Bulletin of Electrical Engineering and Informatics
Vol. 14, No. 5, October 2025, pp. 3509~3519
ISSN: 2302-9285, DOI: 10.11591/eei.v14i5.9630

Fixed and fair power allocation in downlink and uplink NOMA: outage probability analysis and bit error rate comparative study

Abdelbari Falloun, Abdessalam Ait Madi
Laboratory of Advanced Systems Engineering, National School of Applied Sciences, Ibn Tofail University, Kenitra, Morocco

Article Info

Article history:

Received Dec 1, 2024
Revised Jul 25, 2025
Accepted Aug 8, 2025

Keywords:

Bit error rate
Fair power allocation
Fixed power allocation
Non-orthogonal several access
Outage probability
Power allocation

ABSTRACT

Non-orthogonal multiple access (NOMA) is a crucial technology for upcoming radio access networks since it allows several users to use the same time and frequency resources. It is positioned as a viable option for next-generation communication systems because to its capabilities to increase system capacity and spectrum efficiency. This essay investigates the effects of fair and fixed power allocation (PA) techniques on NOMA systems' uplink and downlink performance. It specifically assesses bit error rate (BER) and outage probability (OP), two crucial performance parameters. The paper provides a thorough comparison of the fixed and fair PA approaches, highlighting the advantages, and disadvantages of each. While fixed PA is easier to deploy, results show that it performs poorly in dynamic situations, increasing BER and OP, particularly for users with less reliable channels. Fair PA, on the other hand, improves system dependability, and user fairness by dynamically allocating power depending on user situations, thus reducing OP and BER. Future wireless networks will benefit greatly from its enhanced spectrum efficiency and up to 78% reduction in outage likelihood. With fair PA's higher flexibility and effectiveness in real-world, varied circumstances, the results underline the significance of selecting appropriate PA techniques for NOMA systems.

This is an open access article under the CC BY-SA license.

Corresponding Author:

Abdelbari Falloun
Laboratory of Advanced Systems Engineering, National School of Applied Sciences, Ibn Tofail University
BP 242 Av. From the University, Kenitra 14000, Morocco
Email: abdelbari.falloun@uit.ac.ma

1. INTRODUCTION

Multiple access (MA) is a fundamental aspect of wireless communication systems, enabling multiple users to share radio resources like time, frequency, and code simultaneously. This efficient spectrum utilization is crucial for modern communication needs. A recent advancement in MA is non-orthogonal multiple access (NOMA), which has attracted attention for its ability to enhance spectral efficiency and support a large number of users. Unlike traditional orthogonal multiple access (OMA) schemes, where users are assigned exclusive resource blocks, NOMA allows users to share the same resources [1]. It achieves this through non-orthogonal superposition of signals, which are separated at the receiver using advanced signal processing techniques. NOMA offers several advantages over conventional MA techniques. It optimizes performance by allocating more power to weaker users, thereby accommodating diverse channel conditions. Additionally, it facilitates simultaneous transmission and reception for multiple users, increasing system capacity, and spectral efficiency. NOMA supports a wide range of applications, including voice, data, and internet of things (IoT) devices, making it a promising technology for future communication systems. However, deploying NOMA introduces challenges such as power allocation (PA), user pairing, interference management, and receiver design [2]. NOMA operates in both downlink and uplink scenarios. In downlink (forward link) transmission, a base station (BS) transmits data to multiple users simultaneously using the same resources, with signals superimposed via power domain multiplexing. Advanced signal processing techniques separate these signals at the receivers [3]. In uplink (reverse link) transmission, users send data to the BS, which processes the superimposed signals using similar techniques. NOMA's efficient spectrum utilization and ability to handle varying channel conditions make it advantageous, but it requires addressing critical challenges like PA, user pairing, and interference management [4], [5]. PA strategies significantly influence the efficiency and fairness of NOMA systems. Two commonly studied approaches are fair PA and fixed PA. Fair PA aims to allocate power equitably among users, considering factors such as channel conditions and quality of service requirements, ensuring balanced performance [6]. Conversely, fixed PA assigns predetermined power amounts to users based on priorities or system requirements. While fixed PA simplifies system design, it may not adapt well to changing channel conditions, potentially leading to suboptimal performance [7]. Both strategies have advantages and limitations, and their impact on key performance metrics, such as system capacity, spectral efficiency, outage probability (OP), and bit error rate (BER), needs thorough investigation. Another critical aspect of NOMA is the role of successive interference cancellation (SIC), a signal processing technique for separating superimposed signals. Ideal SIC would perfectly cancel interference from stronger users, enabling accurate decoding of weaker user signals. However, in practical scenarios, SIC is often imperfect due to factors like noise, channel estimation errors, and hardware constraints [8]. Imperfect SIC introduces residual interference, negatively impacting decoding accuracy, system capacity, and performance. Addressing these challenges is crucial for realizing the full potential of NOMA. Research efforts focus on developing advanced signal processing techniques and interference cancellation algorithms to mitigate the effects of imperfect SIC. Enhancing SIC performance will improve system reliability, increase capacity, and optimize spectral efficiency, enabling better utilization of wireless resources. This paper aims to explore the impact of fair and fixed PA strategies in downlink and uplink NOMA scenarios. It evaluates system performance metrics and examines the effects of imperfect SIC. The analysis provides insights into the trade-offs between PA techniques and their role in enhancing the efficiency and fairness of wireless networks [9]. The findings contribute to designing robust and efficient NOMA systems for practical implementations.

