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Department of Electrical and Electronics Engineering

OUTAGE PROBABILITY ANALYSIS FOR NOMA OVER ALPHA-MU GENERALIZED FADING CHANNEL

Master Thesis

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DECLARATION

I hereby declare that in the preparation of this thesis, scientific ethical rules have been followed, the works of other persons have been referenced in accordance with the scientific norms if used, there is no falsification in the used data, any part of the thesis has not been submitted to this university or any other university as another thesis.

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SUMMARY

Non-orthogonal multiple access (NOMA) is a promising technology that can meet the needs of wireless communication generations, such as the fifth generation (5G) and beyond. The NOMA can provide high spectral/energy efficiency, high connectivity, and low latency. Unlike orthogonal multiple access (OMA) techniques that use orthogonal resources, NOMA allocates non-orthogonal resources to multiple users, resulting in higher spectral efficiency. In the power domain NOMA, users are superimposed with different power levels based on their channel conditions, and receivers use successive interference cancellation (SIC); hence a good balance between system throughput and user fairness can be provided. The thesis examines the system's outage probability (OP) performance in α-μ generalized fading channels. In particular, we derive the instantaneous signal-to-interference-and-noise ratio (SINR) and then obtain the OP expression for each user in a closed form. The derived expression for OP is general and includes special cases such as Nakagami-m, Weibull, Gamma, Rayleigh, and Exponential distributions. This α-μ expression helps quantify the improvement of the OP performance. In order to improve the OP performance, multiple antennas are included for the users, and then receive antenna selection (RAS) scheme is employed. The theoretical OP expressions are verified via Monte Carlo simulations.

Key Words: Nonorthogonal multiple access (NOMA), Orthogonal multiple access (OMA).

ÖZET

Ortogonal olmayan çoklu erişim (NOMA), beşinci nesil (5G) ve sonrası gibi kablosuz iletişim nesillerinin ihtiyaçlarını karşılayabilecek umut verici bir teknolojidir. NOMA, yüksek spektral/enerji verimliliği, yüksek bağlantı ve düşük gecikme süresi sağlayabilir. Ortogonal kaynakları kullanan ortogonal çoklu erişim (OMA) tekniklerinden farklı olarak NOMA, ortogonal olmayan kaynakları birden fazla kullanıcıya tahsis ederek daha yüksek spektral verimlilik sağlar. Güç alanı NOMA'da, kullanıcılar kanal koşullarına bağlı olarak farklı güç seviyeleriyle üst üste bindirilir ve alıcılar ardışık girişim iptali (SIC) kullanır; dolayısıyla sistem verimi ile kullanıcı adaleti arasında iyi bir denge sağlanabilir. Tez, α-μ genelleştirilmiş sönümleme kanallarında sistemin kesinti olasılığı (OP) performansını incelemektedir. Özellikle, anlık sinyal-parazit-ve-gürültü oranını (SINR) türetiyoruz ve ardından her kullanıcı için OP ifadesini kapalı bir biçimde elde ediyoruz. OP için türetilmiş ifade geneldir ve Nakagami-m, Weibull, Gamma, Rayleigh ve Üstel dağılımlar gibi özel durumları içerir. Bu α-μ ifadesi, OP performansındaki gelişmeyi ölçmeye yardımcı olur. OP performansını iyileştirmek için, kullanıcılar için çoklu antenler dahil edilmiş ve ardından alıcı anten seçimi (RAS) şeması kullanılmıştır. Teorik OP ifadeleri, Monte Carlo simülasyonları ile doğrulanmıştır.

Anahtar kelimeler: Ortogonal olmayan çoklu erişim (NOMA), Ortogonal çoklu erişim (OMA).

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ABBREDIVATIONS

IoT	**:**	Internet of Things
QoS	**:**	quality of services
mmWave	**:**	millimeter wave
MIMO	**:**	multiple input multiple output
MA	**:**	multiple access
OMA	**:**	orthogonal multiple access
NOMA	**:**	nonorthogonal multiple access
FDMA	**:**	frequency division multiple access
1G	**:**	First generation
TDMAC	**:**	time division multiple access
2G	**:**	the second generation
CDMA	**:**	code division multiple access
3G	**:**	third generation
OFDMA	**:**	orthogonal frequency division multiple access
4G	**:**	fourth generation
SIC	**:**	successive interference cancellation
MUSA	**:**	multiuser shared access
SCMA	**:**	sparse code multiple access
LDS	**:**	low-density spreading
PDMA	**:**	pattern division multiple access
BDM	**:**	bit division multiplexing
IMT	**:**	International Mobile Telecommunications
eMBB	**:**	enhanced mobile broadband
mMTC	**:**	massive machine type communication
URLLC	**:**	ultrareliable and low-latency communication
PDF	**:**	probability density function
CDF	**:**	cumulative distribution function
SINR	**:**	signal-to-interference-and-noise ratio
RAS	**:**	receive antenna selection
BER	**:**	poor Bit Error Rate

GOS	**:**	Global Optimal Search
APF	**:**	Adaptive Proportional Fair
IPSA	**:**	the ideal partner search algorithm
RSPA	**:**	random subcarrier and power allocation
UG	**:**	user grouping
BER	**:**	bit error rate
J-PA-AS	**:**	joint power distribution and antenna selection
UA	**:**	user association
PA	**:**	power allocation
SE	**:**	spectral efficiency
STAR-RIS	**:**	simultaneous transmitting and reflecting reconfigurable intelligent surface
MS	**:**	mode switching
AF	**:**	amplify-and-forward
CEE	**:**	channel estimation error
FD	**:**	feedback delay
OP	**:**	outage probability
AS	**:**	antenna selection
TAS	**:**	transmit antenna selection
MRC	**:**	maximal ratio combining
JTRAS	**:**	joint transmit and receive antenna selection
EH	**:**	energy harvesting
OP	**:**	outage probability
CSI	**:**	channel state information
AF	**:**	amplify-and-forward
SDR	**:**	software-defined radio

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INTRODUCTION

It is indisputable that wireless mobile communication devices have become a crucial component of our daily lives. However, there has been a significant increase in the number and variety of such devices, necessitating the use of the same radio spectrum by multiple applications or users. Additionally, the expansion of the Internet of Things (IoT) demands the connection of every person and object (Aldababsa, Toka, Gökçeli, Kurt, & Kucur, 2018). Current communication systems face serious limitations that impede adjustments or upgrades necessary to satisfy these requirements. As a result, researchers have explored developing appropriate techniques that can be integrated into the next generation of wireless communication systems to address emerging needs. These needs include high spectral efficiency, low latency, massive device connectivity, high data rate, ultra-reliability, user fairness, high throughput, and support for diverse quality of services (QoS), energy efficiency, and a compelling user experience. Furthermore, there is a need to improve the user experience (Andrews, et al., 2014).

The academic and business communities have identified several potential technological solutions aimed at meeting the exacting standards outlined earlier, as well as addressing the challenges that future generations may face. As an example, the massive multiple input multiple output (MIMO) concept has been introduced to enhance capacity and energy efficiency, and ultra dense networks have been developed to increase throughput and decrease energy consumption by utilizing numerous small cells (Rappaport, et al., 2013),(Larsson, Edfors, Tufvesson, & Marzetta, 2014).

Millimeter wave (mmWave) technology has also been proposed to expand transmission bandwidth for high-speed communications. Furthermore, researchers have created a novel radio access technology intended for implementation in communication networks due to its potential to improve system capacity. This technology has been developed in addition to the aforementioned approaches. Recent advancements in the design of nonorthogonality-based system architectures have garnered significant attention from academia for use in communication networks. Consequently, multiple access (MA) approaches now can be effectively categorized as orthogonal multiple access (OMA) and nonorthogonal multiple access (NOMA) (Kamel, Hamouda, & Youssef, 2016).

To reduce multiple access interference, OMA allocates orthogonal communication resources to each user inside a particular time slot, frequency range, or code. These resources can be classified into three categories: time slots, frequency bands, and codes. OMA schemes have been utilized in previous generations of networks, such as frequency division multiple access (FDMA) in the first generation (1G), time division multiple access (TDMA) in the second generation (2G), code division multiple access (CDMA) in the third generation (3G), and orthogonal frequency division multiple access (OFDMA) in the fourth generation (4G). In contrast, multiple users can simultaneously access nonorthogonal resources through the use of NOMA, which provides a high level of spectral efficiency and allows a certain degree of multiple access interference at receivers (Li, Niu, Papathanassiou, & Wu, 2014)

In the field of nonorthogonal multiple access (NOMA), two types of multiplexing are commonly employed: power-domain multiplexing and code-domain multiplexing. Power-domain multiplexing allocates different power coefficients to various users based on their channel conditions, in order to achieve high system performance. Specifically, information signals from multiple users are layered one on top of another at the transmitter end, and Until the desired user's signal is acquired, successive interference cancellation (SIC) is utilized at the receiver end to decode each signal individually. With this strategy, system throughput and user fairness are well-balanced (Umehara, Kishiyama, & Higuchi, 2012). Code-domain multiplexing, on the other hand, assigns unique codes to different users, which are then multiplexed over the same time-frequency resources. This approach is utilized in protocols such as multiuser shared access (MUSA), sparse code multiple access (SCMA), and low-density spreading (LDS) (Li, Niu, Papathanassiou, & Wu, 2014) (Verdu & Detection, 1998)

