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Outage performance analysis of NOMA under $\eta-\mu$ fading channels in presence of imperfect SIC

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ABSTRACT

The introduction of 5th and 6th-generation wireless networks has elevated the demand for huge device connectivity, spectral efficacy, and improved signal quality. The non-orthogonal multiple access technique (NOMA) has been demonstrated to be a candidate to address these requirements. NOMA can assist many users using the same resource block by varying the assigned power levels fairness to the users. To perform this, the NOMA technique superimposes the signals from both the users and transmits them to the receiver. On the receiver side, it performs successive interference cancellation (SIC) techniques to separate the respective signals. Meanwhile, the fading channels also play a major role in deciding the quality of the signal that is being transmitted. In our paper, a NOMA system is considered in presence of two users having $\eta-\mu$ fading channels. The closed-form expressions are derived for outage probability and throughput of the system in presence of perfect SIC and imperfect SIC. The expressions are numerically analyzed by varying various parameters such as fading channels, power level coefficients, and the number of antennas at the receivers. The obtained results demonstrate that each parameter plays a major role in enhancing the quality of each user's signal and the outage performance of the system.

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1. INTRODUCTION

The non-orthogonal multiple access (NOMA) technique has proven to be productive in trending tech-nologies. With the introduction of 5th and 6th generation wireless communication networks, the requirement for massive connectivity has grown and this requirement can be satisfied by NOMA because of its unique features. NOMA can share its resources among two users at a time, thereby increasing the device connectivity and keeping the signal quality. Different from remaining the techniques such as orthogonal multiple access (OMA), frequency division multiple access (FDMA), or time division multiple access (TDMA), the NOMA can increase the spectral efficiency by utilizing all the available resources without wasting it for any guard band or interval [1]. While the data transmission is performed in NOMA, the signals get superimposed and then sent to the user. At the user side, successive interference cancellation (SIC) technique is performed to separate the superimposed signals [2]. During this procedure, the system will be fully aware of channel state information (CSI). In ideal cases of research, the CSI and SIC are considered to be perfect, whereas, in real-time scenarios, these conditions are fully perfect. Therefore considering minimal imperfections at any of these would be a given direction of practical researches.

Though the NOMA has immense advantages for wireless networking, there are major challenges to deal with such as multipath fading and shadowing effects. Few statistical models can differentiate the multipath fading based on line of sight (LOS) and non-LoS (NLOS) such as Rayleigh, Rice, Rician, Nakagami-m [3]-[5]. Researches were performed to understand the effects based on various performance measurements such as outage probability, channel capacity, bit error rate, etc. $\alpha-\eta-\mu$ is considered to be a more generalized fading model for understanding the mathematical evaluations and performance comparison in any system. Various authentic studies have evaluated the performance of various fading models such as $\alpha-\mu$, $\alpha-\eta$, $\eta-\mu$, $\lambda-\mu$ and $\kappa-\mu$ [6], [7] in terms of outage probability, bit error rate, and average capacity. Moreover, in [8], the author has studied the generalized fading effect of the channels $\alpha-\eta-\mu$ combined. In general, when the fading distributions are considered, in$\eta-\mu$, the $\eta$is considered to be the correlation between in-phase and quadrature multipath clusters, and μ defines the number of multipath clusters. Similarly, in $\kappa-\mu$, κ is defined as the ratio between power dominants and μ defines the number of multipath clusters. The special cases of $\eta-\mu$are Rayleigh, Nakagami-m, and Hoyt distributions whereas in $\kappa-\mu$, Rayleigh, Nakagami-m, and Rician distributions. Depending on the performance of the channels, the generalized fading channels are evaluated.

