperative relaying scenarios of the cooperative NOMA system over Nakagami-m fading channels has been investigated in [11,12]. Furthermore, in [13] the authors used relay nodes with NOMA To improve system performance in addition to beamforming. The system performance is demonstrated through closed-form expression of outage probability (OP) and ergodic rate (ER) over Rayleigh fading channels.

In an effort to rise the transmission reliability for the sixth generation (6G) cognitive Internet of Things network, some academics have recently taken cooperative relaying protocols into consideration in their research, as in [14] where achievable rates of the cognitive IoT system with amplify-and-forward (AF) and decode-and-forward (DF) relaying modes are maximized.

However, in underwater, wireless communications [15], signal and image processing [16], and molecular communications [17], impulsive noise can arise; impulsive cannot be held using Gaussian models. A key class of these models are the symmetric α-stable distributions, which can be viewed as generalizations of zero-mean Gaussian models (α = 2) and preserve stability for independent random variables. This approach leads to the additive symmetric α-stable noise channel. Interestingly, among the exploited distributions, the α-stable distribution could most precisely fit the actual deployment of legacy base stations (BSs), which is also consistent with the traffic distribution in broadband and cellular networks [18]. Despite this extensive study of the NOMA on individual channels, it remains α-stable. There is no study on α-stable noise channel, to the best of the authors' knowledge. The rest of this paper is organized as follows: Section II introduces the proposed system model. Simulation results and discussions are presented in the III Section. Our conclusions are outlined in Section IV.

2 Methodology

In this section, we study the performance of an envisioned scenario of cooperative NOMA over alpha stable noise channel. We provide an expression for the outage probability and the achievable rate for each user. We adopt the system model proposed in[19]. In this system model, a downlink cooperative NOMA network system with the source represented by the base station (BS), and three users: the near user (Dn), the middle user (Dm), and the far user (Df). Assuming the near user has very good channel conditions with the base station, assume that each node in the system has a single antenna (the base station and each user has one antenna). Also, consider the model with a fixed power allocation has a power control circuit in the base station to divide the transmit power among the three users and give the signals a power weight. Unlike Gaussian models, the α-stable distribution is used which characterized by heavy tails, which accounts for a high probability of large amplitude noise[20]. Evaluating system performance under Additive Symmetric α-Stable Noise fading channel is rather challenging. In order to derive the exact expression of the achievable rate, we propose an analytical method using incomplete Gamma function.

The α-stable random variables are heavy-tailed probability density functions. The probability density function of an α-stable random variable is parameterized by four parameters[21]: the exponent $0 < \alpha \leq 2$; the scale parameter $\gamma \in$ R+; the skew parameter $\beta \in [-1, 1]$; and the shift parameter $\delta \in$ R. As such, a common notation for a general α-stable distributed random variable is $N' \sim S\alpha(\gamma, \beta, \delta)$. In the case $\beta = \delta = 0$, the random variable N is a symmetric α-stable random variable denoted by $N \sim S\alpha(\gamma, 0, 0)$[22]. Specifically, we consider the case where there are users located at the cell edge or out of coverage, in that case their signal can be relayed by a relay to improve the reliability for those users[23]. This scenario is depicted in Figure 1 below.

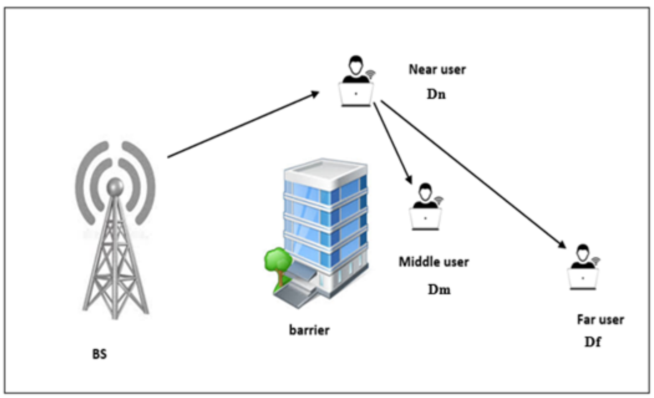

Fig 1. The envisioned scenario

Assume that the power allocation vector is $w = \{w_n, w_m, w_f\}$, for system in Figure 1 the achievable rate according to[19],