Other NOMA methods include pattern division multiple access (PDMA) and bit division multiplexing (BDM), in addition to power-domain and code-domain multiplexing. Although code-domain multiplexing has the potential to improve spectral efficiency, it is challenging to implement in existing systems due to the need for a wide transmission bandwidth. Power-domain multiplexing, on the other hand, is relatively simple to install, since it doesn't necessitate major changes to already-existing networks and doesn't call for additional capacity to increase spectral efficiency (Yuan,, Yu,, & Li,, 2015), Power-domain NOMA will be the major topic of this effort. In an ideal environment, orthogonal multiple access (OMA) approaches may achieve acceptable system performance even with basic receivers, but they are currently unable to handle the new problems brought on by the rising needs for 5G networks and beyond. According to the International Mobile Telecommunications (IMT), three major kinds of use cases should be supported by 5G technology by 2020 and beyond (Dai, et al., 2015). These include massive machine type communication (mMTC), ultrareliable and low-latency communication (URLLC), and improved mobile broadband (eMBB). The two main requirements for the eMBB scenario are an increase in spectrum efficiency of more than three times over prior LTE releases and a user perceived data rate of 100 Mbps. To offer services like high-definition video experiences, virtual reality, and augmented reality, these enhancements are required. Offering a connection density of one million devices per square kilometer is the main difficulty of mMTC. This is necessary since a high number of Internet of Things devices would have access to the network. In the case of URLLC, the primary criteria are a latency of 0.5 milliseconds from beginning to finish and a dependability of 99.999% or higher (Rappaport T. S., et al., 2014). The use of NOMA can increase the number of user connections for mMTC and URLLC applications by a factor of five and nine, respectively (CATT, korea, & rep, 2016). In eMBB, NOMA has been shown to be more spectral bands efficient than OMA by a factor of 30% for the downlink and 100% for the uplink (Aldababsa, Toka, Gökçeli, Kurt, & Kucur, A Tutorial on Nonorthogonal Multiple Access for 5G and Beyond, 2017). As a result, NOMA has been acknowledged as a strong choice among all MA approaches since it contains key characteristics to get beyond OMA's drawbacks and meet the demands of next-generation mobile communication systems (Aldababsa, Toka, Gökçeli, Kurt, & Kucur, A Tutorial on Nonorthogonal Multiple Access for 5G and Beyond, 2017) (Pei, et al., 2020). Due to this, NOMA is now regarded as an excellent option among all MA methods.

CHAPTER ONE

BACKGROUND

This serves as a preface to the problem and illustrates the problem's explanation, points and objectives, and examination questions that are suggested to reach the review's goal.

1.1. Motivations

Regarding most of the works in literature, the motivations of this thesis can be highlighted as follows.

Several types of fading distributions have been suggested to model wireless channels, such as Rayleigh, Nakagami-m, etc., which are suitable for different channel conditions. However, in some cases, experimental data does not fit any of these distributions well, which forces to have more general fading distribution. In this context, the α-μ distribution is considered an essential general fading distribution. It encompasses several vital distributions, such as Nakagami-m, Rayleigh, Gamma, exponential, and Weibull. Its probability density function (PDF) and cumulative distribution function (CDF) are also expressed in closed form. The extraordinary benefits of α-μ distribution motivate us to study it in NOMA networks.

Even though some works investigated the NOMA in α-μ fading channels, these works only considered the single antenna case. Nevertheless, multi-antenna-based NOMA networks offer better performance compared to single-antenna-based networks. This motivates us to integrate multiple antennas into the NOMA network, significantly improving the considered network's performance

1.2. Contributions

The main contributions of this thesis can be summarized below:

We study the performance of the NOMA network over α-μ generalized fading channels. In the considered network, a BS communicates concurrently multiple users. The BS and each user are equipped with single transmit and single receive antennas, respectively.

For the considered network, using the CDF and PDF of the α-μ distribution, we derive the expressions of the instantaneous signal-to-interference-and-noise ratio (SINR).

Using the derived SINR expressions, we derive each user's closed-form expression of the OP. The obtained OP expression is general for fading channels, including Nakagami-m, Rayleigh, Gamma, exponential and Weibull as special cases.

The receive antenna selection (RAS) scheme is employed at the receivers of users in order to enhance the OP performance.

The Monte Carlo simulations finally verify the theoretical OP expressions.images

1.3. Outline

The remainder of the thesis is organized as follows:

Chapter Two: This chapter presents an introduction to the concept of NOMA and its application in wireless communication systems.

Chapter Three: This chapter provides a comprehensive literature survey of the related work, comparing and analyzing the effective factors in the field of NOMA-based communication systems.

Chapter Four: In this chapter, a detailed system model is proposed and explained, including the technical specifications and design considerations.

Chapter Five: This chapter presents the results of the work conducted in this thesis.

Chapter Six: This chapter summarizes the main findings, conclusions, and contributions made to the field of NOMA-based communication systems.

CHAPTER TWO

BASIC CONCEPT OF NOMA

This chapter presents an introduction to the concept of NOMA and its application in wireless communication systems.

2.1. Concepts of NOMA

The proliferation of mobile and wireless communication technologies has led to an increased demand for spectrum resources. To this end, NOMA is being considered for the massive expansion of the 5th-generation mobile communication system. Unlike conventional multiple access techniques, NOMA overlays customer signals on top of each other in the power domain using SIC for signal decoding. SIC eliminates the signal of the user with the worst channel conditions as compared to the user with better channel conditions. The benefits of NOMA are many, and it is expected to play a vital role in the development of 5G networks. One of the most significant advantages of NOMA is its ability to serve multiple users simultaneously with varying degrees of authority, providing efficient spectrum gain and improved system throughput compared to OMA. NOMA can be classified into two categories, namely, code-based NOMA and power-domain-based NOMA.

2.2. Power Domain NOMA

In this work, the technique of Power domain NOMA is employed for the transmission of signals from the base station to the customers. The SIC is the key concept used by the Power domain NOMA to transmit signals from the BS to users. This strategy is utilized to maintain a significant power imbalance between two users for example. In the absence of such an imbalance, the detection of the User-1 signal suffers from poor Bit Error Rate (BER) performance (Xinyue Pei et al., 2020). Consequently, the SIC at the receiver's end for User-2 fails to reduce the interference from User-1, leading to a high BER performance for User-2. When two users participate in an uplink, the BS receives a robust power reception from User-1 but only a poor power reception from User-2 (Xinyue Pei., 2013). Additionally, the BS can detect the signal from User-1 and eliminate it from the received signal to recognize the weak signal from User-2. If the signals received by the two users are not significantly different in power, the detection method's performance is poor in both the uplink and the downlink. When SC is employed at the transmitter end and SIC at the receiver's end, all users can use the same spectrum (Xinyue Pei et al., 2017). Power-domain NOMA achieves this kind of multiplexing. Initially, the transmitter combines the three signals into a single waveform using end SC. In contrast, SIC decodes the signal one by one until it obtains the intended signal at the receiver's end. It is apparent that the first decoded signal is considered a powerful signal, while other signals are considered noise or interference, as shown in Figure 1.

The received signal now has the strongest signal, which has already been decoded, and eliminated from it (Xinyue Pei et al., 2013). Only when the decoding process is performed accurately can the waveform containing the residual signals be considered flawless. The process of successive interference cancellation is iterated repeatedly until the desired signal is obtained (Xinyue Pei et al., 2017).

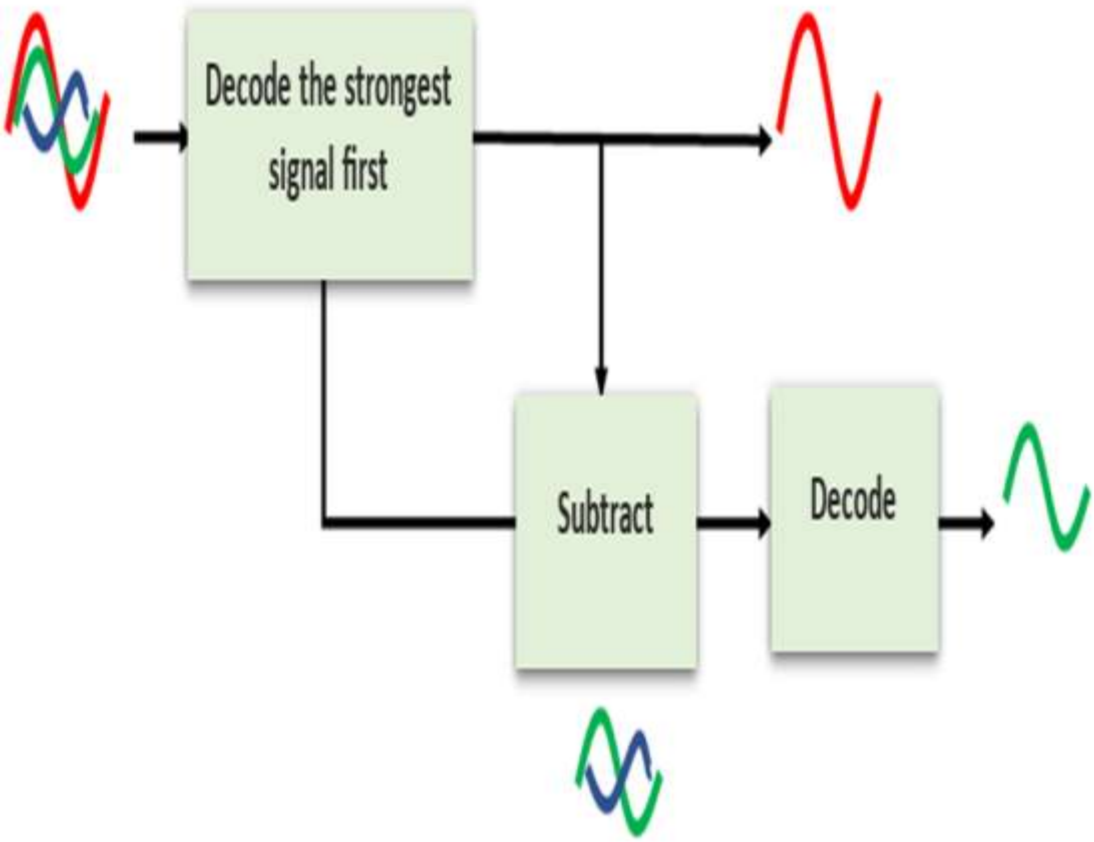


Figure 1. Successive Interference Cancellation.