As mentioned, the effect of fading has significant role in analyzing the efficacy of a system. The Nakagami-M fading effect was studied for a single user [9] and an entire system [10] in terms of outage performance. The implementation of a multiple-input-multiple-output (MIMO) system has shown a significant impact in enhancing the spectral efficiency of the system in the NOMA network over the Rayleigh fading channel. There are a few types of research that demonstrate the sum-rate performance of the NOMA system over various fading channels such as Gaussian, Rayleigh, Nakagami-m, and others. Wang *et al.* [11] have used the multi-user beamforming method in the NOMA system under Rayleigh fading to elevate the sum capacity performance. Kimy *et al.* [12], the authors have developed a new power allocation method for the NOMA system over a complex-Gaussian channel to elevate the capacity. Wang *et al.* [13] considered the NOMA downlink system under Nakagami-m fading and analyzed the ergodic sum rate. Men [14] direct-sequence-code-division multiple access systems were considered under $\alpha-\eta-\mu$ fading channels and analyzed the outage performance of the system. Kapucu *et al.* [15] have studied the sum rate and ergodic rate performance of the MIMO-NOMA system with a device pairing method and it has proved that MIMO-NOMA has a better performance compared to the MIMO-OMA. A similar system was considered with beamforming techniques to understand the user pairing effect in [16]. A similar study was performed in [17] with a fixed power allocation method in cognitive radio (CR) assisted NOMA system. Various power allocation strategies are provided in [18], [19] to enhance the efficiency of the NOMA system. Cooperative communications are also applied with NOMA in [20], [21], where the strong user assists the weak user to enhance its performance. To perform a similar operation, the authors in [22], [23] have applied the relay technique to enhance weak user performance. Regarding a performance analysis for downlink non-orthogonal multiple accesses (DL-NOMA) systems where the channel gains follow the $\alpha-\mu$fading distribution in [24], [25]. The authors considered bit error rate (BER), and ergodic capacity (EC).

Understanding the above studies, there is still a huge requirement to study the effect of various fading models in the NOMA system. Though few research articles provide the studies based on $\alpha-\eta-\mu$, only the ideal cases were considered such as perfect CSI and SIC. Therefore motivated by this analysis, in this article, we are aimed to provide a detailed analysis of the outage performance of the NOMA system with two users under $\eta-\mu$ fading distribution with different scenarios. Moreover, we consider the imperfect SIC scenario and study its effect on the fading channel. The major contributions of this paper include deriving the expressions of exact outage probability and throughput of the NOMA system with two users under $\eta-\mu$ fading distribution facing perfect and imperfect SIC and validating the performance of the system based on the expressions obtained, along with Monte-Carlo simulations.

This paper is organized as follows: In section 2, we introduce and describe the system model and the channel characteristics. In section 3, we compute the outage probability (OP) expressions of the system with perfect SIC and imperfect SIC. In section 4, we compute the expression for throughput of the system, using the previously obtained expressions. In section 5, we evidence the simulations based on expressions obtained and in section 6, we conclude the paper.

2. SYSTEM MODEL AND CHANNEL CHARACTERISTICS

2.1. System model

In this system model, shown in Figure 1. We have considered a base station (BS) transmitting the signals between two users D_1 and D_2 using NOMA technique over $\eta-\mu$ fading channels. D_1 is consider to be having M antennas and D_2 is consider to be having N antennas. The channel between BS to D_1 is $g_{1,m}$ and BS to D_2 is $g_{2,m}$. The received signal at the two NOMA users destination, D_1 and D_2 are given by [26].

$$\tilde{y}_1^m = g_{1,m}\left(\sqrt{P\nu_1}\tilde{x}_1 + \sqrt{P\nu_2}\tilde{x}_2\right) + \tilde{\omega}_1^m, \tag{1a}$$

$$\tilde{y}_2^n = g_{2,n}\left(\sqrt{P\nu_1}\tilde{x}_1 + \sqrt{P\nu_2}\tilde{x}_2\right) + \tilde{\omega}_2^n, \tag{1b}$$

where P denotes the normalized transmission power at the BS, $\tilde{\omega}_1^m \sim CN\left(0, N_0\right)$ and $\tilde{\omega}_2^n \sim CN\left(0, N_0\right)$ denotes the noise terms are additive white Gaussian noise (AWGN) at the user node D_1 and D_2, respectively, and $\tilde{x}_1$ and $\tilde{x}_2$ are assumed to be normalised the unity power signal for the two users, i.e., $\mathrm{E}\left\{\left|\tilde{x}_1\right|^2\right\} = \mathrm{E}\left\{\left|\tilde{x}_2\right|^2\right\} = 1$ in which E is the expectation operator. The two user's power allocation factor ν_j satisfies the relationship $\nu_2 > \nu_1$ with $\sum_{j=1}^{2}\nu_j = 1$, which is for the purpose of the user fairness.