$$R^n_{coop} = \frac{1}{2}log_2(1+\frac{|h_{sn}|^2\ P_t w_n}{\sigma^2}) \tag{1}$$

$$R^m_{coop} = \frac{1}{2}log_2(1+\frac{|h_{sn}|^2\ P_t w_m}{\sigma^2}) \tag{2}$$

$$R^f_{coop} = \frac{1}{2}log_2(1+\frac{|h_{sn}|^2\ P_t w_f}{|h_{sn}|^2\ P_t W_m\ +\sigma^2}) \tag{3}$$

Where:

h_{sn} : The fading coefficient between the BS and the near user D_n.

h_{nm} : The fading coefficient between the near user D_n and the middle user D_m.

h_{nf} : The fading coefficient between the near user D_n and the far user D_f.

W_n : power allocation coefficient for near user
W_m: power allocation coefficient for middle user
W_f: power allocation coefficient for far user
σ^2: the variance of the AWGN.
P_t : transmitted power
In the next section we provide mathematical expression of the achievable for the α-stable noise channel model for each user.

2.1 Achievable Rate

In Equation (4) the achievable rate of the near user under symmetric α-stable noise channel is presented, the near user (relay) will send the signals to both the middle and far users through a special channel between the relay and the middle user and another one between the relay and the farthest user. Assume that the power allocation vector is $w = \{w_n, w_m, w_f\}$, then the rate equations for the users can be written as shown in Equations (4), (5) and (6).

$$R^n_{coop} = \frac{1}{\alpha} log_2(1 + \frac{|h_{sn}|^\alpha\ c^\alpha_n}{\gamma^\alpha_N}) \tag{4}$$

$$R^m_{coop} = \frac{1}{\alpha} log_2(1 + \frac{|h_{nm}|^\alpha\ c^\alpha_m}{\gamma^\alpha_N}) \tag{5}$$

$$R^f_{coop} = \frac{1}{\alpha} log_2(1 + \frac{|h_{nf}|^\alpha\ c^\alpha_f}{|h_{nf}|^\alpha\ c^\alpha_m + \gamma^\alpha_N}) \tag{6}$$

Where:

$$c_n = w_n\ P_t \tag{7}$$

$$c_m = w_m\ P_t \tag{8}$$

$$c_f = w_f\ P_t \tag{9}$$

- h_{sn} : The fading coefficient between the BS and the D$_n$.
- h_{nm} : The fading coefficient between the D$_n$ and the D$_m$.
- h_{nf} : The fading coefficient between the D$_n$ and the D$_f$.
- γ_N: symmetric α-stable noise channel.

2.2 Outage probability

The outage probability defined as the probability that the received SNR falls below a given threshold [22] is expressed mathematically as follows:

$$P_{out} = Pr(C\ \leq\ R_o) \tag{10}$$

Next we provide the outage probabiltiy expression in Claim 1.

Claim 1: For the scenario shown in Figure 1 with the communications links follow α-stable distribution where $0 < \alpha \leq 2$, then the outage probability expression for the three users is given by:

$$1.\ For\ the\ near\ user{:}P^n_{out} \cong 1 - exp\left[-\lambda\left(\frac{2^{(\alpha R^n_0)} - 1}{SNR^{\ \alpha}_{\ n}}\right)^{\frac{2}{\alpha}}\right] \tag{11}$$

$$2.\ For\ the\ middle\ user: P_{out}^{m} \cong 1 - exp\left[-\lambda\left(\frac{(2^{\alpha\, R_0^m}) - 1}{SNR\,_m^{\alpha}}\right)^{\frac{2}{\alpha}}\right] \tag{12}$$

$$3.\ For\ the\ far\ user: P_{out}^{f} \cong 1 - exp\left[-\lambda\left(\frac{y\gamma_N^{\alpha}}{(1 - yc_m^{\alpha})}\right)^{\frac{2}{\alpha}}\right] if\ \frac{\beta_f}{\beta_m} > ((2^{\alpha R_o^f}) - 1)^{\frac{1}{\alpha}} \tag{13}$$