2.3. Downlink NOMA

Downlink NOMA Network. On the transmitting end of the downlink NOMA network, as seen in Figure 2, BS sends out a combined signal to all mobile users. This signal is a superposition of the intended signals of numerous users, and each one has a distinct power coefficient given to them. It is expected that the SIC procedure will be carried out in a linear manner at the receiver of each user until the user's signal is recovered.

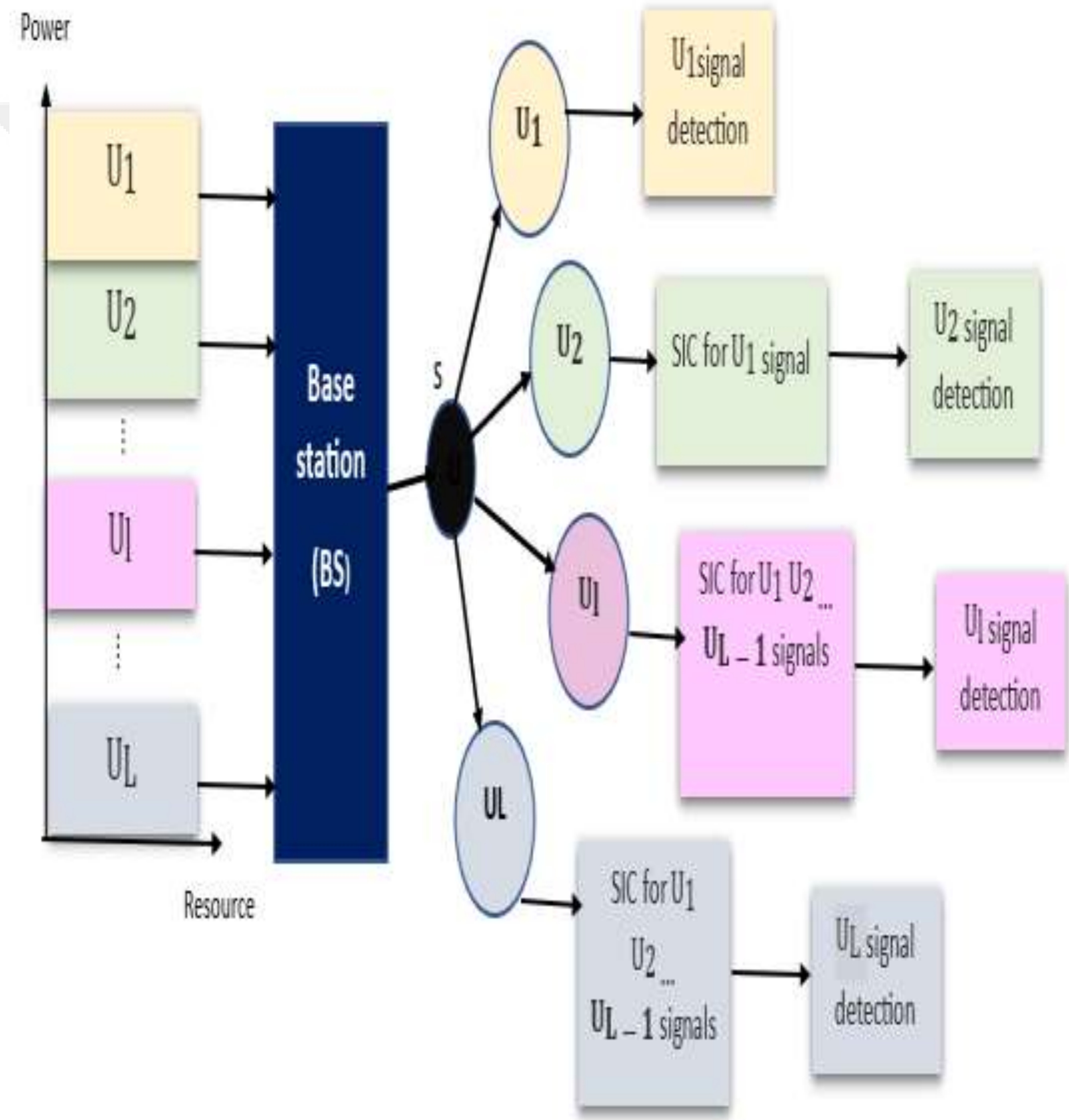


Figure 2. Downlink NOMA Network

The power coefficients of users are assigned in an inversely proportionate way, depending on the characteristics of their respective channels. In compared to the transmission power for the user who has a good channel condition, the transmission power for the user with a bad channel condition is raised. Therefore, assuming that the user with the highest transmission power views other users' signals as noise, it is able to recover its signal instantly without engaging in any SIC procedure since it has the highest transmission power. Nonetheless, other users are need to carry through SIC procedures. While using SIC, the receiver of each user initially looks for signals that are more powerful than the one that they want to receive. Then, when the linked user's own signal is found, those signals are subtracted from the incoming signal and the process repeats. The last step in the process is for each user to decode their own signal by ignoring other users whose power coefficients are lower and treating them as noise (GOLDSMITH, 2005). The following is a detailed representation of the signal that was broadcast at the BS

$$S= \sum_{i=1}^{L} \sqrt{a_i p_s x_i} \qquad \ldots (1)$$

where xi is information about the user i (Ui) with unit energy. Ps is the power of transmission at the BS and ai is the power factor specified for the user i subjected to $\sum_{i=1}^{L} a = 1$ and $a1 \geq a2 \geq \cdots \geq a_L$ as it is expected that the channel gains are generally ordered $|h1|2 \leq |h2|2 \leq \cdots \leq |hL|2$, where hl is the coefficient of channel of lth user based on NOMA concept. The received signal at lth user is expressed as follows:

$$y_1 = h_1 s + n_1 = h_1 \sum_{i=1}^{L} \sqrt{a_i P_s x_i} + n_1 \qquad (2)$$

where n_l is zero mean complex additive Gaussian noise with a variance of σ^2; that is, $n_l \sim CN(0, \sigma^2)$. [20]

2.4. Uplink NOMA

Uplink NOMA is a multiple access technique used in wireless communication networks. In Uplink NOMA, multiple users share the same frequency and time resources to transmit their signals to the base station simultaneously. NOMA allows multiple users to access the same time-frequency resource by superimposing their signals in the power domain. Each user is assigned a unique power level to encode their data. By using power domain multiplexing, multiple users can be served simultaneously, and the same frequency band can be reused for different users, resulting in increased spectral efficiency. The base station can distinguish between different users' signals by using advanced signal processing techniques. The users with weaker signals are given higher power allocations, while the users with stronger signals are allocated lower power levels. This ensures that all users can transmit their signals simultaneously, regardless of their signal strength. Uplink NOMA is considered a promising technology for 5G and beyond, as it can significantly improve the network's spectral efficiency, capacity, and user experience (molisch, wiley, & sons, 2012).

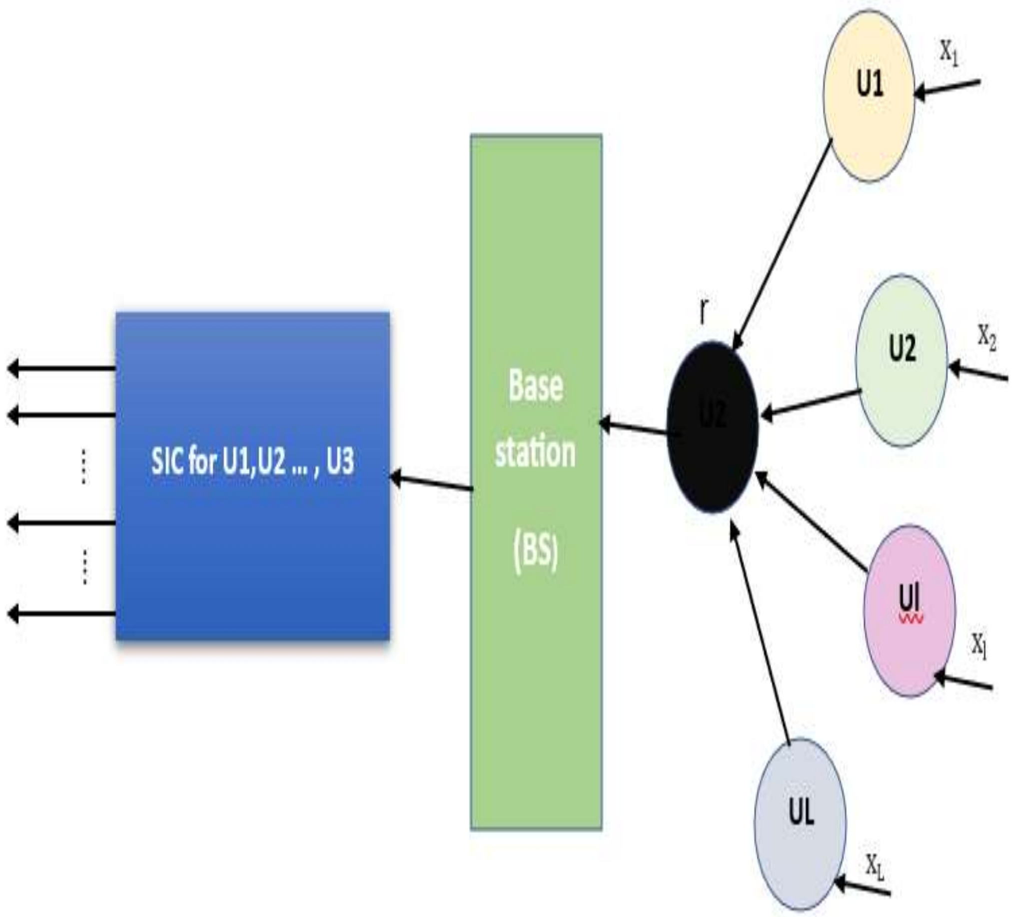


Figure 3. An example of the dataset Visualization

CHAPTER THREE

LITERATURE REVIEW

This chapter provides a comprehensive literature survey of the related work, comparing and analyzing the effective factors in the field of NOMA-based communication systems.