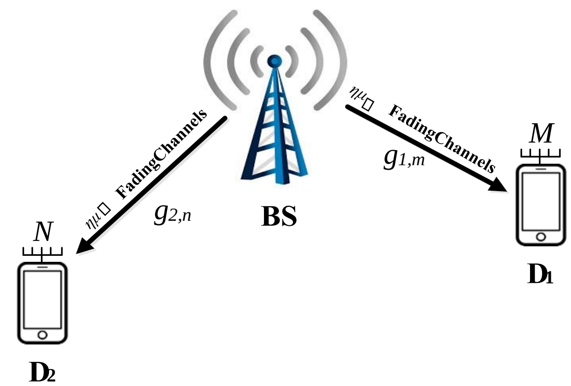

Figure 1. Downlink NOMA with $\eta-\mu$ fading channels

In the first phase, the signal to interference-plus-noise ratio (SINR) after treating $\tilde{x}_1$ as interference is given by

$$\tilde{\Gamma}_{D_1,x_2}^{m} = \frac{\nu_2 P\left|g_{1,m}\right|^2}{1+\nu_1 P\left|g_{1,m}\right|^2} = \frac{\nu_2\rho\gamma_1}{1+\nu_1\rho\gamma_1}, \tag{2}$$

where $\gamma_1 \triangleq \left|g_{1,m}\right|^2$ and the transmit signal to noise ratio (SNR) calculated at the BS as $\rho = P/N_0$. Note that γ_1 and γ_2 are independent random variables (RVs). It should be noted that imperfect SIC (ipSIC) occurs, the SINR of detect $\tilde{x}_2$ is given as [27]

$$\tilde{\Gamma}_{D_1,x_1}^{m,ipSIC} = \frac{\nu_1\rho\gamma_1}{1+\rho\left|h_I\right|^2}, \tag{3}$$

where $|h_I|^2 \sim CN(0,\lambda_I)$ in with $\lambda_I\,(0 \le \lambda_I < 1)$ indicate as the residual interference level caused by ipSIC in [28] and $CN \sim (x, y)$ complex normal distribution with average x and variance y.
Similarly, the instantaneous SINR at D_2 to detect $\tilde{x}_2$ is given as

$$\tilde{\Gamma}^n_{D_2,x_2} = \frac{\nu_1 P|g_{2,n}|^2}{1+|g_{2,n}|^2 P\gamma_2} = \frac{\nu_1\rho\gamma_2}{1+\nu_2\rho\gamma_2}, \tag{4}$$

where $\gamma_2 \triangleq |g_{2,n}|^2$

2.2 Channel characteristics

First, we suppose that the antennas numbers of two users are equivalent, i.e $N = M$. We have the probability density function (PDF) of $\gamma = \gamma_1 = \gamma_2$ is given by [29] (1)

$$f_\gamma(x) = \frac{2\sqrt{\pi}\mu^{\mu-0.5}h^\mu x^{\mu-0.5}}{\Gamma(\mu)H^{\mu-0.5}\bar{\gamma}^{\mu-0.5}} e^{-\frac{2\mu h}{\bar{\gamma}}x} I_{\mu-0.5}\left(\frac{2\mu H}{\bar{\gamma}}x\right), \tag{5}$$

where $\Gamma(x)$ is the Gamma function, $I_z(.)$ is the modified Bessel function of the first kind, $\bar{\gamma} = \mathrm{E}\{\gamma\}$, μ is related to the fading severity, $h = (2+\eta^{-1}+\eta)/4$ and $H = (\eta^{-1}-\eta)/4$ with $0 < \eta < \infty$. For arbitrary values of μ. According to [30] (2) the cumulative distribution functions (CDF) of γ can be obtained as

$$F_\gamma(x) = \frac{(\Lambda_1\Lambda_2)^\mu}{\Gamma(1+2\mu)} x^{2\mu}\Phi_2(\mu,\mu;1+2\mu;-\Lambda_1 x,-\Lambda_2 x), \tag{6}$$

