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Single and Multi-Point Non-Orthogonal Multiple Access based Power Adaptive Design for Improving Bit Error Ratio

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Abstract: In the framework of next-generation communication systems, Non-Orthogonal Multiple Access (NOMA) has attracted considerable interest. The fundamental advantage is that it has greater spectrum utilization than its orthogonal equivalents. This proposed work integrates Single-Input Single-Output NOMA (SISO) with Coordinated Multi-Point (CoMP). It uses both systems based on Quadrature Phase-Shift Keying (QPSK). A power-tolerant NOMA reduces the system's vulnerability to erroneous power allocation by adaptively modifying each user's signal power. The transmitted data is used to modify the power in the Power-Adaptive NOMA (PANOMA). PANOMA helps improve the Bit Error ratio and also improves the computational complexity. The Bit Error Rate (BER) and the lower limit capacity efficiency across Rayleigh fading channels are determined in precise closure representations of more than two consumer situations to measure its capability. The proposed method PA-CoMP-NOMA improves the Bit Error ratio in both systems. It improves the average BER among all users. Compared to its orthogonal cousin, NOMA has higher spectral efficiency. Nevertheless, our proposed method retains this feature as well as superior BER performance, although its spectral effectiveness is lower than that of the classic sum-rate based power NOMA.

Keywords: NOMA, power adaptive, bit error ratio, computational complexity, quadrature phase-shift keying, coordinated multi-point.

1. INTRODUCTION

The effective use of physical resources, especially wavelength, duration, and energy, has long attracted considerable interest. Given the tremendous increase in traffic, multiplexing fewer resources across wireless nodes on both sides has become inevitable. The Time-Division Multiple Access (TDMA) method is a design that helps a thorough investigation. Thereafter it is used in today's wireless communication. Orthogonal Frequency Division Multiple Access (OFDMA) is another such method that has emerged as a crucial technology accelerator for 4th and 5th generation (4G/5G) cellular technologies. However, these orthogonal shared resource solutions come at the cost of lower bandwidth utilization [1].

Narrowband IoT (NB-IoT), for example, will enable tremendous networking of reduced, limited devices that have minimal data-rate requirements, similar to Wireless Sensor Networks (WSNs) [2]. The transmission program's multiple access capabilities are primarily responsible for meeting such criteria. Orthogonal Multiple Access (OMA) techniques, such as Frequency-Division Multiple Access (FDMA), TDMA, and orthogonal FDMA, are commonly used in past and present mobile communication systems [3]. When orthogonal spreading sequences are used, the Code-Division Multiple Accesses (CDMA) can also be called an OMA approach.

Non-Orthogonal Multiple Access (NOMA) has attracted much interest in industry and academia in the next wireless protocols, partly because it allows multiple members to submit the same resources. Compared to orthogonal multiple access, the main advantage is the efficient use and distribution of physical resources, as well as improved spectral efficiency. NOMA comes in a variety of forms, including power domain NOMA, Cognitive Radio (CR)-based NOMA, and others [4].

This study focuses solely on the strength of NOMA. The research in [5] shows that optimizing the overall rate can achieve the best allocation of transmission antennas among multiple users, while [6] indicates that the energy NOMA with fairness restrictions exceeds OMA with the weakest channel quality. In [7], [8] suggests a hybrid bandwidth and transmission power strategy based on the total full rate allotted bandwidth efficiency. In [9], power allocation is discussed using certain Quality-of-Service (QoS) criteria as well as Peak to Average Power Reduction (PAPR) and max-min justice. Also, [10] contains a full review of the energy NOMA.

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A combined sub-channel and multi-cell energy allocation challenge in a NOMA - Coordinated Multi-Point (NOMA-CoMP) scheme is evaluated in some works. The author [11] proposed a coordinated NOMA-based multi-criteria user's cooperation mode selection method. The effect of incomplete Channel State Information (CSI) and Successive-Interference-Cancellation (SIC) were considered in the development of 2 allocations of resource methods. The proposed system can effectively minimize energy usage and improve user adaptability, as shown by numerical simulations.