3.1. Introduction

A comprehensive and up-to-date understanding of the current state of knowledge on this thesis is shown in this chapter, and will serve as a foundation for the research and analysis presented in this thesis. It involves identifying, analyzing, and synthesizing relevant literature, including scholarly articles, books, and other sources of information. Providing an overview of the current state of knowledge and identify gaps in the existing literature, and suggest areas for future research. In this thesis, the literature review will focus on the outage probability analysis for NOMA over alpha-mu generalized fading channel. The literature review will begin by providing a brief background historical context and significance. It will then move on to examine the existing research on the topic, discussing the key theories, concepts, and findings that have emerged from previous studies. The review will also critically classify the previous work according to the year, Transmission scenario Max users in each sub channel, No. of antennas, No. of cells and Cal. External interference

3.2. Literature review

In (Lakshmanan et al.,2006), The QoS restrictions were taken into consideration during the NOMA downlink power allocation study. The goal of the study was to optimize the total user rate. By using the dynamic matching algorithm in conjunction with the optimum power allocation, efficient solutions for power distribution and sub-channel allocation have been simultaneously suggested. According to the findings, in compared to OFDMA schemes, the method suggested for optimizing the shared resources achieved close to ideal performance. A thorough analysis of how wireless resource allocation algorithms function in the downlink NOMA system was conducted for the research article known as (Aldababsa Mahmoud, et al.2018). It was discovered via this investigation that these strategies are essential for boosting NOMA throughput. The Divide-the-nextlargest-difference-based User Pairing method D-NLUPA was suggested to provide fairness among users with high system throughput. MIMO-OMA and MIMO-NOMA have been evaluated and contrasted side by side. The results showed that MIMO-NOMA was superior in terms of throughput and outage likelihood. The distribution of resources in an OFDMA-based NOMA downlink system with a base station and an even number of users was examined in (Liu, Tsiftsis, Kim, Kwak, & Poor, 2020). When each shared user pair was present in a certain subchannel. The ideal proportion of power will be distributed to each user who is utilizing the same sub-channel, but there will be a minimum user capacity requirement for this power. To distribute energy and amplify profits among several subcarriers while upholding the bounds of user fairness, a water-filling technique has been developed. The proposed scenario outperforms the conventional OFDMA in terms of system capacity, according to simulation findings. In (Zhu, Wang, Huang, He, & You, 2017), the issue of wireless resource management was specifically explored, as was the challenge of power allocation to strike a compromise between raising the system's overall total rate while still maintaining the user's minimal limit in the NOMA system. The problem of matching the sub-channel with the number of users and allocating the best power is addressed by the Global Optimal Search (GOS) approach. This may be accomplished by matching the number of users to the sub-channel. The throughput of the system could be increased using the proposed algorithm, but due to the algorithm's high complexity, it was not the best solution. Adaptive Proportional Fair (APF) is the name of the algorithm that was suggested as a solution to this problem since it has a low level of complexity. In (Islam, Zeng, Dobre, & Kwak, 2018). Studied the optimal relationship between the channel conditions of two NOMA downlink users in terms of maximizing the overall rate of the system. This was done in order to ensure that the maximum amount of data could be transmitted. The problem of allocating the sub-channel to the users can be solved by using the ideal partner search algorithm (IPSA), which selects the most appropriate partner for each user on the same sub-channel. This will allow the problem to be solved. The results of this investigation showed that the performance of the system is considerably impacted by even the smallest variation in the statuses of the channels between two different users. This difference is extremely reliant on the circumstances surrounding each channel. The results of the simulation demonstrated that the proposed algorithm was superior to many other methods. For example, it was superior to the bit error rate (BER), feasible total rate, and the number of users that the system can support for the random subcarrier and power allocation (RSPA) and user grouping (UG). As (L, Y, F, & S., 2018), have examined the power allocation issue that occurs in the NOMA-OMA downlink hybrid network. A system that selects users at random brings together two users, one of who has favorable channel conditions and the other of whom has unfavorable channel conditions. In order to achieve the highest overall rate possible, these pairs compete with one another for the appropriate amount of transmitter power that is transmitted by the BS. This procedure is performed for each pair in order for the base station to provide each with the proper amount of transmitted power. Comparing the recommended system to those that just utilize OMA or solely use NOMA, the simulation results show that it achieves a respectable overall rate.. In (Long, Wang, Li, & Chen, 2019), the non-orthogonal multiple access scenario was used to study the use of new strategies for power allocation and sub-channels. These strategies have been developed with the intention of lowering the amount of spectrum that is used while keeping the required data rate for each user unchanged. Among these tactics is the selection of user pairings to either achieve optimum or sub-optimal power allocation; also, a non-orthogonal hybrid approach has been implemented. This hybrid technique allows for dynamic change from non-orthogonal multiple access (NOMA) to orthogonal signals, as well as dynamic switching to orthogonal signals when non-orthogonal multiple access (NOMA) does not increase the data rate attained for each sub band. On the other hand, one of the shortcomings of these techniques is the high complexity that is brought on by the frequent employment of the SIC at the receiver side. This involves both orthogonal and non-orthogonal access. As a direct consequence of this, there are now studies and research being conducted to simplify it while preserving the same level of total sum rates for consumers. In (Cejudo, Zhu, Wang, & Alluhaibi, 2019), for downlink clustered non-orthogonal multiple access (NOMA) networks, the subject of joint power distribution and antenna selection (J-PA-AS) is addressed. In order to maximize the network's overall rate while meeting QoS requirements, the objective is to carry out antenna selection for each user group and assign transmit power to its users. On the other hand, a two-stage, low-complexity technique has been given. The problem of maximizing the power of the sum-rate distribution for each pair (antenna, user group) is ideally resolved in the first step of this method. In the subsequent stage, Kuhn-Munkres' ideal KMB backtracking approach was used to solve the polynomial complexity problem of antenna selection. The simulation results are shown to support the suggested approach, which has been shown to be more effective than alternative scaling schemes and to provide the optimized network sum rate faster than the optimized J-PA-AS scheme (resolved using a global optimization program). The simulation's findings have been presented to achieve this. The impact of geographic diversity on network aggregate was further highlighted by the finding that the base station's outage ratio decreased and the network aggregate rate increased with the number of antennas available. In the academic work known as (Lamba, Kumar, & Sharma, 2020). M. Aldababsa, The user association (UA) and power allocation (PA) issues were concurrently addressed with the intention of increasing the sum-rate of the MIMO-enabled megadelivery network while still making use of full-duplex and NOMA approaches. Based on the suggested framework, the hitch and jumper rate equations with incomplete channel state information CSI have been constructed. In addition, the overall rate is maximized with minimum restrictions placed on the service quality and delivery while accounting fairness problems are being considered. First, a non-convex issue is formed, and then a solution is produced by splitting the non-convex problem into numerous convex sub-problems. The results of the simulation revealed that applying the suggested algorithm resulted in a considerable improvement in the sum rate in comparison to the existing methods. The results shown that the total rate is influenced by the self-cancellation factor and the minimum transmission rate in addition to the number of antennas and SBS stations. Future research will be done to address the common UA and PA issue of many antennas in each SBS with faulty CSI and more than one MBS in the network, which will improve its suitability for future practical applications. Additionally, in order to conduct research on the trade-off between power consumption and spectral efficiency (SE) and improve the performance of the system, the energy efficiency measure of the proposed framework was examined and modified. According to the limited body of published research, channel correlation may be of assistance to massive MIMO technology when combined with NOMA technology. As a result, increasing the performance of the suggested framework may also be researched in the future while taking channel correlation into consideration in order to make the study more robust for deployment in real time. The relevant works are summarized for viewing reference in Table 1, which follows the previous section.