where $\Phi_2 \equiv \Phi_2^{(2)}$ is the confluent Lauricella function [31], $\Lambda_1 = \frac{2\mu(h-H)}{\bar{\gamma}}$ and $\Lambda_2 = \frac{2\mu(h+H)}{\bar{\gamma}}$. For integer values of μ and with the help of [32], (15) and [33], (8.352.6), $F_\gamma(x)$ can be greatly simplified as

$$F_\gamma(x) = \frac{\sqrt{\pi}}{\Gamma(\mu)}\sum_{k=0}^{\infty}\frac{H^{2k}\Gamma(2(\mu+k))}{k!\Gamma(\mu+k+0.5)2^{2(\mu+k)-1}h^{\mu+2k}}\left[1-e^{-2\mu hx}\sum_{l=0}^{2(\mu+k)-1}\frac{(2\mu h)^l x^l}{m!}\right]. \tag{7}$$

Finally, we have PDF and CDF of $|h_I|^2$ are given by [34]

$$f_{|h_I|^2}(x) = \frac{1}{\lambda_I}e^{-\frac{x}{\lambda_I}}, \tag{8a}$$

$$F_{|h_I|^2}(x) = 1-e^{-\frac{x}{\lambda_I}}. \tag{8b}$$

3. ANALYSIS OF OUTAGE PROBABILITY

The OP of D_1 under ipSIC is calculated as

$$\tilde{P}_{D_1}^{ipSIC} = \Pr\left(\underbrace{\max_{m \in M}}_{m \in M} \left\{ \tilde{\Gamma}_{D_1,x_2}^{m} \right\} < \tilde{\gamma}_{th2} \mid \underbrace{\max_{m \in M}}_{m \in M} \left\{ \tilde{\Gamma}_{D_1,x_1}^{m,ipSIC} \right\} < \tilde{\gamma}_{th1} \right) \tag{9}$$
$$= \prod_{n=1}^{N} \left[1 - \Pr\left(\tilde{\Gamma}_{D_1,x_2}^{m} > \tilde{\gamma}_{th2}, \tilde{\Gamma}_{D_1,x_1}^{m,ipSIC} > \tilde{\gamma}_{th1} \right) \right] = \left[1 - \Pr\left(\gamma_1 > \delta_2, \gamma_1 > \delta_1 \left(\rho |h_I|^2 + 1 \right) \right) \right]^M ,$$

where $\tilde{\gamma}_{thi} = 2^{2R_i} - 1$, for $i = 1,2$ is called as target rate at D_i, $\delta_2 = \tilde{\gamma}_{th2} \left[\rho \left(\nu_2 - \nu_1 \tilde{\gamma}_{th2} \right) \right]^{-1}$ and $\delta_1 = \tilde{\gamma}_{th1} \left(\nu_1 \rho \right)^{-1}$ We assuming $\delta_1 \left(\rho |h_I|^2 + 1 \right) \square \delta_2$, $\tilde{P}_{D_1}^{ipSIC}$ can be calculated by

where $\varepsilon_i = 2^{2R_i} - 1$ for $i = 1,2$ is called as target rate at $\ell_e = \left(\rho_S \Omega_e + 1 \right)$, $\delta_2 = \dfrac{\varepsilon_2 \ell_e}{\rho_S \left(\nu_2 - \nu_1 \varepsilon_2 \right)}$ and $\delta_1 = \dfrac{\varepsilon_1}{\nu_1 \rho_S}$. Assuming $\delta_1 \left(\rho_S |h_I|^2 + \ell_e \right) \square \delta_2$, OP_1 can be calculated by

$$\tilde{P}_{D_1}^{ipSIC} = \left[1 - \Pr\left(\gamma_1 > \delta_1 \left(\rho |h_I|^2 + 1 \right) \right) \right]^M = \left\{ 1 - \int_0^{\infty} f_{|h_I|^2}(x) \left[1 - F_{\gamma_1}\left(\delta_1 \left(\rho x + 1 \right) \right) \right] dx \right\}^M . \tag{10}$$