The paper is structured to provide an overview of NOMA and PA strategies, discuss results and implications, and conclude with insights for future wireless communication systems [10]. The rest of this paper is organized as follows. Section 2 provides an overview about NOMA with fixed and fair PA to enhance the efficiency and fairness of wireless networks. In section 3, we present the result and discussion by describing fixed and fair PA strategies in NOMA. In addition, we discuss the impact of PA on NOMA and OP of uplink NOMA and we give an effect of imperfect SIC in NOMA. In the end, the work is concluded in section 4.

2. SHORT OVERVIEW

NOMA with fixed and fair PA is a technique designed to enhance efficiency and fairness in wireless networks [11]. NOMA allows multiple users to share the same time and frequency resources, enabling simultaneous communication. The PA strategy plays a crucial role in distributing power among users, influencing system performance [12]. In fixed PA, power levels are predetermined and assigned to users based on factors like priorities, channel conditions, or system requirements. This approach simplifies system design by avoiding real-time adjustments but lacks adaptability to dynamic channel conditions, potentially leading to suboptimal performance. Conversely, fair PA dynamically allocates power based on real-time feedback and optimization algorithms, ensuring equitable distribution and minimizing performance gaps. Fair PA is ideal for scenarios where fairness or varying channel conditions are critical. The choice between fixed and fair PA depends on system requirements. Fixed PA suits stable environments or when simplicity is prioritized, while fair PA excels in systems requiring fairness and adaptability [13]. Studies have evaluated these strategies using metrics like system capacity, spectral efficiency, OP, and BER to identify optimal trade-offs between efficiency and fairness.

A significant challenge in NOMA systems is imperfect SIC, a key technique used to decode superimposed signals. In practical scenarios, SIC may leave residual interference due to noise, channel estimation errors, or hardware limitations, affecting weaker users most. This can degrade system performance, increase error rates, and reduce capacity. Mitigating imperfect SIC involves techniques such as advanced interference cancellation algorithms, iterative decoding, and adaptive PA strategies. These efforts aim to enhance interference cancellation, improving the accuracy and reliability of NOMA systems. Overall, NOMA with fixed and fair PA is a vital area of research, offering solutions to optimize capacity, fairness, and performance in future wireless networks [14].

3. RESULTS AND DISCUSSION

In NOMA, PA is crucial. Regardless of the channel circumstances, we fixed the values of, PA coefficient for the two users U_1 and U_2, α_1 and α_2 utilized fixed PA for U_2 (near user) and U_1 (far user). However, taking into account the channel state information (CSI) values, there are more effective approaches to dynamically optimize α_1 and α_2. Numerous dynamic power distribution techniques exist, everyone striving to fulfill distinct goals. Maximizing energy efficiency, and the total rate, might be one of these goals [15]. The objective of the PA strategy is to guarantee fairness among users. We call this the fair PA system. Priority is given by our equitable PA to the users U_1 and U_2. To put it differently, the computation of the PA coefficients guarantees U_1 desired rate is attained [16]. U_2 only receives all available power when the U_1 desired rate is attained. So, we obtain the required PA coefficients to fulfill this requirement. The PA coefficients for the dynamic PA technique known as fair PA will be computed. we will additionally model and examine the fair PA's total rate performance and outage. The NOMA for both user's capacity is expressed by using in (1) and (2):

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

$$R_2=\log_2\left(1+\frac{|h_2|^2P\alpha_2}{\sigma^2}\right) \quad (2)$$

R_2 is achieved by employing SIC to eliminate the interference caused by U_1 transmission. Rayleigh fading channel coefficient for both users are respectively represented by h_2 and h_1. Also, σ^2 represents power of noise. Let R* represents U_1's goal rate. Our objective is to determine α_2 and α_1 such that $R_1 \geq R^*$. Now let us put $R_1=R^*$.

$$\log_2\left(1+\frac{|h_1|^2P\alpha_1}{|h_1|^2P\alpha_2+\sigma^2}\right)=R^* \quad (3)$$

Let's take 2^x on both sides to eliminate the $\log_2$ first.

$$1+\frac{|h_1|^2P\alpha_1}{|h_1|^2P\alpha_2+\sigma^2}=2^{R^*} \quad (3a)$$

$$\frac{|h_1|^2P\alpha_1}{|h_1|^2P\alpha_2+\sigma^2}=2^{R^*}-1 \quad (3b)$$

Let's indicate $\xi=2^{R^*}-1$.
For U_1 with target rate R^*, ξ is the target signal interference to noise ratio (SINR).

$$\frac{|h_1|^2P\alpha_1}{|h_1|^2P\alpha_2+\sigma^2}=\xi \quad (4)$$

$$|h_1|^2P\alpha_1=\xi|h_1|^2P\alpha_2+\xi\sigma^2$$

Since $\alpha_1+\alpha_2=1$, $\alpha_2=1-\alpha_1$;

$$|h_1|^2P\alpha_1=\xi|h_1|^2P(1-\alpha_1)+\xi\sigma^2 \quad (4a)$$

$$=\xi|h_1|^2P-\xi|h_1|^2P\alpha_1+\xi\sigma^2 \quad (4b)$$

Gathering every α_1 terms to be sent to the left-hand side, we obtain in (5).