Table 1. Previous Work summarization

No.	Paper Title	Year	Transmission scenario	No. of cells	Cal. External interferences
1	Multichannel Resource Allocation for Downlink NOMA (Zhu,etal.2017)	2017	Downlink	Single-cell	No
2	Resource Allocation for Downlink NOMA Systems: Key Techniques and Open Issues (Islam,et al.2018)	2018	Downlink	Single	No
4	Low-Complexity Resource Allocation for Downlink Multicarrier NOMA System (Wang,et al.2018)	2018	Downlink	Single	No
5	Spectrum Resource and Power Allocation With Adaptive Proportional Fair User Pairing for NOMA Systems (Long,et al.2019)	2019	Downlink	Single	No

6	A Fast Algorithm for Resource Allocation in downlink multicarrier NOMA (Cejudo, Zhu, Wang, & Alluhaibi, 2019)	2019	Downlink	Single cell	No
7	Power allocation for downlink multiuser hybrid NOMA OMA systems: Anauction game approach (Lamba,et.al.2000)	2019	Downlink	Single cell	No
8	New Optimal and Suboptimal Resource Allocation Techniques for Downlink NOMA (Ye, Li, Yang, & An, 2022) (Hojeij,et al.2016)	2020	Downlink	Single	No
9	Joint Power Allocation and Antenna Selection for Network Sum-Rate Maximization in Clustered Downlink NOMA Networks (Baidas,et al.2021)	2021	Downlink	Single cell	No
10	Low-Complexity Joint User and Power Scheduling				

	for Downlink NOMA over Fading Channels (Umehara, Kishiyama, & Higuchi, Enhancing user fairness in non-orthogonal access with successive interference cancellation for cellular downlink, 2012)	2021	Downlink	Single cell	No
11	Performance Enhancement of NOMA Based on Optimization Techniques (, AHMED & MOHAMMED., 2022)	2022	Downlink	Multi cell	Yes

In the research paper referred to as (Aldababsa, khaleel, & Basar, Simultaneous Transmitting and Reflecting Intelligent Surfaces-Empowered NOMA Networks, 2023)MIMO-NOMA relaying networks' OP performance is investigated. With the use of an AF-EH-based, several can speak with the. There are many antennas on each node that transmits and receives data. The best TAS/MRC and the worst TAS-maj/MRC, respectively, are used in the first and second hops. SINR expressions were first created by us. In the following step, it extracts the closed-form OP expression for each across Nakagami-m fading channels. We have verified the results of Monte Carlo simulations. In this study referred to as (Aldababsa, khaleel, & Basar, Simultaneous Transmitting and Reflecting Intelligent Surfaces-Empowered NOMA Networks, 2023), Provide NOMA networks with STAR-RIS (simultaneous transmitting and reflecting reconfigurable intelligent surface) assistance. The under consideration STAR-RIS serves many NOMA users spread over both sides of the RIS surface by means of the mode switching (MS) protocol. Each STAR-RIS component can function in full transmission or reflection mode depending on the MS protocol. It suggests a unique method inside this framework to divide the STAR-RIS surface among the available users.

In the research paper referred to as (Aldababsa, khaleel, & Basar, Simultaneous Transmitting and Reflecting Intelligent Surfaces-Empowered NOMA Networks, 2023), the performance of simultaneous transmitting and reflecting reconfigurable intelligent surfaces (STAR-RISs) in NOMA networks is examined in this letter. A STAR-RIS uses the mode switching protocol to provide service to numerous non-orthogonal users situated on each side of the surface in the network under investigation. According to the results, STAR-RIS-NOMA performs better than the traditional NOMA system in terms of BER performance, and it may be a viable NOMA 2.0 option.

In the research paper referred to as (M. Aldababsa,et al.2021),, This paper presents a unified outage probability (OP) performance analysis of two hybrid antenna selection (AS) schemes, transmit antenna selection (TAS) and maximal ratio combining (MRC), and joint transmit and receive antenna selection (JTRAS), in a multiple-input multiple-output non-orthogonal multiple access-based downlink amplify-and-forward (AF) relaying network with channel estimation error (CEE) and feedback delay (FD). The AS is implemented as an optimal TAS/MRC or JTRAS in the first hop and a suboptimal majority-based TAS/MRC or JTRAS in the second hop because the communications in the first and second hops are single-user and multi-user communications, respectively. For the TAS/MRC and JTRAS schemes, the OP expressions are obtained over Nakagami-m fading channels in both the ideal and realistic cases.

In the research paper referred to as (Demirkol, Aldababsa, Toka, & Kucur, 2021), (Baidas, AbdelGhaffar, & Alsusa, 2021)examines the performance of the JTRAS/RAS scheme for HD and FD relaying modes across Nakagami-m fading channels in a dual-hop AF EH NOMA system. The networks' joint closed-form formulas for exact OP and asymptotic OP for both relaying modes have been found, and Monte Carlo simulations have been used to confirm the analytical findings. When compared to a situation with fewer antennas, it has been demonstrated that the system's performance increases with an increase in the number of antennas.

In the research paper referred to as (Aldababsa, et al., 2021), In downlink energy harvesting (EH) relaying networks based on multiple-input, multiple-output nonorthogonal multiple access, A combined transmit-and-receive antenna selection (JTRAS) scheme's outage probability (OP) is studied. This dual-hop and amplify-and-forward relaying-based network's first and second hops, which represent single-user and multiuser systems, respectively. To confirm that the theoretical analysis is accurate, Monte Carlo simulations are run. It is demonstrated that different users at the EH relay have varying optimal power splitting ratios, with the users that have favorable channel conditions having the lowest ideal ratios.

In the research paper referred to as (Aldababsa, Göztepe, Kurt, & Kucur, 2020), the JTRAS-maj technique is used in this paper to examine the BER performance of the downlink MIMO-NOMA network over Nakagami-m fading channels in the presence of CEE, FD, and SIC error for the first time in the literature. In closed-form, the precise BER expression is obtained. The acquired BER is also subjected to high SNR analysis in order to achieve the asymptotic and EF expressions. Theoretical findings supported by simulations show that the NOMA network contains non-zero diversity.

In the research paper referred to as (Aldababsa, Khaleel, & Basar, STAR-RIS-NOMA Networks: An Error Performance Perspective, 2020), TAS-maj/MRC and JTRAS-maj, two majority-based AS algorithms, have been created. In the downlink MIMO-NOMA network, the outage behavior of the TAS-maj/MRC and JTRAS-maj has been jointly examined across Nakagami-m fading channels in the presence and absence of both the CEEs and FD. In closed form, the exact OP expression is obtained. Additionally, the presence of the CEEs and FD allows for the achievement of the OP's upper bound. Due to the presence of the CEEs and FD in the high SNR region, the OP reaches the EF and the diversity order declines, While diversity and array gains are greater when the CEEs and FD are absent . In the research paper referred to as (M. Aldababsa et al.2020), the performance of downlink non-orthogonal multiple access networks for binary phase-shift keying modulation is examined in this letter with regard to bit error rate (BER). Under additive white Gaussian noise and Rayleigh fading channels in perfect and imperfect (SIC) scenarios, exact BER expression is derived for each user in closed-form.

In this paper referred to as (M. Aldababsa et al.2020), This paper investigates a non-orthogonal half-duplex cooperative multiple-input multiple-output multiple access system with imperfect channel state information (CSI) and successive interference cancellation. Communication between the BS and mobile users with numerous antennas is facilitated via a CSI-based or fixed gain amplify-and-forward (AF) relay with a single antenna. The use of diversity schemes, transmit antenna selection, and maximal ratio combining are forced on the BS and mobile clients, respectively.

In the research paper referred to as (Aldababsa, Toka, Gökçeli, Kurt, & Kucur, A Tutorial on Nonorthogonal Multiple Access for 5G and Beyond, 2018). This research has looked at the MRT/RAS's outage behavior in the downlink NOMA network with AF relay in both the presence and absence of CEEs over Nakagami-m fading channels. The approximated closed-form expression of the OP is shown to be too close to the exact one. The OP's lower and upper boundaries are also met.Finally, compared to the traditional OMA with MRT/RAS, the suggested NOMA with MRT/RAS promises greater performance. In the research paper referred to as (Kumson, Russ, & Aldababsa, 2022), which is discussed the NOMA technique was developed as a result of the failure of traditional OMA techniques to guarantee low latency rates, high spectrum efficiency, large device connection, and enhanced QoS. Wireless systems' capacity and error rate can both be increased and decreased with the use of MIMO technologies. Because of the benefits listed before.

In the research paper referred to as (Aldababsa, et al., 2019) which is discussed improve the system performance of NOMA, present a novel suboptimal antenna selection (AS) algorithm in this study called majority based transmit antenna selection (TAS-maj) The Monte Carlo simulations are used to examine the outage behavior of the NOMA with the TAS-maj/MRC scheme over Rayleigh fading channels. In the research paper referred to as (Aldababsa, et al., Unified Performance Analysis of Antenna Selection Schemes for Cooperative MIMO-NOMA With Practical Impairments, 2019), which is discussed the performance of NOMA in a dual hop amplify-and-forward relay network across Rayleigh fading channels is examined in this paper. While the relay has several receive antennas and a single broadcast antenna, the base station and mobile users in the network also have multiple antennas. In the research paper referred to as (Aldababsa & Kucur, Outage performance of NOMA with TAS/MRC in dual hop AF relaying networks, 2017), which is discussed in this research, we investigate the outage performance of a dual hop amplify-and-forward (AF) relay communication system over frequency non-selective and slow fading channels with Nakagami-m distribution using a downlink MIMO-NOMA.

In the study referred to as (Durmaz, et al., 2020), which is discussed a software-defined radio (SDR) platform-based downlink NOMA system is constructed with four more users. Our NOMA system, which employs power domain NOMA, primarily relies on SIC at each receiver and four user superposition coding at the transmitter. Real-time tests have been used to test the intended NOMA system, and constellation variations are contrasted with SIC output. Bit error rate (BER) results have also been suggested in addition to these.