The main contribution of the proposed work is given below:

Power Adaptive NOMA (PANOMA) is proposed for evaluating power assignments. PANOMA improves the robustness of the system.

It uses Single-Input Single-Output (SISO) and CoMP systems for both Base Station (BS) and Users.

We calculate the Bit Error Rate (BER)'s significant improvement by extending the proposed system to Quadrature Phase-Shift Keying (QPSK) modulation. Fascinatingly, the in-phase and quadrature elements must be given distinct powers for each user to reduce the BER.

We evaluate the ability of both systems to achieve an overall lower bound, as well as the PANOMA increase for Binary Phase-Shift Keying (BPSK) and QPSK.

The remaining sections of this paper are organized as follows: Section 2 discusses the related research works, Section 3 describes the NOMA, Coordinated Multiple Access and PANOMA, Section 4 presents the methods used to adopt the proposed model, Section 5 discusses the experimental results, and Section 6 concludes the proposed system with future work.

2. Related works

In NOMA, energy allocation can be set as either fixed or dynamic. Constant power allocation is simple, but does not require previous information about the (CSI) [12]-[16]. Therefore, it cannot meet the BER needs of consumers or lower the average BER. Dynamic power allocation, on the other hand, is able to meet the (QoS) standards while lowering the BER. The energy is often allocated for each user using the immediate or probabilistic CSI in dynamic power allocation [17]-[20]. If the allocated energy is used to reduce certain key metrics such as the BER, it can be called optimal.

Very little research has been done on decreasing the BER sensitivity to non-optimal energy allocation. To improve the symbol error rate (SER) and enable greater low-latency IoT devices, disturbance synchronization is proposed in [21]. To lower the required asymptotic SER, dynamic power management is used in conjunction with the statistical CSI. While the scheme improves SER and is resistant to non-optimal power allocation, it is computationally costly, the detection procedure requires pilot signals to prevent detecting confusion, and the method is limited to a two-user NOMA. In [22]-[24], a robust NOMA design is investigated in terms of overall rate and power effectiveness. However, such approaches are not generally applicable to the BER situation and require a significant amount of computer capacity.

Other methods to increase NOMA's BER include implementing a specific phase rotation for each user while keeping the energy constant and integrating signal space variety using ideas such as interleaving [25], [26]. The findings show that even an increase of about 1.3 dB can be achieved for one of the users, but only for one of them. Table 1. shows the comparison of the different existing systems.

Table 1. Analysis of existing systems.

Ref. No	Method & Year	Pros	Cons
16	Joint Transmission Comp (JT-Comp) Sub-channels (2018)	Many-To-Many, Two-Side Sub-channel.	Communication channel can become more complex and difficult to manage.
21	Power Allocation with Energy Competence in Downlink (2017)	By allocating power in an efficient manner, energy consumption can be reduced.	It was designed to maximize energy efficiency; may not be able to adapt to changing conditions in the network.
23	Non-Orthogonal Multiple Access visibility increasing (2017)	NOMA allows users with weaker channel conditions to function well at lower power levels.	Decoding and identifying user signals can be computationally expensive, causing delays and power consumption.
24	Performances of Downlink and Uplink with BER metrics (2018)	BER can be used to evaluate the impact of different channel impairments.	BER does not take this into account. This can lead to misleading results when comparing systems.
25	Error Probability Analysis of Non-Orthogonal Multiple Access (2019)	Proper error optimization in signal handling can increase the system capacity by allowing more users to access.	Error probability of NOMA systems is higher than that of traditional OMA systems.