$$|h_1|^2P\alpha_1+\xi|h_1|^2P\alpha_1=\xi|h_1|^2P+\xi\sigma^2$$

$$|h_1|^2P\alpha_1(1+\xi)=\xi(|h_1|^2P+\sigma^2)$$

$$\alpha_1=\frac{\xi(|h_1|^2P+\sigma^2)}{|h_1|^2P(1+\xi)} \quad (5)$$

α_1 should not be more than 1. So let us establish a limit as shown by (6):

$$\alpha_1=\min\left(1, \frac{\xi(|h_1|^2P+\sigma^2)}{|h_1|^2P(1+\xi)}\right) \tag{6}$$

After computing α_1 with the equation mentioned above, α_2 may be obtained with ease as mentioned by (7):

$$\alpha_2=1-\alpha_1 \tag{7}$$

3.1. Fixed and fair power allocation strategies in non-orthogonal multiple access

Thus, we were able to obtain the PA coefficients for fair PA, our dynamic PA method. Then, let's see how our equitable PA does. The outage performance of fair and fixed PA systems is compared. As we can see in Figure 1 is what we obtain when we plot the OP indicatively the target rate R* of the U_1. The overall transmit power in this case has been set at 30 dBm. To obtain the outage likelihood, the same goal rate has been set for both users [17].

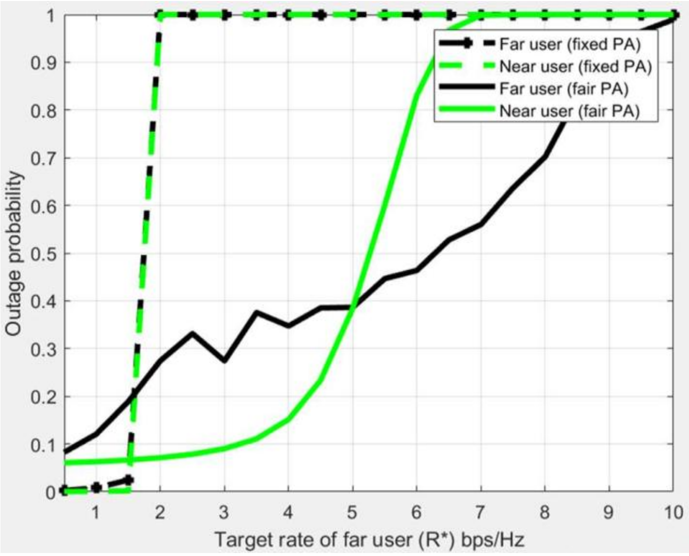

Figure 1. Target rate indicatively outage for a fair and fixed PA

In all cases, the OP saturates at 1 when R* is greater than 1.5 bps/Hz. Put another way, using a constant PA where R* is more than 1.5 bps/Hz guarantees that the receiver is always in an outage condition. This is because fixed PA ignores the goal rate requirements and does not take use of the instantaneous CSI. Therefore, even if fixed PA is easy to implement, it's not really that great. Nevertheless, with α_2 and α_1 continuously changing based on the CSI and goal rate need, our fair PA has a decreased probability of an outage. We can observe in our fair PA that when the U_1's goal rate needs to rise, his OP increases as well. This makes sense, as there is a decreasing likelihood that a U_1 will reach the target rate as the target rate rises. Its outage likelihood would rise as a result. The U_2 outage exhibits a rather rapid variation R* values ranging from 4 to 7 bps/Hz. Furthermore, the U_2 is constantly unavailable. Still, compared to fixed PA, this is better [17]. In order to further minimize the U_2's outage, we offer an answer to the issues with our fair PA plan. The BS and the U_1 have a poor channel. Upon performing the limiting procedure.

$$\alpha_1=\min\left(1, \frac{\xi(|h_1|^2P+\sigma^2)}{|h_1|^2P(1+\xi)}\right) \tag{8}$$

In actuality, we set a restriction on α_1 such that it would always equal one whenever it was found to be larger than one. For instance, suppose we receive $\frac{\xi(|h_1|^2P+\sigma^2)}{|h_1|^2P(1+\xi)}=50$. We decide to α_1=min (1,50)=1. This calculation indicates that we can only meet the target rate R*, of the U_1 if we suggest α_1=50. Under such users, setting α_1 to 1 is ineffective. Since any value of α_1<50 may cause the U_1 to lose connectivity. Alternatively, put $\frac{\xi(|h_1|^2P+\sigma^2)}{|h_1|^2P(1+\xi)}$>1. The U_1 (i.e., α_1=1) will remain in outage even if we assign all of the power to him. An additional effect of setting α_1=1 is that we also automatically set α_2=0. This is problematic since it means that the U_2 is now also without power as we are not giving him any power at all. To solve this issue, let's apply a small adjustment to our fair PA. Every time $\frac{\xi(|h_1|^2 P+\sigma^2)}{|h_1|^2 P(1+\xi)}$ exceeds 1, as an alternative, let's put α_1=0 instead of limiting it to 1. This immediately sets α_2=1. We are unable to recover U_1 from outage, not even with α_1=1 (giving him all power). This small adjustment has resulted in an amazing outage trend for our fair PA as we show in this Figure 2 [17].