CHAPTER FOUR

SYSTEM MODEL WITH THE ANALYSIS

In this chapter, a detailed system model is proposed and explained, including the technical specifications and design considerations

4.1. System Model

In Figure 4, K users ({Uk } , k = 1, ..., K) are communicated with by the BS at once. Both the BS and the users only have a single send and receive antenna. It is assumed that each user and the BS have a fading channel coefficient of hUk . There is a signal at the BS.

$$x_s = \sum_{t=1}^{K} \sqrt{at\ st}$$

$$= \sum_{t=1}^{k-1} \sqrt{a_t\, s_t} + \sqrt{a_k\, s_k} + \sum_{t=k+1}^{K} \sqrt{a_t\, s_t} \qquad (1)$$

Where a_k and s_k are the Uk 's power factor and symbol, respectively. Here,

$$a_1 + \cdots + a_K = 1 \qquad (2)$$

And

$$a_1 \geq \cdots \geq a_K \text{ opposite to } |h_{U_1}{}^2 \leq \ldots \leq |h_{U_K}|^2 \qquad (3)$$

The UK's signal is

$$y_{U_k} = h_{U_k} x_s + n_{U_k}$$

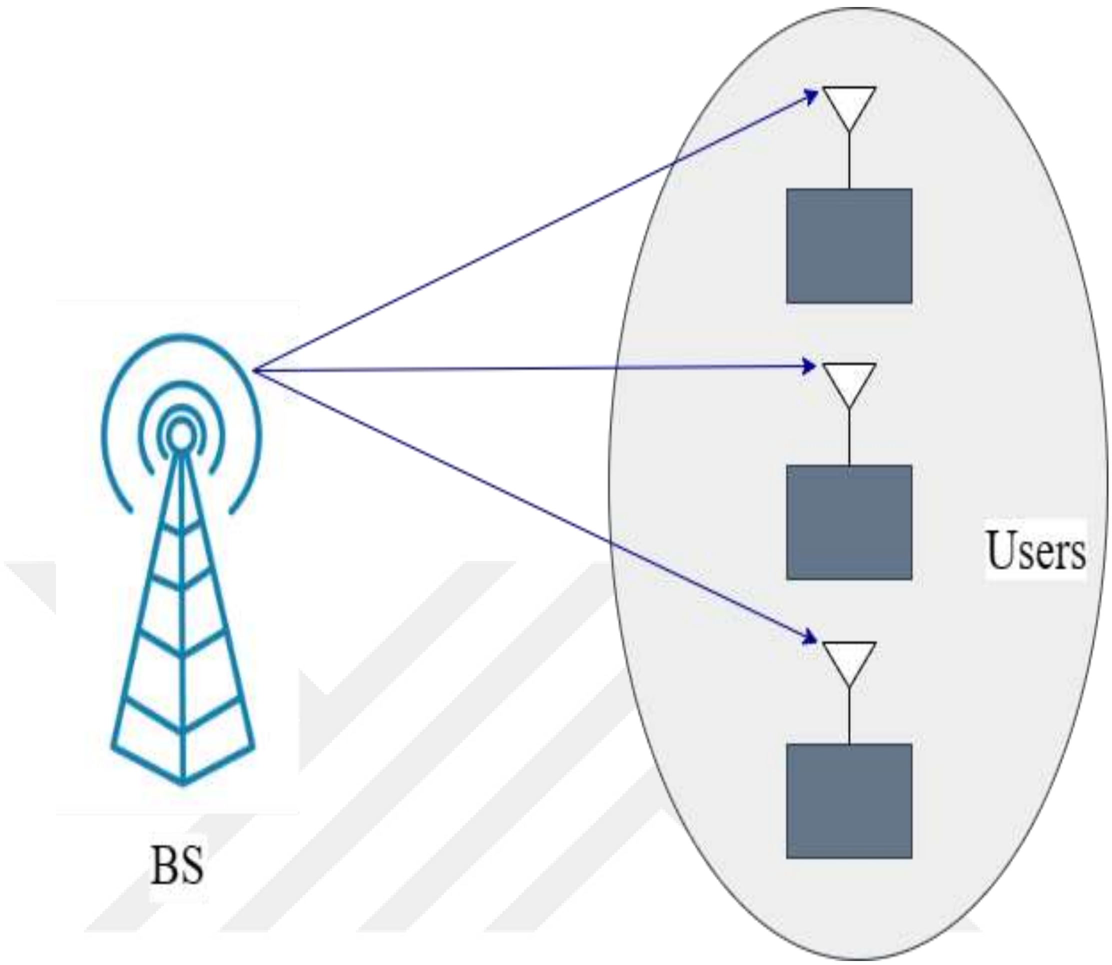


Figure 4. Considered NOMA network.

4.2. Channel model

The signals from U_1, ..., U_{k-1} are terminated and U U_{k+1} ,...,U U_k considers them as interference. $\sum_{t=1}^{k=1} \sqrt{a_t s_t}$ is removed for the ideal successive interference cancellation SIC procedure.

$$y_k = h_{U_k} \sqrt{a_k s_k} + h_{U_k} \sum_{t=k+1}^{K} \sqrt{a_t s_t} + n_{U_k} \qquad (5)$$

From (5), the Uk's signal-to-interference-and-noise ratio (SINR) to detect the Ul is

$$xl,k = \frac{\overline{x} \left|h_{U_k}\right|^2 \; a_l}{\bar{x} \left|h_{RU_k}\right|^2 + \sum_l + 1} \; , l \neq K, l < k \, , \qquad (6)$$

where $\overline{\chi} = \frac{1}{\sigma^2}$ is the signal-to-noise ratio **(SNR), σ2** = $\boldsymbol{\sigma 2 Uk}$ and $\sum_l = \sum_{t=l+1}^{K} \boldsymbol{at}$. After detecting Ul perfectly the Uk's SINR to detect its own signal is

$$\mathrm{xk,k} \;=\frac{\bar{\mathrm{x}}\left|\mathrm{h}_{\mathrm{U_k}}\right|^2\;\; a_k}{\bar{\mathrm{x}}\left|\mathrm{h}_{\mathrm{RU_k}}\right|^{2} + \sum_{\mathrm{k}}\; +1}\;. \qquad (7)$$

Since UK has the highest allocated power factor, it does not perform any SIC. Accordingly, the UK's SNR is

$$\chi\mathrm{K} = \bar{\chi}\;|\mathrm{hUK}|2\;\mathrm{aK} \qquad (8)$$

Table 2: The table shows the results of ship detection

(α, μ)	**Distribution**
(1, 1)	Exponential
$(K, 1)$	Weibull-*K*
(2, 1)	Rayleigh
$(2, m)$	Nakagami-*m*
$(1, a)$	Gamma-*a*

The probability density function (PDF) and cumulative distribution function (CDF) of α-μ generalized fading gains are, respectively

$$\mathrm{FX}\;(\boldsymbol{x}) = 1 - \frac{\psi\left(\mu\;,\mu\;(\frac{x}{\Omega})^{\frac{\alpha}{2}}\right)}{\Gamma\;(\;\mu)} \qquad (9)$$

$$\mathrm{f\;x}\;(\boldsymbol{x}) = \frac{\alpha\;\mu^{\mu}\;x^{\frac{\alpha\mu}{2}-1}}{2\Gamma\;(\;\mu)\Omega^{\frac{\alpha\mu}{2}}}\;e^{-\mu\;(\frac{x}{\Omega})^{\frac{\alpha}{2}}} \qquad (10)$$

Note that ψ(·,·) and Γ(·) in (9)-(10) are upper incomplete Gamma and Gamma functions, respectively, α and μ are the parameter of α-μ distribution (special cases are given in Table I) and $\Omega = E[|X|^2]$.

In the following Lemmas, we state the expressions of CDF for both unsorted ($F_{|h_{U_k}|^2}(\boldsymbol{x})$) and sorted ($F_{|h_{U_k}|^2}(\boldsymbol{x})$)) channel gains.

Lemma 1. $F_{|h\;U_k|^2}(\boldsymbol{x})$ *is*

$$F_{|h\;U_k|^2}(\boldsymbol{x}) = 1 - e^{-\mu_U\;(\frac{x}{\Omega\;U})^{\frac{\alpha U}{2}}}\;\;\sum_{M=0}^{\mu_U-1}\frac{\left((\mu_U\;\;(\frac{x}{\Omega\;U})^{\frac{\alpha U}{2}}\right)^{m}}{m!} \qquad (11)$$

Proof. From (9)

$$F_{|h_{U_k}|^2}(\boldsymbol{x}) = 1 - \frac{\psi\left(\mu_U, \mu_U\left(\frac{x}{\Omega_U}\right)^{\frac{\alpha U}{2}}\right)}{\Gamma(\mu_U)} \tag{12}$$

With $\Gamma(\mu_U) = (\mu_U - 1)!$

$$\frac{\psi\left(\mu_U, \mu_U\left(\frac{x}{\Omega_U}\right)^{\frac{\alpha U}{2}}\right)}{\Gamma(\mu_U)} = e^{-\mu_U\left(\frac{x}{\Omega_U}\right)^{\frac{\alpha U}{2}}} \sum_{M=0}^{\mu_U - 1} \frac{\left(\mu_U\left(\frac{x}{\Omega_U}\right)^{\frac{\alpha U}{2}}\right)^m}{m!} \tag{13}$$

Substituting (13) into (12), then Lemma 1 is obtained.