<u>Case 1</u>: when $\mu \in \square, \forall \mu \geq 0$ then we using PDF of (8a) and CDF of (7), (10) is given as

$$\tilde{P}_{D_1}^{ipSIC} = \left\{ 1 - \int_0^{\infty} f_{|h_I|^2}(x) \left[1 - F_{\gamma_1}\left(\delta_1 \left(\rho x + 1 \right) \right) \right] dx \right\}^M \tag{11}$$
$$= \left\{ \frac{\sqrt{\pi}}{\Gamma(\mu)} \sum_{k=0}^{\infty} \frac{H^{2k} \Gamma\left(2(\mu + k) \right)}{k! \Gamma\left(\mu + k + 0.5 \right) 2^{2(\mu+k)-1} h^{\mu+2k}} \times \left[1 - \frac{e^{-2\mu h \delta_1}}{\lambda_I} \sum_{m=0}^{2(\mu+k)-1} \frac{\left(2\mu h \delta_1 \right)^m}{m!} \int_0^{\infty} e^{-\left(\frac{1}{\lambda_I} + 2\mu h \delta_1 \rho_S \right) x} \left(\rho_S x + 1 \right)^m \right] dx \right\}^M .$$

Using [33] (1.111) and (3.351.3), $\tilde{P}_{D_1}^{ipSIC}$ is given by

$$\tilde{P}_{D_1}^{ipSIC} = \left\{ \frac{\sqrt{\pi}}{\Gamma(\mu)} \sum_{k=0}^{\infty} \frac{H^{2k} \Gamma\left(2(\mu + k) \right)}{k! \Gamma\left(\mu + k + 0.5 \right) 2^{2(\mu+k)-1} h^{\mu+2k}} \times \left[1 - e^{-2\mu h \delta_1} \sum_{m=0}^{2(\mu+k)-1} \sum_{r=0}^{m} \binom{m}{r} \frac{r! \left(2\mu h \delta_1 \right)^m \lambda_I^r \rho_S^r}{m! \left(1 + 2\lambda_I \mu h \delta_1 \rho_S \right)^{r+1}} \right] dx \right\}^M . \tag{12}$$

<u>Case 2</u>: when $\mu \in \mathrm{I}, \forall \mu \geq 0$ then we using PDF of (8) and CDF of (6), (10) is given as

$$\tilde{P}_{D_1}^{ipSIC} = \left\{ 1 - \frac{1}{\lambda_I} \int_0^{\infty} e^{-\frac{x}{\lambda_I}} \left[1 - \frac{\left(\Lambda_1 \Lambda_2 \right)^{\mu}}{\Gamma(1 + 2\mu)} \left(\delta_1 \left(\rho_S x + 1 \right) \right)^{2\mu} \times \Phi_2\left(\mu, \mu; 1 + 2\mu; -\Lambda_1 \delta_1 \left(\rho_S x + 1 \right), -\Lambda_2 \delta_1 \left(\rho_S x + 1 \right) \right) \right] dx \right\}^M . \tag{13}$$

Specifically, we let $q = \dfrac{x}{\lambda_I}$ and with the help of Gauss-Laguerre integration in [35] (25.4.45). The closed-form approximation of the $\tilde{P}_{D_1}^{ipSIC}$ is can be given as

$$\tilde{P}_{D_1}^{ipSIC} \approx \left[\frac{\left(\Lambda_1 \Lambda_2 \right)^{\mu} \delta_1^{2\mu}}{\Gamma(1 + 2\mu)} \sum_{w=1}^{W} X_w \Theta\left(q_w \right)^{2\mu} \Phi_2\left(\mu, \mu; 1 + 2\mu; -\Lambda_1 \delta_1 \Theta\left(q_w \right), -\Lambda_2 \delta_1 \Theta\left(q_w \right) \right) \right]^M , \tag{14}$$

where $\Theta\left(q_w \right) = \left(\rho_S \lambda_I q_w + 1 \right)$, X_w and q_w are the weight and abscissas for the Gauss-Laguerre integration, respectively. More specifically, q_w is the w-th zero of Laguerre polynomial $L_W\left(q_w \right)$ and the corresponding the w-th weight is given by $X_w = \frac{(W!)^2 q_w}{\left[L_{W+1}(q_w)\right]^2}$. The parameter W is to ensure a complexity-accuracy trade off.