Proof:

Outage probability for the near user:

Starting by the definition of the outage probability,

$P_{out}^{n} = Pr\left(R^n \leq R_O^n\right) \leq Pr\left(\frac{1}{\alpha}\, log_2(1 + \frac{(h_{sn}|^{\alpha}\ c_n^{\alpha}}{\gamma_N^{\alpha}} \leq R_0^n\right)$

Using the approximation $F_g^2\ (x) = 1 - e^{-\lambda x}$, and let $\frac{c_n^{\alpha}}{\gamma_N^{\alpha}}$ $=SNR\,_n^{\alpha}$,

Then, $\frac{1}{\alpha}\ log_2(1 + |h_{sn}|^{\alpha}\ SNR\,_n^{\alpha}) \leq R_0^n \Rightarrow log_2(1 + |h_{sn}|^{\alpha}\ SNR\,_n^{\alpha}) \leq \alpha\, R_o^n$

$= 1 + |h_{sn}|^{\alpha}\ SNR\,_n^{\alpha} \leq 2^{\alpha\, R_0^n} \Longrightarrow |h_{sn}|^{\alpha} \leq \frac{2^{\left(\alpha\, R_0^n\right)} - 1}{SNR\,_n^{\alpha}}$

$$\Longrightarrow P_{out}^{n} = Pr\left(|h_{sn}|^{\alpha} \leq \left(\frac{2^{\left(\alpha\, R_0^n\right)} - 1}{SNR\,_n^{\alpha}}\right)^{\frac{1}{\alpha}}\right) = 1 - exp\left[-\lambda\left(\frac{2^{\left(\alpha\, R_0^n\right)} - 1}{SNR\,_n^{\alpha}}\right)^{\frac{2}{\alpha}}\right.$$

$$\Longrightarrow P_{out}^{n} \cong 1 - exp\left[-\lambda\left(\frac{2^{\left(\alpha\, R_0^n\right)} - 1}{SNR\,_n^{\alpha}}\right)^{\frac{2}{\alpha}}\right. \tag{11}$$

Outage probability for the middle user:

$P_{out}^{m} = Pr\left(R^m \leq R_O^m\right) \leq Pr\left(\frac{1}{\alpha} log_2\left(1 + \frac{|h_{nm}|^{\alpha}\ c_m^{\alpha}}{\gamma_N^{\alpha}} \leq R_0^m\right)\right.$. Using the approximation $F_g^2\ (x) = 1 - e^{-\lambda x}$ and letting $\frac{c_m^{\alpha}}{\gamma_N^{\alpha}}$ $=SNR\,_m^{\alpha}$,

$\Longrightarrow \frac{1}{\alpha} log_2(1 + |h_{nm}|^{\alpha}\, SNR\,_m^{\alpha} \leq R_0^m \Longrightarrow log_2(1 + |h_{nm}|^{\alpha}\, SNR\,_m^{\alpha}) \leq \alpha\, R_0^m \Longrightarrow 1 + |h_{nm}|^{\alpha}\, SNR\,_m^{\alpha} \leq 2^{\alpha\, R_0^m}$. As a result,

$|h_{nm}|^{\alpha} \leq \frac{(2^{\alpha\, R_0^m}) - 1}{SNR\,_m^{\alpha}} \Longrightarrow P_{out}^{m} = Pr(|h_{nm}|^{\alpha} \leq \left(\frac{(2^{\alpha\, R_0^m}) - 1}{SNR\,_m^{\alpha}}\right)^{\frac{1}{\alpha}}$ = 1-exp $[-\lambda\left(\frac{(2^{\alpha\, R_0^m}) - 1}{SNR\,_m^{\alpha}}\right)^{\frac{2}{\alpha}}$

$$\Longrightarrow P_{out}^{m} \cong 1 - exp\left[-\lambda\left(\frac{(2^{\alpha\, R_0^m}) - 1}{SNR\,_m^{\alpha}}\right)^{\frac{2}{\alpha}}\right. \tag{12}$$