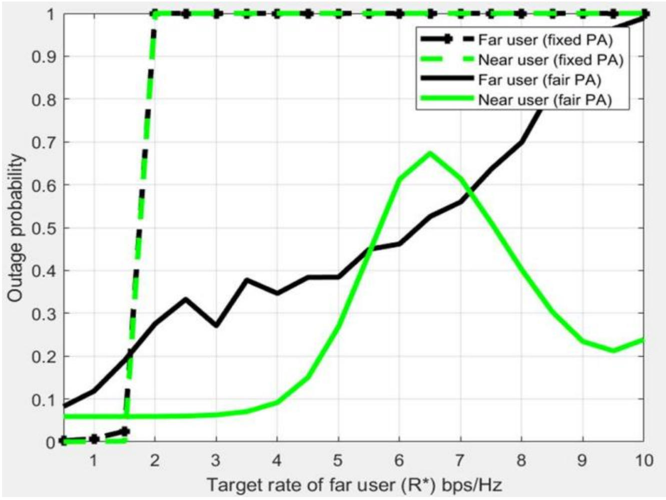

Figure 2. Failure compared to the desired rate for both fixed and enhanced fair PA

The pattern shown in Figure 1 is followed by the U_1 outage. This suggests that the adjustment we made to set α_1=0 when necessary did not affect whatever the U_1 outage. Allow us to examine the U_2 outage graph now. After increasing and peaking, the chance of an outage begins to decline. R^* appears to be increasing the power provided to the U_1 at the price of the U_2's performance when it is between 0 and 6.5 bps/Hz. However, if α_1 is more than 6.5 bps/Hz, it might not completely fulfill R*. Instead of focusing all of our energy on the U_1 when this occurs, we give preference to U_2. Advantages result from this: U_2 outage is minimized, especially when R* is more than 6.5 bps/Hz, while the U_1 outage is never impacted. So, we compare our improved fair PA to the fixed PA and examine its overall rate, which has been our traditional approach up to this point. R_1+R_2 is what we mean when we talk about the sum rate. We will obtain Figure 3 when we plot the total rate indicatively transmit power [17]. In terms of possible capacity, it is clear that our fair PA outperforms fixed PA.

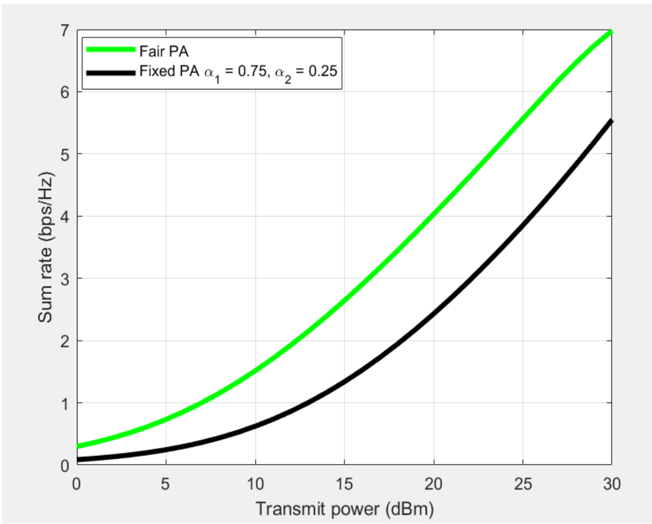

Figure 3. Fixed and equitable PA's sum rate indicatively transmit power

3.1. Impact of power allocation on non-orthogonal multiple access

Through the use of the fixed PA approach, we were able to replicate several performance metrics, BER, capacity, and NOMA outage likelihood, among others [18]. Through continuous power distribution, we imply that α_1=0.75 for U_1 and α_2=0.25 for U_2 are always set, independent of the channel state. This is one method for PA. Additionally, this fixed PA strategy has the following advantages, including no calculation is necessary and there is no familiarity with CSI is needed [19]. However, this distribution is not optimal of power. When PA are used, we can see how the BER changes, as we can see in Figure 4.

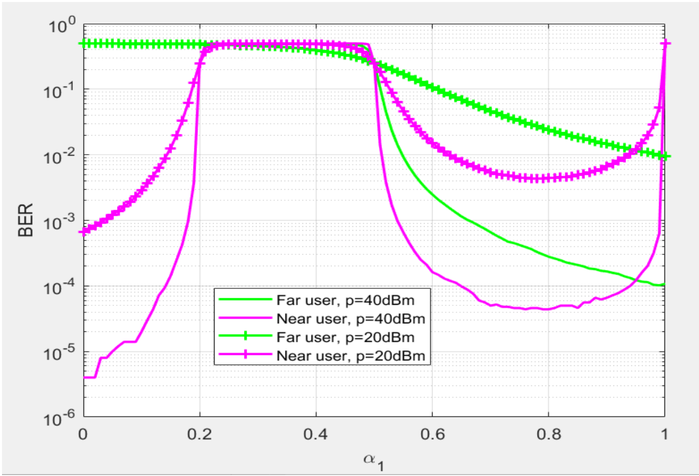

Figure 4. PA in NOMA

U_1 is the far user while U_2 is the near user [20]. The fixed PA approach has also been utilized. In other words, the coefficients were not changed in response to the channel conditions. Also, plotting the BERs at various PA coefficient values is what we have just done 40 dBm of transmit power is shown by the solid lines, while 20 dBm is indicated by the dotted lines [21]. By transforming the figure above into $\alpha_2=1-\alpha_1$, it may be understood in terms of α_2 (because $\alpha_1>\alpha_2$ and $\alpha_1+\alpha_2=1$ is known to exist).