PANOMA is a proposed method for managing power allocations in wireless communication systems. It aims to improve the robustness of the system by using the Single-Input Single-Output (SISO) and CoMP systems for both the BS and the users. By extending the system to QPSK modulation, the BER is significantly reduced. PANOMA also assigns different powers to the in-phase and quadrature elements for each user to further decrease the BER. The overall lower bound capabilities of both systems and the improvement in PANOMA for BPSK and QPSK are also evaluated. NOMA allows multiple users to use the same frequency band simultaneously, which increases the spectral efficiency of the system.

3. PROPOSED MODEL

The proposed model contains two systems, namely Single-Input Single-Output (SISO) and Coordinated Multi-Point (CoMP). Each user is connected to the BS. The point-to-point and multi-point channel is implicit. The architecture of the proposed model is shown in Fig. 1.

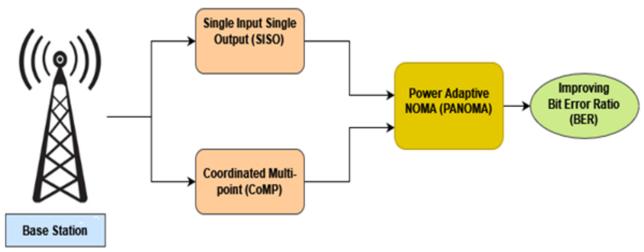

Fig. 1. Architecture of the proposed model.

It consists of the system model, the PANOMA scheme, and the Many-to-Many channel to improve BER and power allocation.

A. *System model*

Consider a BS with N linked users. The point-to-point component is considered to have flat frequency fading, with each user and BS having a single antenna. Assume that both BS and the ith user have higher network efficiency. Suppose the maximum energy sent from BS is P_γ. The ith user receives $\alpha_i P_\gamma$ energy from BS, wherein 0<I<1 denotes the second derivative of PT belonging to that users. Let X_i be the information sent to the ith customer. At BS, the aggregate data sent is entered as

$$X = \sum_{t=1}^{N} \sqrt{a_i P_\gamma X_i} \quad (1)$$

Following that, the ith user's received power Y_i could be expressed in the format below:

$$Y_i = H \sum_{t=1}^{N} \sqrt{a_i P_\gamma X_i} + \omega_t \quad (2)$$

Here wi is the additive white Gaussian noise (AWGN) with a range of $\sigma 2$ and zero mean. wi is believed to be self-contained among all users. We additionally assume that users were sorted according to their current channel conditions and additive noise ratios. BS uses the power adaptive NOMA setup. To transfer the information of all users, use the "superposition" approach. SIC is used by users for cancelling information from people who are below the order of the order. Encoding and decoding all of its information as a result, the ith categorized user is the user. Then decode information from i+1, i+2 first . . . , and they are the Nth user. The information of 1, 2, and 3 are removed from the Y_i, but the information from 1, 2, and 3 are retained, the 1st (i)th user is considered as obstructive.

Cost function

The probability of transmission errors at each receiver is included in the Cost Function (CF). Dealing with accurate expressions for BER is more difficult than working with the Symbol Error Ratio (SER). For a higher SNR BER could be estimated directly using SER, as $BER \approx \frac{SER}{log\,2M}$ for the un-coded system. In the research, MBER difficulties have mostly been addressed using SER, which is a small misapplication of the concept. Therefore, SER and BER are consistently used in this application. SER is evaluated differently for each user and depends on the constellations in question. The SER obviously depends on the factor of relevance α_i. Let us assume that SER i s for the ith user $\rho(\alpha)$, with $\alpha = \{\alpha_1, a_2 \ldots\ldots \alpha_n\}$. As a result, the composite median CF is as follows

$$P_e(\alpha) = \frac{1}{N} \sum_{t=1}^{N} P_e(\alpha) \quad (3)$$

We also ensure that each user keeps a standard price, say R^{req} similar to how the classic summing rate-based energy NOMA system works. The optimal schedule issue can be written as follows, if the speed for the ith user is again R_i

$$=_i log_2 \left(1 + \frac{P_t \sigma_X |H_i| 2\alpha_i}{\sigma_w^2 + P_t \sigma_X^2 |H_i| \sum_{j=1}^{i-1} 2\alpha_i}\right) \quad (4)$$

Power adaptive NOMA

We investigate the two-user situation using BPSK modulation to facilitate the presentation of the proposed PANOMA method.