Outage probability for the Far user:

$P_{out}^{f} \leq Pr\left(R_{coop}^{f} \leq R_O^f\right) \leq Pr\left(\frac{1}{\alpha} log_2\left(1 + \frac{|h_{nf}|^{\alpha}\ c_f^{\alpha}}{|h_{nf}|^{\alpha}\ c_m^{\alpha} + \gamma_N^{\alpha}} \leq R_O^f\right)\right.$

$\Longrightarrow 1 + \frac{|h_{nf}|^{\alpha}\ c_f^{\alpha}}{|h_{nf}|^{\alpha}\ c_m^{\alpha} + \gamma_N^{\alpha}} \leq 2^{\alpha R_O^f} \Longrightarrow \frac{|h_{nf}|^{\alpha}\ c_f^{\alpha}}{|h_{nf}|^{\alpha}\ c_m^{\alpha} + \gamma_N^{\alpha}} \leq 2^{\alpha R_O^f} - 1$

Let $|h_{nf}|^{\alpha} = x^{\alpha}$, $y = \frac{(2^{\alpha R_O^f}) - 1}{c_f^{\alpha}}$, then,

$x^{\alpha} \leq y(x^{\alpha} c_m^{\alpha} + \gamma_N^{\alpha}) = yx^{\alpha} c_m^{\alpha} + y\ \gamma_N^{\alpha}$

$\Longrightarrow x^{\alpha} - yx^{\alpha} c_m^{\alpha} \leq y\ \gamma_N^{\alpha}$

$\Longrightarrow x^{\alpha}\ (1 - yc_m^{\alpha}) \leq y\ \gamma_N^{\alpha}$

Assume $1 - yc_m^{\alpha} > 0 \Longrightarrow yc_m^{\alpha} < 1 \Longrightarrow \frac{(2^{\alpha R_O^f}) - 1}{c_f^{\alpha}} c_m^{\alpha} < 1$

$$\Longrightarrow \left(\frac{c_f}{c_m}\right)^{\alpha} > (2^{\alpha R_O^f}) - 1 \Longrightarrow \frac{c_f}{c_m} > \left(\ (2^{\alpha R_O^f}) - 1\right)^{\frac{1}{\alpha}}$$

$$\Longrightarrow \frac{\beta_f P_t}{\beta_m P_t} > \left(\left(2^{\alpha R_O^f}\right) - 1\right)^{\frac{1}{\alpha}} \Longrightarrow \frac{\beta_f}{\beta_m} > \left(\left(2^{\alpha R_O^f}\right) - 1\right)^{\frac{1}{\alpha}}$$

$$\Longrightarrow x \leq \left(\frac{y\,\gamma_N^{\alpha}}{(1 - y c_m^{\alpha})}\right)^{\frac{1}{\alpha}} \Longrightarrow |h_{nf}| \leq \left(\frac{y\,\gamma_N^{\alpha}}{(1 - y c_m^{\alpha})}\right)^{\frac{1}{\alpha}}$$

$$\Longrightarrow P_{out}^{f} \leq Pr\left[|h_{nf}| \leq \left(\frac{y\,\gamma_N^{\alpha}}{(1 - y c_m^{\alpha})}\right)^{\frac{1}{\alpha}}\right]$$

$$\Longrightarrow P_{out}^{f} \cong 1 - exp\left[-\lambda \left(\frac{y\,\gamma_N^{\alpha}}{(1 - y c_m^{\alpha})}\right)^{\frac{2}{\alpha}}\right] \tag{13}$$

which proves Claim 1.

Table 1 below provides a description for the used notations.

Table 1. Description for the Notation

Notation	Description
γ_N^{α}	Symmetric α-stable noise channel
α	Characteristic exponent
β	Skew parameter
δ	Shift parameter
SNR_n^{α} *and* SNR_m^{α}	Signal to noise ratio for near (n refer to near user) and middle (m refer to middle user) user under effect of alpha channel
c_n^{α}, c_m^{α} and c_f^{α}	Signal power for near, middle and far user under effect of alpha channel. (n refer to near user, m refer for middle user and f refer to far user)
w_n, w_m and w_f	power allocation vector for near user, middle user and far user.