First, we see that there are better and worse values for the PA coefficients. That is, for some values of α_1, the BER is low, whereas for other values, it is large. Two areas of this plot have low BER ($<10^{-4}$) for U_2, that is, approximately $\alpha_1<0.9$) and approximately $\alpha_1\approx0.8$ (that is, $\alpha_2\approx0.2$). When $\alpha_1<0.1$ ($\alpha_2>0.9$) rather than $\alpha_1\approx0.8$ ($\alpha_2\approx0.2$), the BER for U_2 is less. Thus, selecting $\alpha_1<0.1$ and $\alpha_2>0.9$ is not possible. In this regime, the U_1 has an extremely high BER. Since U_2 data is dominant and $\alpha_1\approx0$ and $\alpha_2\approx1$, it would take time for U_1 to decode his signal. His high BER can be explained by this. At the plot's right end, $\alpha_1\approx1$ and $\alpha_2\approx0$. This indicates that the U_1 is allotted a significant amount of power. He therefore exhibits a declining BER trend. The U_2 experiences high BER as $\alpha_1\approx1$, due to the high-power U_1 data interference [22], [23].

3.2. Outage probability for uplink non-orthogonal multiple access

As we can see in Figure 5, U_1 is considered the far user, whereas U_2 is considered the nearby user. Denote the distances between them and the BS by d_1 and d_2. Their respective Rayleigh fading coefficients are represented by the symbols h_1 and h_2. As well as ($h_{12}<h_{22}$ and $d_1>d_2$) [24].

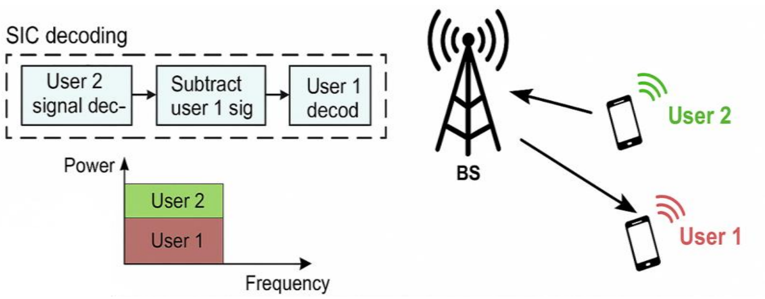

Figure 5. Uplink NOMA system with two users

Uplink NOMA systems enable 2 users to send data to the BS concurrently over the same spectrum, as shown in Figure 5. In order to decipher the signals from various users, the BS uses SIC. Once more, we suppose that U_2 has a higher channel gain than U_1, i.e., $\frac{|h_2|^2}{{\sigma_2}^2}\geq\frac{|h_1|^2}{{\sigma_1}^2}$. The signal that the receiver has received is (9):

$$y=h_1x_1+h_2x_2+n_B \quad (9)$$

where n_B is the receiver-side AWGN with zero mean and ${\sigma_2}^2$ variance. When the received signal is decoded by the BS in a decreasing sequence, the data rate for both users is (10) and (11):

$$R_1=\log_2(1+\frac{p_1|h_1|^2}{{\sigma_B}^2}) \quad (10)$$

$$R_2=\log_2(1+\frac{p_2|h_2|^2}{p_1|h_1|^2+{\sigma_B}^2}) \quad (11)$$

However, if the BS decodes the signal it has received in ascending order, the data rate for both users become expression of (12) and (13):

$$R_1=\log_2(1+\frac{p_1|h_1|^2}{p_2|h_2|^2+{\sigma_B}^2}) \quad (12)$$

$$R_2=\log_2(1+\frac{p_2|h_2|^2}{{\sigma_B}^2}) \quad (13)$$

It is important to note that the users' total rate in each scenario is the same as what is stated in (14):

$$R_1+R_2=\log_2(1+\frac{p_2{h_2}^2+p_1{h_1}^2+{\sigma_B}^2}{{\sigma_B}^2}) \quad (14)$$

Stated otherwise, if there is no error propagation throughout the SIC process, the total rate in the uplink NOMA is independent of the SIC order. On the other hand, carrying out SIC in the decreasing sequence of channel quality levels is more realistic [25], [26]. In uplink communication, users send data to the BS. Let's look at the network below, it has two users who wish to send information to the BS. For uplink NOMA, a little different method is used for the power domain multiplexing section. We understand that superposition coding (SC) is used by the BS for power domain multiplexing in the downlink NOMA scheme. In contrast, users transmit power in uplink is solely constrained by the capacity of their batteries. In other words, each user can transmit data at full power. The variations in the users' channel gains cause the distinction in the power domain at the receiver side BS. Let's say that x_1 and x_2 stand for the messages that U_1 and U_2 will send, respectively. Assuming equal signal transmission power from both users [27]. The signal that U_1 is transmitting is $\sqrt{p}x_1$. In the same way, $\sqrt{p}x_1$ is the signal that U_2 transmits. At the BS the signal received is given by (15).

$$y=\sqrt{p}x_1h_1+\sqrt{p}x_2h_2+\omega \quad (15)$$

Compared to U_1, U_2 is located closer to the BS based on our prior estimates, indicating a stronger channel gain. i.e., $|h_2|^2>|h_1|^2$. The strength of the U_2's expression ($\sqrt{p}x_2h_2$) will as a result dominate the signal that is received. Put otherwise, the BS might interpret the x_2 phrase straight and regard the U_1's term as interference. The x_1 can then be recovered by performing SIC. The power domain distinction is already becoming apparent. This is the area in which uplink and downlink NOMA diverge [28], [29]. There would be different channel advantages if the users were far enough apart from one another. Therefore, even in the absence of power control, also known as SC, the BS can correctly separate their signals. To put it another way, unlike downlink NOMA, where power control is achieved by purposeful SC, here it is caused by natural variances in the channel gains. Notably, in order for uplink NOMA to achieve success, it is essential for the user's channel gains to exhibit significant variability. In the power domain, the BS cannot identify the signals of the two users if their channel gains are equivalent. Power regulation is therefore required. In other words, the users' transmission powers must differ. In uplink NOMA, we see that the SIC order is inverted, first to be deciphered is the signal from U_2 [30]. In the downlink NOMA, on the other hand, starts with the U_1's signal decoding. By classifying the U_1's signal as interference, the U_2's signal is decoded first [31]. As a result, the BS's achievable rate to decode U_2 data is given by (16):