From (9), the scenario pSIC. We set $\rho|h_I|^2 \approx 0$, we have the outage probability $\tilde{P}_{D_1}^{pSIC}$ is given by

$$\begin{aligned}\tilde{P}_{D_1}^{pSIC} &= \left[1-\Pr\left(\gamma_1 > \delta_2, \gamma_1 > \delta_1\right)\right]^M = \left[1-\Pr\left(\gamma_1 > \delta_{\max}\right)\right]^M = \left[F_{\gamma_2}\left(\delta_{\max}\right)\right]^M \\ &\overset{\mu\in\square}{=} \left\{\frac{\sqrt{\pi}}{\Gamma(\mu)}\sum_{k=0}^{\infty}\frac{H^{2k}\Gamma\left(2(\mu+k)\right)}{k!\Gamma(\mu+k+0.5)2^{2(\mu+k)-1}h^{\mu+2k}}\left[1-e^{-2\mu h\delta_{\max}}\sum_{l=0}^{2(\mu+k)-1}\frac{\left(2\mu h\delta_{\max}\right)^l}{l!}\right]\right\}^M \\ &\overset{\mu\in\mathrm{I}}{=} \left[\frac{\left(\Lambda_1\Lambda_2\right)^\mu \delta_{\max^{2\mu}}}{\Gamma(1+2\mu)}\Phi_2\left(\mu,\mu;1+2\mu;-\Lambda_1\delta_{\max},-\Lambda_2\delta_{\max}\right)\right]^M,\end{aligned} \tag{15}$$

where $\delta_{\max} = \max(\delta_1, \delta_2)$.

Finally, the outage probability of D_2 is calculated as

$$\tilde{P}_2 = \Pr\left(\underbrace{\max_{n\in N}}_{n\in N}\left\{\tilde{\Gamma}_{D_2,x_2}^n\right\} < \tilde{\gamma}_{th2}\right) = \prod_{n=1}^{N}\left[1-\Pr\left(\tilde{\gamma}_{th2} > \tilde{\gamma}_{th2}\right)\right] = \left[1-\Pr\left(\gamma_2 > \delta_2\right)\right]^N = \left[F_{\gamma_2}\left(\delta_2\right)\right]^N. \tag{16}$$

<u>Case 1</u>: when $\mu \in \square, \forall\mu \geq 0$ then we using CDF of (7), (16) is given as

$$\tilde{P}_2 = \left\{\frac{\sqrt{\pi}}{\Gamma(\mu)}\sum_{k=0}^{\infty}\frac{H^{2k}\Gamma\left(2(\mu+k)\right)}{k!\Gamma(\mu+k+0.5)2^{2(\mu+k)-1}h^{\mu+2k}}\left[1-e^{-2\mu h\delta_2}\sum_{l=0}^{2(\mu+k)-1}\frac{\left(2\mu h\delta_2\right)^l}{l!}\right]\right\}^N. \tag{17}$$

<u>Case 2</u>: when $\mu \in \mathrm{I}, \forall\mu \geq 0$ then we using CDF of (6), (16) is given as

$$\tilde{P}_2 = \left[\frac{\left(\Lambda_1\Lambda_2\right)^\mu \delta_2^{2\mu}}{\Gamma(1+2\mu)}\Phi_2\left(\mu,\mu;1+2\mu;-\Lambda_1\delta_2,-\Lambda_2\delta_2\right)\right]^N. \tag{18}$$

4. THROUGHPUT ANALYSIS

It may be assessed further using additional metrics, such as the total throughput, which can be calculated using the outage probability acquired. The throughput of system can be obtained in delay-limited mode at set target rates R_1, R_2. As a result, the throughput may be expressed as follows [36]

$$\tau_1^{å} = \left(1-\tilde{P}_{D_1}^{å}\right)R_1, å \in \left\{ipSIC, pSIC\right\}, \tag{19a}$$

$$\tau_2 = \left(1-\tilde{P}_2\right)R_2. \tag{19b}$$

5. NUMERICAL RESULTS

We set parameters of μ and η in [37] and antennas M and N of U_1 and U_2, respectively as 2. Monte-Carlo results averaging over 10^7 independent channel realizations. Target data-rates for the fixed-rate transmission $R_1 = R_2 = 1$. Mean values of the channel power gains of interference signal $\lambda_I = 0.01$. The power allocation coefficients $\nu_1 = 0.2$ and $\nu_2 = 0.8$. Number of points for Gauss-Laguerre quadratures as $W = 40$.