In the next section we show the performance of the system according to our derived equations. However, these equations, Equations (1), (2), (3), (4), (5) and (6), show that the classical assumption of Gaussian channel does not hold and the value of α directly affects the performance.

3 Result and discussion

In this section, we use outage probability and achievable rate of system as metrics to verify the performance of the cooperative NOMA system over symmetric alpha stable noise channel. MATLAB is used to simulate the model.

As seen from Figure 2 the achievable rate for both near and middle user are similar. The near user sends the signals to both the middle and far users through a special channel between the relay and the middle user and another one between the relay and the farthest user.

From the simulation, one can perceive that the achievable rate changes as α it changes from 0.75 to 1.1. For example, at 20 dBm, the achievable rates for near, middle, and far users are = 46 bps/Hz, = 47 bps/Hz, and = 1.7 bps/Hz for α equal to 0.75. At 20 dBm and α equal to 1.1, the achievable rates for three users are = 27 bps/Hz, 28 bps/Hz, and 1.16 bps/Hz. Also, results show that by increasing the transmitted power, an improvement in data rates for the middle user can be achieved, with a value ranging from 22 bps/Hz to 50 bps/Hz. As α increases to 2, it results in a significant decrease in the achievable rates for all users compared to the scenario where α is 0.75.

In the next part of the simulation we consider the outage probability with different $\frac{c_n}{\gamma_N}$ values. The simulated curves are based on Monte-Carlo simulations over 1000 realizations of the fading channel. Figure 3 presents the outage probability for the near user for different values of R_0 and α when $\frac{c_n}{\gamma_N}$ equals to 1 and 3. As seen from Figure 3 for we observe that for small R_0 the

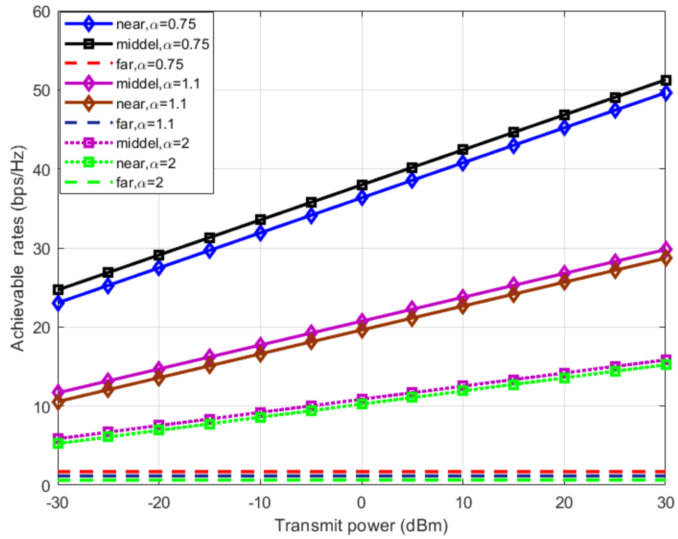

Fig 2. The achievable rate performance of near, middel and far users for $\alpha = 0.75,\ 1.1\ \textit{and}\ 2$

outage probability is highly influenced by α. As $\frac{c_n}{\gamma_N}$ increased to 6 and 10 in Figure 4 the outage probability is highly influenced by α for high R_0 values.

In Figures 5 and 6, for the middle user, the user with the lowest power allocation still suffers from changing the value of α more than the other users. However, the far user in Figures 7 and 8 shows interesting behavior because there seems to be a point below $R_0 \approx 0.425$ where the value of $\alpha = 2$ gives a better outage probability performance for the far user, where the knote appears in the far user curve at a higher value of $R_0 \approx 0.64$, also an interesting knote for $R_0 \approx 0.67$. This shows that increasing $\frac{c_n}{\gamma_N}$ beyond certain limits does not affect the outage probability in a senseable way. As a result, increasing the $\frac{c_n}{\gamma_N}$ is more beneficial to the far user since this is combined with higher power allocation for that user.