The $B_{11} = (\sqrt{\alpha_1} + \sqrt{\alpha_2})$ and the $B_{11} = (\sqrt{\alpha_1} + \sqrt{\alpha_2})$ and the constellations positions of the 2 right are most NOMA signs. Consequently, the Euclidean distance $Dis_1^c = |B_{11} - B_{01}| = 2\sqrt{\alpha_1}$ determines the errors that occur with respect to OU1. The amount of DC1 would be maximized if the constant value were chosen to minimize BER. A minor departure in α_1 from the ideal value would decrease the highest benefit of Dis^c, resulting in BER degradation. The energy task was adaptively performed depending on the principles of both users' information bits, as suggested by the interfering aligning concept. Therefore, the energy is allocated depending on the user indices and the quantities of the two users' data are characterized. Consequently, the transferred PANOMA sign is conditionally expressed to reflect the energy's reliance on the data characterized. Consequently

$$Z_{Scon} = \sum_{n=1}^{N} \sqrt{\alpha_n [z_1, z_2, \cdots Z_N] Z_n} \quad (5)$$

To limit BER's exposure to the energy allocation procedure, the energy of some characters is maintained regardless of channel circumstances, while the energy of the other symbols could be chosen to decrease the overall BER. For example, if N = 2 and both users access BPSK, the energy allocation for similar letter instances can be such that $\alpha_1\, 1{,}1 = \alpha_1\,[-1{,}-1] = 0.5$, which is always constant. The NOMA sign that is conveyed can be written as:

$$Z_{Scon} = \left\{ \sqrt{\tfrac{1}{2}} Z_1 + \sqrt{\alpha_1 Z_1} + \sqrt{\alpha_2 Z_2}, Z1 = Z_2 - \sqrt{\tfrac{1}{2}} Z_2, Z_1 = Z_2 \right. \quad (6)$$

It is important to mention that for the situation of $Z_1 = Z_2$, the equally powerful choice $\alpha_1 = \alpha_2 = 1/2$ optimizes the NOMA signal energy for similar signals, which can be proved by computation.

$$\frac{\partial}{\partial \alpha_1} Z_{Scon}^2 \left\| 1 = Z_2 = \frac{1-2\alpha_1}{\sqrt{\alpha_1(1-\alpha_1)}} \right| \quad (7)$$

Whenever $\alpha_1 = 1/2$, the highest value is obtained. The total energy of the PANOMA signals must be set to equality, as in the usual NOMA situation. Comparing the Euclidean distance of the right-hand side of PANOMA signal $E_1^P = |A_{11} - A_{01}| = \sqrt{2 + \sqrt{\alpha_1 - \alpha_2}}$ to $E_1^C = 2\sqrt{\alpha_1}$, it can be seen that the fluctuation of E_1^P' with α_1 is limited by the fixed vector.

By considering each dimension separately, the PANOMA model can be applied to different modulation levels, including such QPSK, where different power components are allocated to the in-phase and quadrature elements. So

$$Z_{Scon} = \sum_{n=1}^{N} \sqrt{\alpha_n^R |R| Z_1, Z_2, \dots, Z_n | R(Z_n)} \quad (8)$$

Here R (.) and I (.) denote the real and imaginary parts, respectively, and α_n^R and. α_n^i are the energy ratios for the in-phase and quadrature parts. As shown in (5) and (6), the information bits of U2 can be detected in the same way as the traditional NOMA, i.e., by using SU MLD and treating all other user symbols as unidentified noises. The SIC detectors could be used immediately for U1, since the energy supplied to U1 can be 0.5 or α_1. If N > 2 and higher-level modes are used, the same method can be applied. Consequently, the proposed complexity of the system is the same as that of the traditional NOMA. It is important to mention that such detecting processes in the systems showed the piloting cycles, which reduces the spectrum utilization. Moreover, the receiving difficulty is greater than in the traditional NOMA.