Lemma 2. *The* $F_{|h_{U_k}|^2}(\boldsymbol{x})$ is

$$F_{|h_{U_k}|^2}(\boldsymbol{x}) = \overline{\omega_k} \sum_{t=0}^{K-k} \sum_{i=0}^{k+1} \sum_{l=0}^{i(\mu_U - 1)} \frac{(-1)^{t+i}}{k+t} C_t^{K\_k} \; C_t^{K+t} \beta_{li}(\mu_U)$$

$$\times \; e^{-i\,\mu_U\left(\frac{\mathcal{T}_k^*}{\Omega_U}\right)^{\frac{\alpha U}{2}}} \left(\mu_U\left(\frac{\mathcal{T}_k^*}{\Omega_U}\right)^{\frac{\alpha U}{2}}\right)^{\boldsymbol{l}} \tag{14}$$

Where $\overline{\omega_k} = \frac{K!}{(K-k)!(k-1)!}$, $C_t^{K-k} = \binom{K-k}{t}$, $C_t^{k+t} = \binom{k+t}{t}$ *and* $\beta_{li}(\mu_U)$ denotes multinomial expansion coefficient (M. K. Simon, M. S. Alouini, 2003).

Proof. The $F_{|h_{U_k}|^2}(x)$ is stated as (david & nagaraja, 2003).

$$F_{|h_{U_k}|^2}(\boldsymbol{x}) = \widetilde{\omega}_k \sum_{t=0}^{K-k} \frac{(-1)^t}{k+t} C_t^{K\_k} \left(F_{|\tilde{h}_{U_k}|^2}(\varkappa)^{k+t}\right) \tag{15}$$

Using Lemma 1

$$F_{|h_{U_k}|^2}(\boldsymbol{x}) = \widetilde{\omega}_k \sum_{t=0}^{K-k} \frac{(-1)^t}{k+t} C_t^{K\_k}$$

$$\times \underbrace{\left(1 - e^{-\mu_U \left(\frac{x}{\Omega_U}\right)^{\frac{\alpha U}{2}}} \sum_{l=0}^{\mu_U - 1} \frac{\left(\mu_U \left(\frac{x}{\Omega_U}\right)^{\frac{\alpha U}{2}}\right)^l}{l!}\right)^{k+t}}_{J_1} \quad (16)$$

By means of binomial

$$J_1 = \sum_{I=0}^{K+1} (-1)^i \ C_t^{k+t} \underbrace{\left(e^{-\mu_U \left(\frac{x}{\Omega_U}\right)^{\frac{\alpha U}{2}}} \sum_{l=0}^{\mu_U - 1} \frac{\left(\mu_U \left(\frac{x}{\Omega_U}\right)^{\frac{\alpha U}{2}}\right)^l}{l!}\right)^{i}}_{J_2} \quad (17)$$

Exploiting multinomial expansions

$$J_2 = e^{-i\,\mu_U \left(\frac{x}{\Omega_U}\right)^{\frac{\alpha U}{2}}} \sum_{l=0}^{i(\mu_U - 1)} \beta_{li}(\mu_U) \left(\mu_U \left(\frac{x}{\Omega_U}\right)^{\frac{\alpha U}{2}}\right)^l, \quad (18)$$

By substituting J_2 into (17) and J_1 into (16), then Lemma 2 is obtained.

4.3. Outage probability (op) analysis

Proposition 1. The OP for the Uk is

$$\mathrm{OP} = \overline{\omega_k} \ \sum_{t=0}^{K-k} \ \sum_{i=0}^{k+1} \sum_{l=0}^{i(\mu_U - 1)} \frac{(-1)^{t+i}}{k+t} \ C_t^{K\_k} \ \ C_t^{K+t} \beta_{li}(\mu_U)$$

$$\times \ e^{-i\,\mu_U \left(\frac{\mathcal{T}_k^*}{\Omega_U}\right)^{\frac{\alpha U}{2}}} \left(\mu_U \left(\frac{\mathcal{T}_k^*}{\Omega_U}\right)^{\frac{\alpha U}{2}}\right)^{l} \quad (19)$$

Proof. The OP of the U_k is

$$\mathrm{OP}_k = 1 - \mathrm{P_r}(\{\chi_{1,k} > \chi_{th1}\} \cap \ldots \cap \{\chi_{k,k} > \chi_{thk}\}), \quad (20)$$

Where χ_{thk} is $U_{K\text{'s}}$ threshold value.

With $a_l - \Sigma_l \chi_{thl} > 0$ and using (6)

$$\{ x_{l,k} > x_{th1} \} = \left\{ |h\ RUk|^2 > \frac{x_{th1}}{\bar{x}\ (a_l - \Sigma_l\, x_{th1})} \right\} \quad (21)$$

$$\text{Assume} \quad \mathcal{T}_k^* = \max \left\{ \frac{x_{th1}}{\bar{x}\ (a_l - \Sigma_l\, x_{th1})} \right\}_{l=1,\ldots\ldots,k}$$

$$OP_k = 1 - P_r\left(\left|h_{U_k}\right|^2 > \mathcal{T}_k^*\right)$$

$$= F_{\left|h_{U_k}\right|^2}\left(\mathcal{T}_k^*\right). \quad (22)$$

Using Lemma 2 in (22), Proposition 1 is then obtained.

4.4. Op Analysis For RAS

It utilize NU receive antennas for each user to enhance the performance of the OP. The BS and Uk channel coefficients are {h_Uk^((i)) ,1 ≤ i ≤ Nu } , where i refers to the ith receive antenna corresponding to the Uk,. The RAS program is used in the Uk. The receive antenna (i_U^*) that provides the maximum | 〖h_Uk^((i)) |〗 ^2 is found by using the RAS technique.

$$i_U^* = arg \max_{1<i<N_U} \left\{ \left|h_{U_k}^{(i)}\right|^2 \right\}. \quad (23)$$

Lemma 3. *The CDF of the unsorted selected* $|\tilde{h}^*_{U_k}|^2$ *is*

$$F_{\left|\tilde{h}_{U_k}^*\right|^2}(x) = \left(1 - e^{-\mu_U \left(\frac{\varkappa}{\Omega_U}\right)^{\frac{\alpha_U}{2}}} \sum_{m=0}^{\mu_U - 1} \frac{\left(\mu_U\left(\frac{\varkappa}{\Omega_U}\right)^{\frac{\alpha_U}{2}}\right)^m}{m!} \right)^{N_U} \quad (24)$$

Proof. From (23)

$$\left|h_{U_k}^*\right|^2 = \max\{ \left|h_{U_k}^{(1)}\right|^2, \ldots\ldots, \left|h_{U_k}^{(i)}\right|^2, \ldots., \left|h_{U_k}^{(N_U)}\right|^2 \} \quad (25)$$

The CDF of $|\tilde{h}^*_{U_k}|^2$ can be calculated as

$$F_{\left|\tilde{h}_{U_k}^*\right|^2}(x) = P_r\left(\left|h_{U_k}^{(1)}\right|^2 \leq \cdots \leq \left|h_{U_k}^{(i)}\right|^2 \leq \cdots \leq \left|h_{U_k}^{(N_U)}\right|^2 \right), \quad (26)$$

which can be written as

$$F_{\left|\tilde{h}^{*}_{U_k}\right|^2}(x) = \prod_{i=1}^{N_U} F_{\left|h^{(i)}_{U_k}\right|^2}(x) = \prod_{i=1}^{N_U} F_X(x) = (F_X(x))^{N_U} \qquad (27)$$

Substituting (12) into (27), then Lemma 3 is obtained.

Proposition 2. *With RAS scheme, the OP for the* U_{k} *is*

$$OP_k^{*} = \overline{\omega_k} \sum_{t=0}^{K-k} \sum_{i=0}^{(k+1)\boldsymbol{N_U}} \sum_{l=0}^{i(\mu_U-1)} \frac{(-1)^{t+i}}{k+t} C_t^{K\_k} \; C_t^{(K+t)\boldsymbol{N_U}} \beta_{li}(\mu_U)$$

$$\times \; \boldsymbol{e}^{-\boldsymbol{i}\,\mu_U \left(\frac{\mathcal{T}_k^{*}}{\Omega_U}\right)^{\frac{\alpha U}{2}}} \left(\mu_U \left(\frac{\mathcal{T}_k^{*}}{\Omega_U}\right)^{\frac{\alpha U}{2}}\right)^{\boldsymbol{l}} \qquad (28)$$

where $C_t^{(K+t)\boldsymbol{N_U}} = \binom{(K+t)\boldsymbol{N_U}}{\boldsymbol{t}}$

Proof.

RESULTE AND CONCLUSION

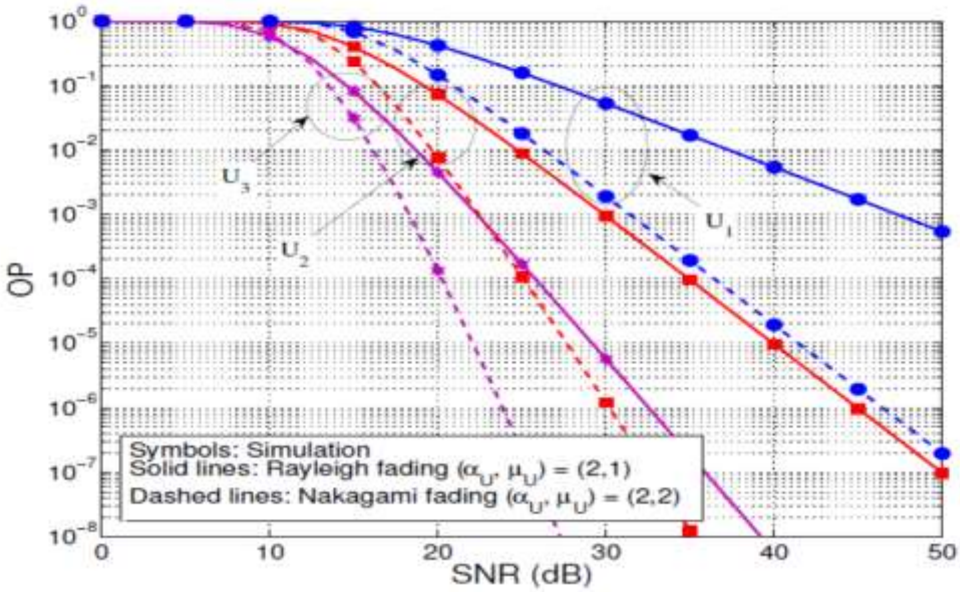
This chapter summarizes the main findings, conclusions, and contributions made to the field of NOMA-based communication systems.