$$R_2 = \log_2\left(1+\frac{p|h_2|^2}{p|h_2|^2+\sigma^2}\right) \quad (16)$$

The achievable rate for U1 after SIC is provided by (17):

$$R_1 = \log_2\left(1+\frac{p|h_1|^2}{\sigma^2}\right) \quad (17)$$

To examine our uplink NOMA network's outage performance [32], we will simulate it. Power control is not used in this scenario. In order to facilitate power domain multiplexing, the intrinsic variations in the channel gains are utilized. Two distinct U_1 and U_2 distance pairs— (800, 200), (800, 300), (800, 400), and (800, 500) meters—are used in the simulation. The following graph, given by the Figure 6, is produced when the outage is plotted. From this Figure 6, we can observe that both users have a higher OP compared to the other distance pairings, for the distance pair (800, 200) m, where they have less outages. This supports the previous argument that we had. In other words, NOMA performs better when user-to-user channel conditions become increasingly unique [33], [34].

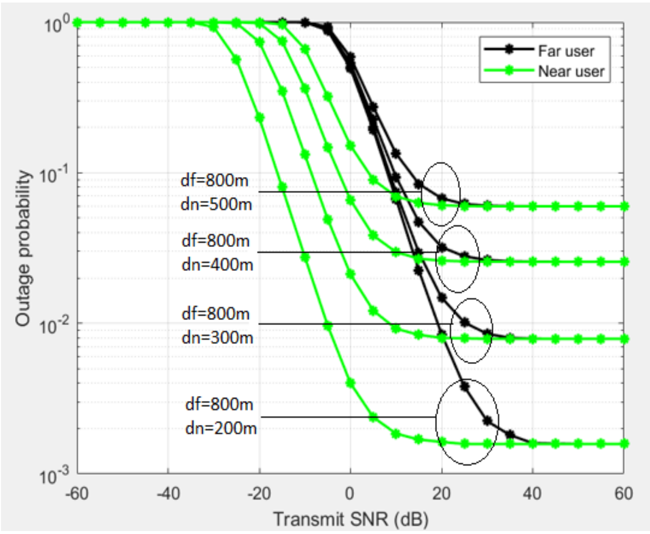

Figure 6. Uplink NOMA outage likelihood

4. CONCLUSION

In NOMA systems, the particular performance needs and trade-offs of the network determine which of the fixed and fair PA algorithms to use. Fixed PA makes system design simpler, but because it is static and does not adjust to users' real-time channel conditions, it may produce less-than-ideal outcomes in dynamic channel settings. Fair PA, on the other hand, dynamically modifies the PA coefficients (α_1 and α_2) to satisfy performance requirements, improving its resilience to channel fluctuations and providing superior results in terms of OP and cumulative rate. In some target data rate settings, for example, fair PA can lower the chance of interference by 78% when compared to fixed PA. Nevertheless, imperfect SIC, which produces residual interference, and reduces performance, can affect both solutions. To mitigate this and increase the efficacy of SIC, sophisticated signal processing and optimization methods are needed. In order to maximize NOMA systems' effectiveness, equity, and interference control, these problems must be fixed. In particular, for 5G, and upcoming 6G networks, where fairness, spectral efficiency, and system capacity are crucial, our findings can help with the design of next-generation wireless communication systems. Enhanced PA systems that use adaptive power regulation and instantaneous CSI will be investigated in future studies to further increase system robustness. Together with testing our models in a variety of more intricate and varied settings, such as multi-user and multi-cell environments, we also want to include other performance measures like energy efficiency, latency, and fairness index. A comparison of these methods with other PA systems will provide further light on their scalability and practical implementation.

FUNDING INFORMATION

The authors express their gratitude to the Scientific Publication Support Center of Ibn Tofail University Kenitra for its financial support of this research about 485 USD. This funding has contributed to covering publication costs and enhancing the dissemination of the study's findings. All authors contributed equally and approved the version of the manuscript to be published. The algorithms are available at https://ecewireless.blogspot.com/.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Abdelbari Falloun	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	
Abdessalam Ait Madi		✓		✓		✓		✓		✓	✓	✓	✓	✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

DATA AVAILABILITY

The data that support the findings of this study are openly available in https://ecewireless.blogspot.com/. This dataset includes all relevant NOMA parameters used for model training and validation, such as BER, OP, Fixed and fair PA in downlink and uplink NOMA collected over the period of 2020–2021. The data has been pre-processed and structured to ensure compatibility with MATLAB for 5G communication system. Researchers can access and utilize the dataset for further studies on NOMA for 5G communication system.