Conditional BER analysis using N-2

This paper focuses on BPSK for both NOMA and PANOMA, but can easily be applied to QPSK. To provide stable interactions over harsh channels, certain alteration techniques are used with many values, including the NB-IoT and WiFi specifications. The study is universal in that it can be used for NOMA and PANOMA systems, regardless of the energy allocation specific to each system.

The BER can be calculated by considering all possible options. The conditioned BER is equivalent for equally likely words.

$$P_{B_n} | \gamma_n = \frac{1}{2^N} \sum_{i=1}^{2^N} P_{B_n}^{(i)} \quad (9)$$

When $\gamma_n[\gamma_{1,n}, \gamma_{2,n}, \dots\dots, \gamma_{L,n}]$, $\gamma_{L,n}$ is a factor based on the SNR and notation energy, and L is the total variety of proposed value systems for the nth use.

B. Many-to-many sub-channel for CoMP systems

The speed of the system is characterized by the sub-channel and the energy, according to the system model. This part first identifies cell users, and assigns sub-channels to them, increasing the complexity of the assignment. The following phases are used to create the user matching metric for many-to-many sub-channels.

Initializing the system

Initially, BS b with k sub-channels transmits a suggestion voltage sr to all individuals in the clusters with identical broadcast capacity. Pr attempts to transform into such a many-to-many two-side clustering problem and use an analog signal strength to improve customer equality. The power Pr is the same for all users within the cell using the same sub-channel. In this method, a BS b with k sub-channels and m consumers can obtain the medium strength set GHb of all cell users.

$$GH_b = \{GH_b(1), GH_b(2), , \dots, GH_b(M)\}, \forall b \in BS \quad (10)$$

Therefore

$$G\hat{H}_b(n) = \{\gamma_b^1(n), \gamma_b^2(n), \dots, \gamma_b^k(n)\}, n = 1, \dots, M \quad (11)$$

Classification of users

Users are categorized based on the generated equal modulation scheme sets. The edge system is designed to control $U^{(e)}b = \{n\}$ when $\max GH_b(n)$ (is the threshold for separating edge users); otherwise, the user places $U^{(c)}b = \{n\}$ in the center of the cell. In the experiment, we chose a suitable importance ($\epsilon = 1.5$) so that the amount of CoMP consumers in the CoMP clusters and the group of non-consumers in each cell are almost equal. Simultaneously, the rates of the software requirements are predicted. We establish the frequency requirements at $R^{min}b$ of the consumers at the edges based on the users $U^{(e)}b$, assuming that its BS can get full user details.

The greater required edge for users put $U^{(hr)}b = \{n\}$ if R^{min}<(n), otherwise the minimum cost demand for edge unit set $U^{(lr)}b = n$. Furthermore, we adjust the importance to 2.5 so that the amount of high-demand users and low-requirement consumers in the cells are approximately equal.

Equivalent Rate Set is evaluated

The channel quality of the users can be expressed by an analog channel gain, since the BS broadcasts the information with almost the same operating voltage (10). If the same baseline energy is assigned to each user of multiple sub-channels, we can determine the information rate for each of them.

$$\hat{R}s_b = \{\hat{R}s_b(1), \hat{R}s_b(2), \dots, \hat{R}s_b(M)\}, \forall b \in B \quad (12)$$

$$\hat{R}s_n = \{\hat{R}s_b^1(n), \hat{R}s_b^2(n,2), \dots, \hat{R}s_b^k(n)\}, \forall b \in B \quad (13)$$

Many-to-Many Sub-channel-user matching algorithm for CoMP systems

This optimization technique seems to be more challenging than the minimum 2 many-to-many selection problem. The method is used in 5G ultra-dense systems where the number of sub-networks and CoMP cell subscribers can be quite large. To tackle this comparison difficulty, we provide a sub-channel-user matching method for the NOMA-CoMP software using the Gale-Shapley technique. We present a sub-channel-user comparison (numerous) method based on the conventional Gale-Shapley algorithm (MSUMA). In the following, we describe the particular modifications to the conventional many-to-many two-side matching method.