Numerical Results

This section shows how Monte Carlo simulations were used to validate the analytical formulas. Table 3 lists the simulation-related parameters. The performance of OP vs SNR is shown in Graphic 1. for different values of μU, which are 1 and 2, while αU is kept constant at 2. It can be seen that when μU rises, the OP's performance gets better. Particularly, the OP performance for Rayleigh fading channels (where μU = 1) and Nakagami fading channels (where μU = 2) is superior to the latter. The SNR gain advantage of μU = 2 over μU = 1 is seen in Table5.2.

Table 3. Simulation Parameters

Parameters	Values
(a1, a2, a3)	$(\frac{1}{2}, \frac{1}{3}, \frac{1}{6})$
(χth1 , χth2 , χth3)	(0.9, 1.2, 2.2)
ΩU	1

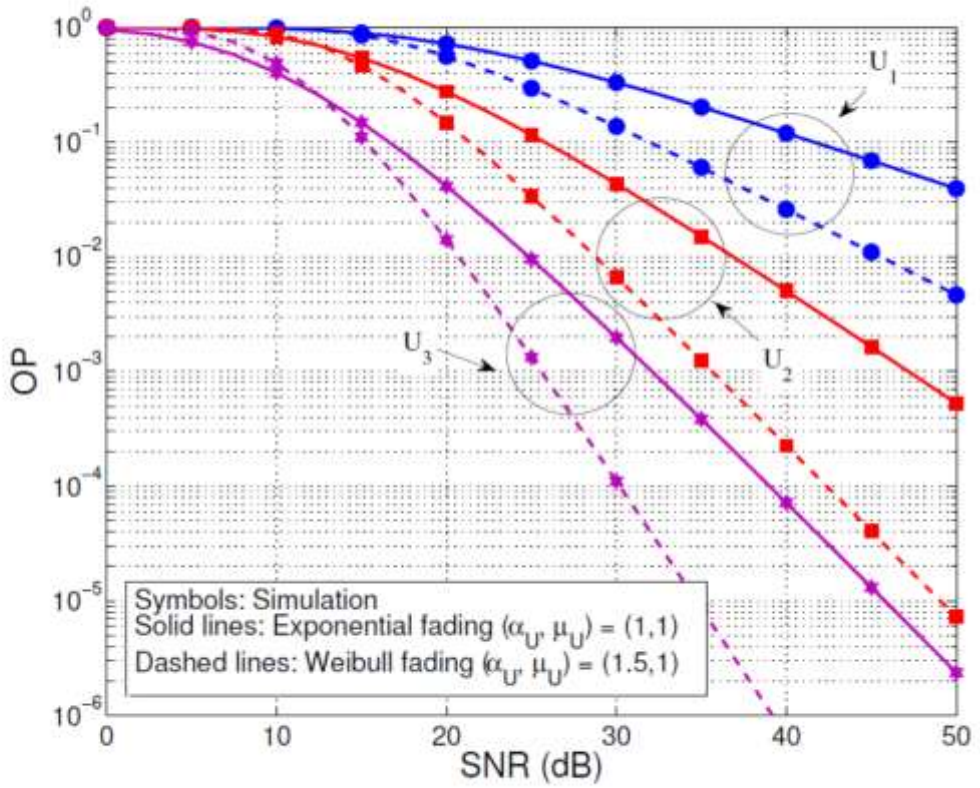


Graphic 1. NOMA's OP performance in Rayleigh and Nakagami fading channels.

The OP performance vs SNR is shown in Graphic 2. For various values of αU, which are 1 and 1.5, whereas μU is fixed at 1. It is obvious that when αU rises, the OP's performance improves. Such as, Weibull fading channels (where αU = 1.5) perform better on the OP than Exponential fading channels (where αU = 1).

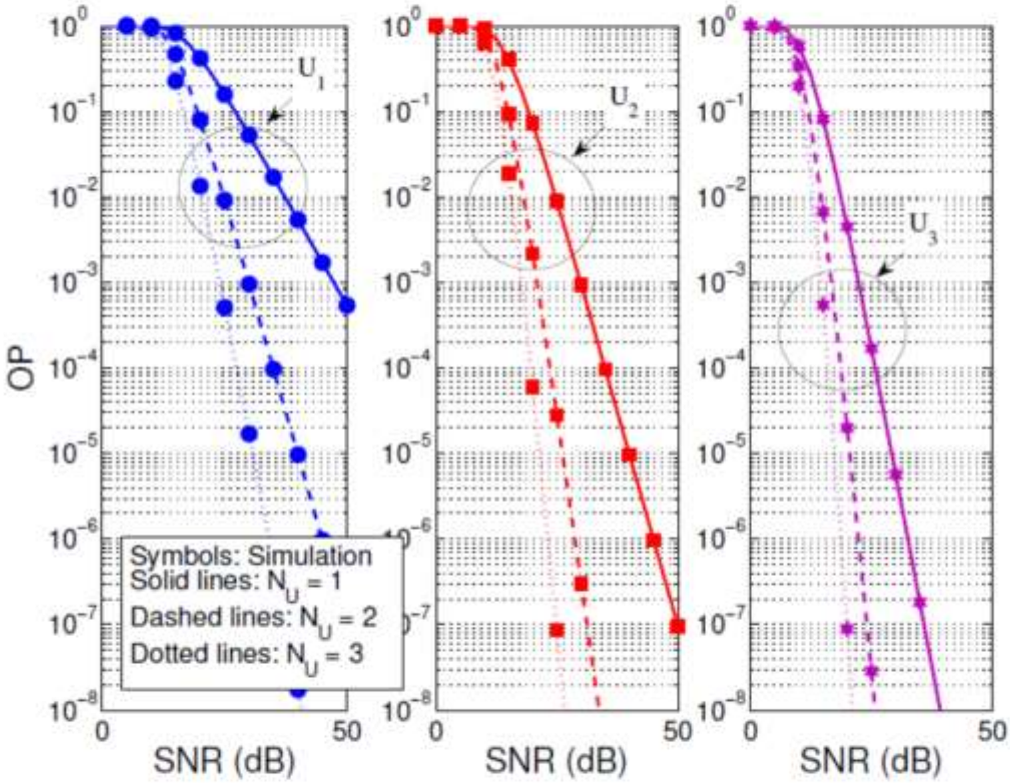
Table 4. SNR Gain Advantage Of Different Parameters Of ((αU, μU)) For Each User.

(αU, μU)	SNR for OP = 10^{-3}			SNR gain advantage		
	U1	U2	U3	U1	U2	U3
(2, 1)	47	30	23	15	7	6
(2, 2)	32	23	17			



Graphic 2. NOMA's OP performance in Exponential and Weibull fading channels.

The OP performance versus SNR in Rayleigh fading channels and various values of Nu are shown in the figure designated as Graphic 3. The improvement in OP performance with increasing Nu can be shown, demonstrating the superiority of multi-antenna-based NOMA networks over



Graphic 3. NOMA's OP performance in Rayleigh fading channels with different values of NU.

Conclusion

We have taken into account downlink networks with many users and power domains. In the mentioned network, the BS continuously interacts with many NOMA users, each of whom has a single receive antenna. The performance of the OP across generalized fading channels has been analyzed. We have computed the instantaneous SINR for this purpose. The OP expression in closed-form for each user was then obtained. This formula applies to a variety of distributions. By computer simulations, we have verified OP equations and discovered that the system performs better when the values of α and μ enhance and when the number of antennas is increased. At the end of the work the system successfully was able to:

• Use α-μ distribution as an essential general fading distribution. It included Nakagami-m, Rayleigh, Gamma, exponential, and Weibull. Its probability density function (PDF) and cumulative distribution function (CDF) are also expressed in closed form. The extraordinary benefits of α-μ distribution because in some cases, experimental data does not fit any of these distributions well, which forces to have more general fading distribution.

• Multi-antenna-based NOMA networks has offered better performance compared to single-antenna-based networks and integrate multiple antennas into the NOMA network, also improve the network's performance.

• Study the performance of the NOMA network over α-μ generalized fading channels with a BS communicates concurrently multiple users. The BS and each user are equipped with single transmit and single receive antennas, respectively.

• Use the CDF and PDF of the α-μ distribution with the expressions of the instantaneous signal-to-interference-and-noise ratio (SINR).

• Use the SINR expressions and derive each user's closed-form expression of the OP. The obtained OP expression is general for fading channels.

• Use receive antenna selection (RAS) at the receivers of users in order to enhance the OP performance.

• verify the theoretical OP expressions through The Monte Carlo simulations.

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RESUME

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