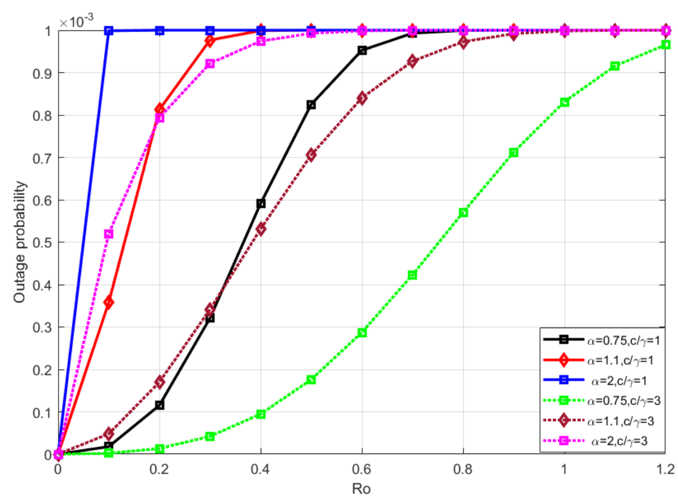

Fig 3. The outage probability for near user for varying R_0 **and** α**,** $(\frac{c_n}{\gamma_N} = 1$ **and** $\frac{c_n}{\gamma_N} = 3)$ **and** $\lambda = 1$

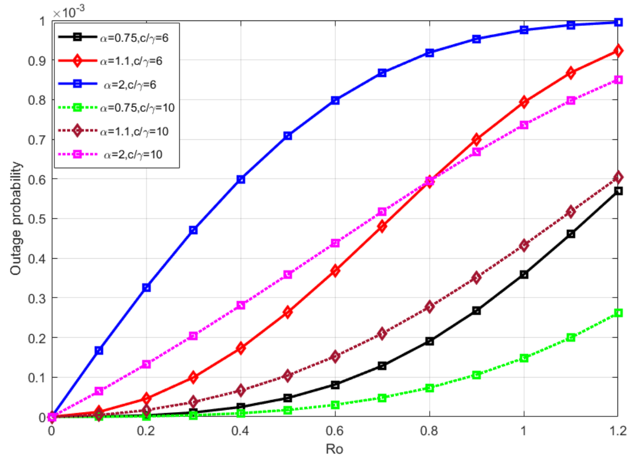

Fig 4. The outage probability for near user for varying R_0 and α, ($\frac{c_n}{\gamma_N}$ = 6 and $\frac{c_n}{\gamma_N}$ = 10) and λ = 1

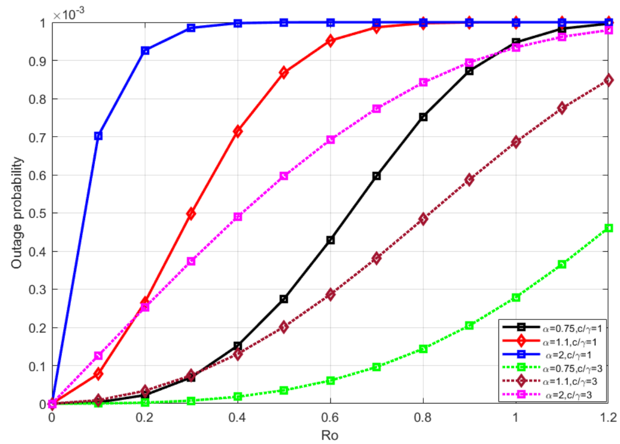

Fig 5. The outage probability for middle user for varying R_0 and α, ($\frac{c_n}{\gamma_N}$ = 1 and $\frac{c_n}{\gamma_N}$ = 3) and λ = 1