We combine distinct BSs and expand the conventional many-to-many two-sided perfectly matched method into different gatherings of users two different sub-channel comparison methods.

The sub-channel of each group should evaluate not only comparison with users in this grouping, but also comparison with CoMP users in other groups.

Users who do not use CoMP and have low-rate need must submit their curriculum vitae (CVs) to the sub-channel in their cells of sustained benefit, while high-rate users must submit CVs only to a sub-channel with the highest percentage need. CoMP consumers must submit their CVs not only to the sub-channel that is always in their cells, but also to the sub-channels in all cells of the CoMP cluster that contain the same resource block.

Sub-channels must determine if the matching user is a CoMP user with increased demand. It must be determined if a joint CoMP cell selects CoMP users on another RB for a CoMP user with a high-rate demand.

Since users expect to be paired with sub-channels, it selects sub-channels based on their ZUb, i.e., expecting that each receiver transmits their CV to sub-channels (non-CoMP users and users with reduced rate need). CoMP consumers transmit CVs only to the sub-channels selected by the local cell; while greater need CoMP users send CVs to all cells in the desired sub-channels of the CoMP groups. Subsequently, depending to their choices, each sub-channel within each cell has the power to reject or receive these CVs ZSb. The current rounds are mutually evaluated onceall consumers have sent their CVs to our preferred sub-channels.

4. RESULT ANALYSIS

The BER performance of the proposed PA-CoMP-NOMA power system is investigated; for users, we considered channel deviations of 0, 2, 4, 5, 6, 7, 8, and 9 dB, respectively. For simplicity, we assume that each user has the same noise variance, i.e., 2w. It is also assumed that each user is able to perform faultless SIC decryption for consumers in the lesser level of the i^{th} user. An un-coded model was determined. We additionally examined a minimum price of 0.2 bits/s/Hz for each user. Performance metrics such as SNR, Sum rate, Channel capacity, power allocation and execution time were evaluated [1]. The acquired signal ratio (SNR) of the i^{th} user is described as:

$$SNRi \triangleq \frac{\sigma_{h,i}^2 \sigma_x^2 \alpha_i P_Y}{\sigma_w^2} \tag{14}$$

We displayed the BER performance of our proposed approach for user 1 against the traditional sum-rate based CF using the above setups. In Fig. 2, we can see that the BER obtained from our proposed approach at an SNR = 15 dB is 3*103, although the same BER is generated at an SNR = 18 dB for the baseline scenario. Thus, compared to the standard method, our proposed method improves the SNR by 6 dB. The proposed model PA-CoMP-NOMA is compared with MBER. The proposed method improves the SNR (sum rates) for user 1.

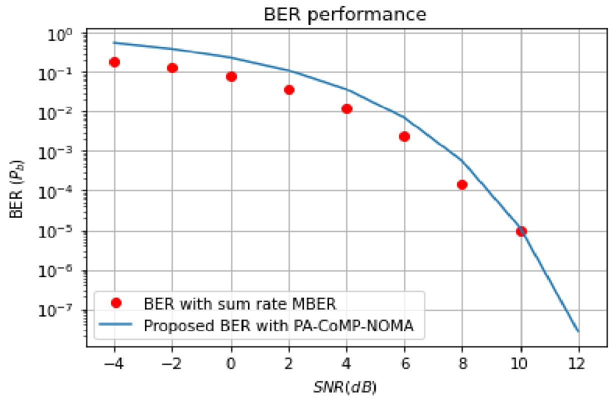

Fig. 2. BER performance comparison.