Figure 2 provides the simulation of outage probability versus transmit SNR for various values of (μ,η) fading distribution, with the same number of antennas as $N = M = 2$. As we can observe that by varying the value of μ, the outage performance is significantly changing for perfect and imperfect SIC at both users. As the μ increases, the performance of the users are increasing comparatively, thereby enhancing the overall system performance. In the simulation, we can observe that the perfect SIC has better performance than the imperfect SIC, which is assumed. It can be called the worst-case scenario as in all cases it demonstrates a very low level of performance.

Figure 3 provides the simulation for outage probability versus transmit SNR for different number of antennas at D_1 and D_2, with $R_1 = R_2 = 1$, $\eta = 0.1$ and $\mu = 1.2$. As we can observe, with the increase in the number of antennas, there is a huge difference between the performance of each user in both imperfect and perfect SIC. D_2 is the far user and it can be seen that D_2 has the better performance compared to D_1 at both the scenarios since it has the highest power allocated to it. This shows the impact of power allocation on improving the performance of the users.

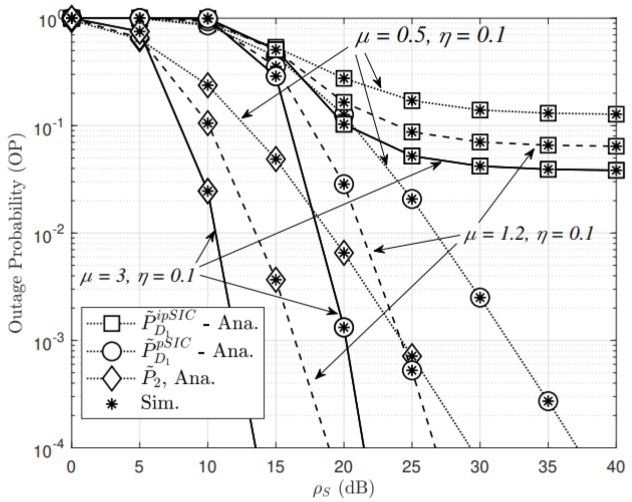

Figure 2. Outage probability versus transmit SNR for different values of (η,μ) fading distribution, with $N = M = 2$

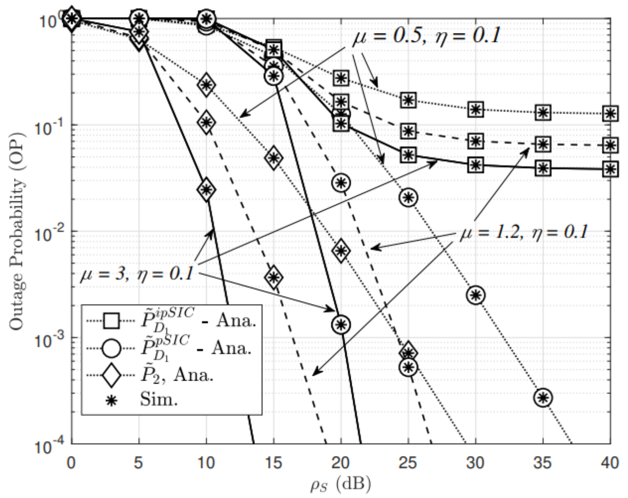

Figure 3. Outage probability versus transmit SNR for different number of antennas at D_1 and D_2, with $R_1 = R_2 = 1$, $\eta = 0.1$ and $\mu = 1.2$

Figure 4 provides the simulation for outage probability versus power allocation coefficients at D_2 for different values of transmit SNR, with $\lambda_I = 1(dB)$, $R_1 = R_2 = 0.5$, $\eta = 0.5$ and $\mu = 1$. We can observe the performance of both users in imperfect and perfect SIC. As the power allocation increases for a particular user, the performance of that user increases and, the other user's performance is decreasing. The primary point to be noticed is with the increase in the transmit SNR, the system performance increases respectively in all scenarios.