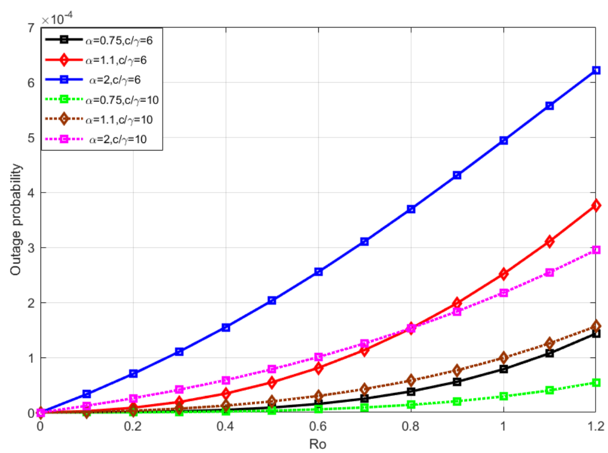

Fig 6. The outage probability for middle user for varying R_0 and α, ($\frac{c_n}{\gamma_N}$ = 6 and $\frac{c_n}{\gamma_N}$ = 10) and λ = 1

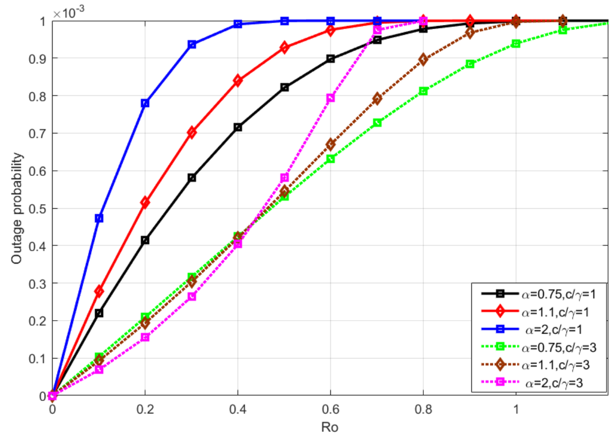

Fig 7. Plot of the outage probability for far user for varying R_0 and α, ($\frac{c_n}{\gamma_N}$ = 1 and $\frac{c_n}{\gamma_N}$ = 3) and λ = 1

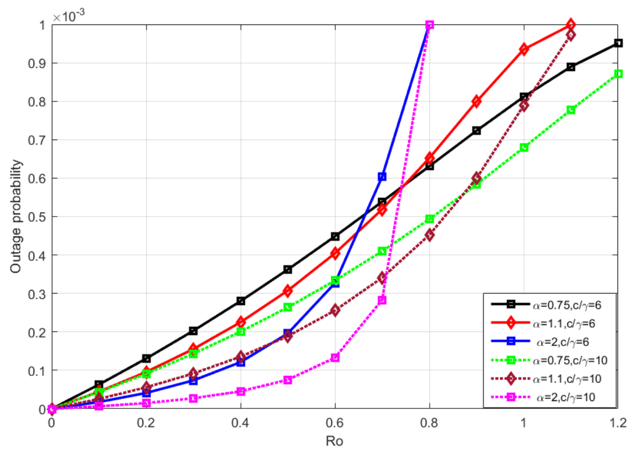

Fig 8. Plot of the outage probability for far user for varying R_0 and α, ($\frac{c_n}{\gamma_N}$ = 6 and $\frac{c_n}{\gamma_N}$ = 10) and λ = 1

4 Conclusion

This paper has investigated user relaying in cooperative NOMA system under symmetric α-stable noise channel with three users. We obtained formulas for the three users' outage probabilities. The outage probability is greatly impacted by the influence of α, with this affect being more pronounced for lower values of α. Furthermore, we have demonstrated that as α increases, the outage probability for near and middle users rises as well. The simulation findings demonstrated that, in the case of the Gaussian distribution model, large achievable rates are shown for low α values and decrease as alpha approaches 2. Based on the analytical results, it was shown that achievable rate of middle user was superior to far user in low α due to channel's strength. In conclusion, accounting for α-stable noise in simulation models for NOMA systems is essential for a more accurate representation of real-world communication channels. The unique statistical properties of α -stable noise introduce challenges that impact interference, system capacity, and the robustness of NOMA schemes, all of which collectively affect the achievable rates in the simulated environment. Interestingly, our simulation results have shown that increasing the signal to noise ratio affects the far user outage probability more than other users and there is some knote in the outage probability curve where α = 2 is better than the lower values for medium to high signal to noise ratio values.

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