REFERENCES

[1] A. Kumar and K. Kumar, "Multiple access schemes for cognitive radio networks: a survey," *Physical Communication*, vol. 38, p. 100953, 2020, doi: 10.1016/j.phycom.2019.100953.
[2] A. Falloun and A. A. Madi, "Enhancing spectral efficiency: promise of SC-NOMA with pairing in 5G and beyond," in *2024 4th International Conference on Innovative Research in Applied Science, Engineering and Technology, IRASET, IEEE*, May. 2024, pp. 1–7, doi: 10.1109/IRASET60544.2024.10549560.
[3] A. Akbar, S. Jangsher, and F. A. Bhatti, "NOMA and 5G emerging technologies: a survey on issues and solution techniques," *Computer Networks*, vol. 190, pp. 1-40, 2021, doi: 10.1016/j.comnet.2021.107950.
[4] E. Erturk, O. Yildiz, S. Shahsavari, and N. Akar, "Power allocation and temporal fair user group scheduling for downlink NOMA," *Telecommunication Systems*, vol. 77, no. 4, pp. 753–766, 2021, doi: 10.1007/s11235-021-00786-x.
[5] K. Umamaheswari, A. C. Pogaku, D. T. Do, A. T. Le, and M. Munochiveyi, "Improving performance of user pair using reconfigurable intelligent surfaces," *Wireless Communications and Mobile Computing*, vol. 2021, no. 1, 2021, doi: 10.1155/2021/2036778.
[6] P. Gupta, A. Kumar, and R. Sharma, "Resource allocation method for improved spectral efficiency, outage probability and user fairness in NOMA," *International Journal of Electronics*, vol. 112, no. 3, pp. 391–410, 2025, doi: 10.1080/00207217.2024.2302340.
[7] K. Kavitha and S. Vappangi, "Performance analysis of novel user pairing-based hybrid NOMA system with fixed/optimal power allocation strategy," *IEEE Access*, vol. 11, pp. 106037–106053, 2023, doi: 10.1109/ACCESS.2023.3319664.

[8] F. Khennoufa, K. Abdellatif, and F. Kara, “Bit error rate and outage probability analysis for multi-hop decode-and-forward relay-aided NOMA with imperfect SIC and imperfect CSI,” *AEU - International Journal of Electronics and Communications*, vol. 147, pp. 1-14, 2022, doi: 10.1016/j.aeue.2022.154124.

[9] R. Dipinkrishnan and V. B. Kumaravelu, “Enhancing sum spectral efficiency and fairness in NOMA systems: a comparative study of metaheuristic algorithms for power allocation,” *IEEE Access*, vol. 12, pp. 85165–85177, 2024, doi: 10.1109/ACCESS.2024.3415813.

[10] V. Ozduran and N. Nomikos, “Performance analysis of inverse successive interference cancellation in NOMA-based communications,” *Wireless Networks*, vol. 30, no. 3, pp. 1893–1907, 2024, doi: 0.1007/s11276-023-03618-9.

[11] M. A. Elnaby, “Sum rate maximization-based fair power allocation in downlink NOMA networks,” *Computers, Materials and Continua*, vol. 71, no. 2, pp. 5099–5116, 2022, doi: 10.32604/cmc.2022.022020.

[12] W. F. Alghasmari and L. Nassef, “Power allocation evaluation for downlink non-orthogonal multiple access (NOMA),” *International Journal of Advanced Computer Science and Applications*, vol. 11, no. 4, pp. 126–132, 2020, doi: 10.14569/IJACSA.2020.0110417.

[13] W. F. Alghasmari and L. Nassef, “Optimal power allocation in downlink non-orthogonal multiple access (NOMA),” *International Journal of Advanced Computer Science and Applications*, vol. 12, no. 2, pp. 318–325, 2021, doi: 10.14569/IJACSA.2021.0120240.

[14] N. Iswarya and L. S. Jayashree, “A survey on successive interference cancellation schemes in NOMA for future radio access,” *Wireless Personal Communications*, vol. 120, no. 2, pp. 1057–1078, 2021, doi: 10.1007/s11277-021-08504-1.

[15] Z. J. Ali, N. K. Noordin, A. Sali, and F. Hashim, “Fair energy-efficient resource allocation for downlink NOMA heterogeneous networks,” *IEEE Access*, vol. 8, pp. 200129–200145, 2020, doi: 10.1109/ACCESS.2020.3035212.

[16] V. Özduran, M. Mohammadi, N. Nomikos, I. S. Ansari, and P. Trakadas, “On the performance of uplink power-domain NOMA with imperfect CSI and SIC in 6G networks,” *Journal of Communications and Networks*, vol. 26, no. 4, pp. 445–460, 2024, doi: 10.23919/JCN.2024.000039.

[17] A. Falloun, A. Deroussi, and A. A. Madi, “MIMO-NOMA and MIMO-OMA: Outage probability analysis and BER comparative study,” in *2023 3rd International Conference on Innovative Research in Applied Science, Engineering and Technology, IRASET 2023*, IEEE, May. 2023, pp. 1–8, doi: 10.1109/IRASET57153.2023.10153065.

[18] B. Pavithra and P. Chakraborty, “Performance Analysis of Bit Error Rate, Capacity and Outage Probability using Power Domain Non-Orthogonal Multiple Access (PD-NOMA) and Orthogonal Multiple Access (OMA) with Far/Near User,” *2022 6th International Conference on Intelligent Computing and Control Systems (ICICCS)*, Madurai, India, 2022, pp. 166-170, doi: 10.1109/ICICCS53718.2022.9788438.

[19] C. I. Chikezie, M. David, and A. U. Usman, “Power allocation optimization in NOMA system for user fairness in 5G Networks,” in *Proceedings of the 2022 IEEE Nigeria 4th International Conference on Disruptive Technologies for Sustainable Development, NIGERCON 2022*, IEEE, Apr. 2022, pp. 1–4, doi: 10.1109/NIGERCON54645.2022.9803107.