Figure 5 provides the simulation for throughput versus transmit SNR for different levels of ipSIC at D_1, with $\nu_1 = 0.05$, $\nu_2 = 0.95$, $\eta = 0.5$ and $\mu = 1$. As we can observe, by reducing the level of ipSIC, the throughput performance of the user is increasing. Meanwhile, the throughput of the pSIC users is also given in the simulation, in which, we can observe that D_2 has the better throughput.

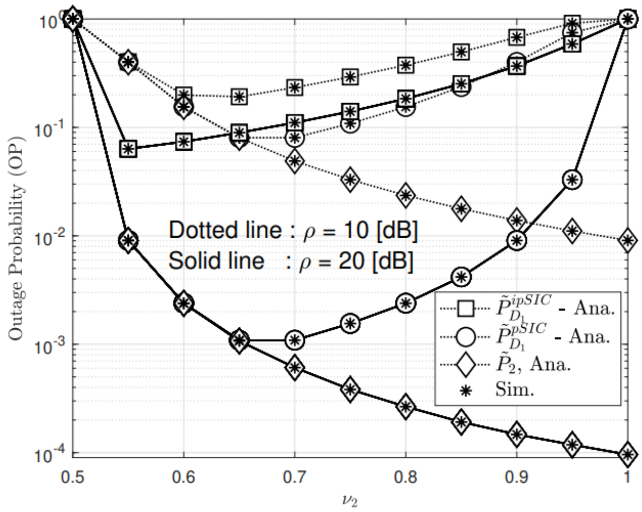

Figure 4. Outage probability versus power allocation coefficients at D_1 for different values of transmit SNR, with $\lambda_I = 1(dB)$, $R_1 = R_2 = 0.5$, $\eta = 0.5$ and $\mu = 1$

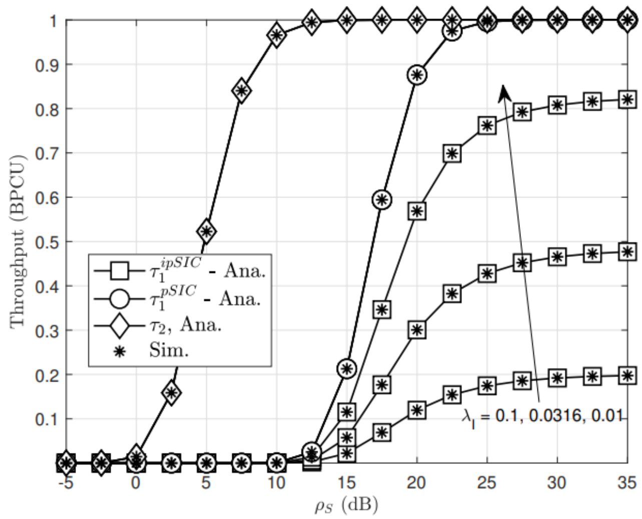

Figure 5. Throughput versus transmit SNR for different levels of imperfect SIC at D_1, with $\nu_1 = 0.05$, $\nu_2 = 0.95$, $\eta = 0.5$ and $\mu = 1$

6 CONCLUSION

In this paper, we have investigated a NOMA system serving two users D_1 and D_2 with the $\eta - \mu$ fading channels. We have considered both the pSIC and ipSIC, at the same time derived the closed-form outage probability expressions and system throughput expressions for the same. The obtained simulations demonstrate that varying the values of η, keeping μ constant, plays a major role in enhancing the performance of the system, even in ipSIC mode, comparatively. Along with this, the paper demonstrates the performance of the system in various of the cases such as the number of antennas, power level coefficients, and transmit SNR. It is primarily noticed that with the increase in the transmit SNR, the outage performance of the system is rapidly increasing, irrespective of the scenario.

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