[20] X. Song, Y. Yue, and S. Xu, “Energy-efficient maximization algorithm for energy harvesting under imperfect channel information,” *Physical Communication*, vol. 66, p. 102465, 2024, doi: 10.1016/j.phycom.2024.102465.

[21] M. O. Babana, M. N. Hussin, and A. A. ALsharef, “Performance of Dynamic Power Assignments for Downlink NOMA System,” *2024 IEEE 4th International Maghreb Meeting of the Conference on Sciences and Techniques of Automatic Control and Computer Engineering (MI-STA)*, Tripoli, Libya, 2024, pp. 364-368, doi: 10.1109/MI-STA61267.2024.10599644.

[22] M. Shen, Z. Huang, X. Lei, and L. Fan, “BER analysis of NOMA with max-min relay selection,” *China Communications*, vol. 18, no. 7, pp. 172–182, 2021, doi: 10.23919/JCC.2021.07.014.

[23] L. Bhardwaj, R. K. Mishra, and R. Shankar, “Sum rate capacity of non-orthogonal multiple access scheme with optimal power allocation,” *Journal of Defense Modeling and Simulation*, vol. 19, no. 4, pp. 759–769, 2022, doi: 10.1177/1548512920983531.

[24] B. Panda and P. Singh, “Performance Analysis of NOMA Systems in Rayleigh and Rician Fading Channels,” *2021 Advanced Communication Technologies and Signal Processing (ACTS)*, Rourkela, India, 2021, pp. 1-6, doi: 10.1109/ACTS53447.2021.9708221.

[25] B. U. Rehman *et al.*, “Uplink power control scheme for spectral efficiency maximization in NOMA systems,” *Alexandria Engineering Journal*, vol. 64, pp. 667–677, 2023, doi: 10.1016/j.aej.2022.11.030.

[26] I. Azam and S. Y. Shin, “On the performance of SIC-free spatial modulation aided uplink NOMA under imperfect CSI,” *ICT Express*, vol. 9, no. 1, pp. 76–81, 2023, doi: 10.1016/j.icte.2021.12.005.

[27] D. H. Thuan, N. T. Nguyen, X. T. Nguyen, N. T. Hau, B. V. Minh, and T. N. Nguyen, “Uplink and downlink of energy harvesting NOMA system: performance analysis,” *Journal of Information and Telecommunication*, vol. 8, no. 1, pp. 92–107, 2024, doi: 10.1080/24751839.2023.2260230.

[28] X. Xie, “Performance Analysis for uplink NOMA system based on hybrid SIC decoding strategy,” in *2024 IEEE 13th International Conference on Communications, Circuits, and Systems, ICCCAS*, IEEE, May 2024, pp. 370–374, doi: 10.1109/ICCCAS62034.2024.10652854.

[29] Y. Tian, B. Xiao, X. Wang, Y. H. Kho, and C. Tian, “Performance analysis of opportunistic NOMA strategy in uplink coordinated multi-points systems,” *Computer Communications*, vol. 177, pp. 207–212, 2021, doi: 10.1016/j.comcom.2021.07.001.

[30] A. Hesam, A. H. Bastami, and M. A. Abdel-Hafez, “Performance analysis of NOMA-based transmission in two-way relay network,” *IEEE Access*, vol. 12, pp. 37051–37068, 2024, doi: 10.1109/ACCESS.2024.3374636.

[31] A. Falloun and A. A. Madi, “Successive interference cancellation in NOMA For 5G communication system,” in *2025 5th International Conference on Innovative Research in Applied Science, Engineering and Technology, IRASET 2025*, IEEE, May. 2025, pp. 1–6, doi: 10.1109/IRASET64571.2025.11008207.

[32] Y. Zhou, Y. Zhang, A. A. Khuwaja, Z. Wang, and Q. Zhang, “Analysis of the outage performance of energy-harvesting cooperative-NOMA system with relay selection methods,” *Scientific Reports*, vol. 14, no. 1, pp. 1-9, 2024, doi: 10.1038/s41598-024-61213-0.

[33] A. Baranwal, S. Dhar Roy, and S. Kundu, “Outage and ergodic capacity analysis of a full-duplex energy-harvesting cooperative non-orthogonal multiple access network,” *International Journal of Communication Systems*, vol. 37, no. 6, 2024, doi: 10.1002/dac.5710.

[34] P. D. Diamantoulakis and G. K. Karagiannidis, “Performance analysis of distributed uplink NOMA,” *IEEE Communications Letters*, vol. 25, no. 3, pp. 788–792, 2021, doi: 10.1109/LCOMM.2020.3037478.

BIOGRAPHIES OF AUTHORS

Abdelbari Falloun received the B.Eng. degree in electronics and communication from Ibn Tofail University, Kenitra, Morocco, in 2020. He is currently pursuing his Ph.D. degree with the National School of Applied Science, Ibn Tofail University, Morocco. He is research in communication engineering, MIMO, OMA/OFDMA, NOMA, and 4G/5G/6G. He can be contacted at email: abdelbari.falloun@uit.ac.ma.

Abdessalam Ait Madi was born in Morocco. He received the teaching engineering degree in electronic from the ENSET of Mohammedia. He received the Master and the Ph.D. degrees from the Faculty of Sciences and Technologies from Sidi Mohamed Ben Abdellah University of Fez in Morocco. He received the Habilitation degree from the Faculty of Sciences of Ibn Tofail University. He is an Associate Professor at the National School of Applied Sciences of Ibn Tofail University in Kenitra, Morocco. He can be contacted at email: abdessalam.aitmadi@uit.ac.ma.