In Fig. 3, the total rate (sum of all users) using our proposed technique is shown next to the sum-rate founded PA-CoMP-NOMA and MBER. Moreover, the system performance of the PA-CoMP-NOMA-based system is reduced, which is expected. However, the reduction is negligible in this simulation model setting. Therefore, the degradation is more pronounced with reduced SNR. The main reason is because noise exacerbates the optimizing challenge at lower SNR. Larger optimizations can be considered, however, they are beyond the scope of this research.

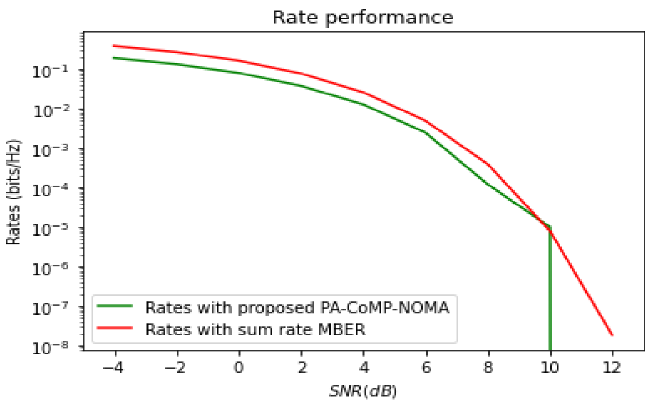

Fig. 3. Rate Performance of PA-CoMP-NOMA.

The fading characteristics of the channels of each realization are modeled as i.i.d. Rayleigh random factors, with $\sigma_{h_n}^2$ small-scale fading assumed to be flat, and the fading coefficients of the channels for each realization are modeled as i.i.d. The BER of a PA-CoMP-NOMA for user 2 and PA-CoMP-NOMA for user 3 methods using BPSK are shown in

Fig. 4, with N = 2. Despite the fact that the power allocation for both devices is not ideal, the MBER surpasses PA-CoMP-NOMA for user 2 by 2.18 dB for U1, while U2 suffers a reduction of about 0.7 dB. Similarly, the proposed method improves the power allocation and for both users the power allocations can vary.

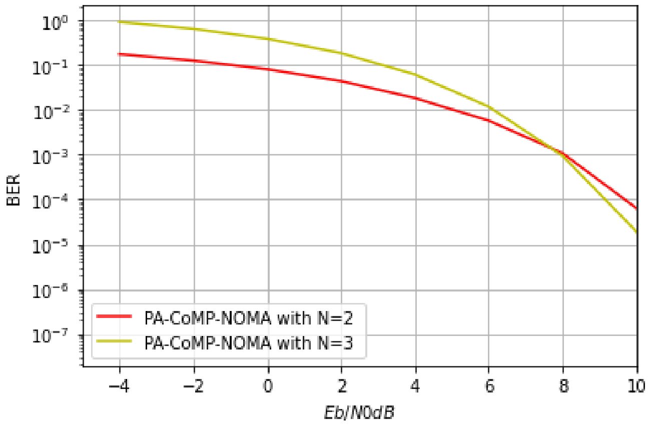

Fig. 4. Power allocation for Users 2 and 3.

Usually calculated across all potential input probabilistic p, the network capability for the nth user is described as the largest achievable mutual information $I(X_n, Y_n)$ between the channels input X_n and output Y_n $p(x_n)$.

$$Ch_n = ma(x_n) I(x_n, y_n) \tag{15}$$

The mutual information can be represented in the following way.

$$(X_n, Y_n) = H(X_n) - H(x_n | y_n) \tag{16}$$

Fig. 5 shows the PA-CoMP-NOMA gain with respect to channel capacity for N = 2 and N = 3 examples, using BPSK and QPSK, respectively.

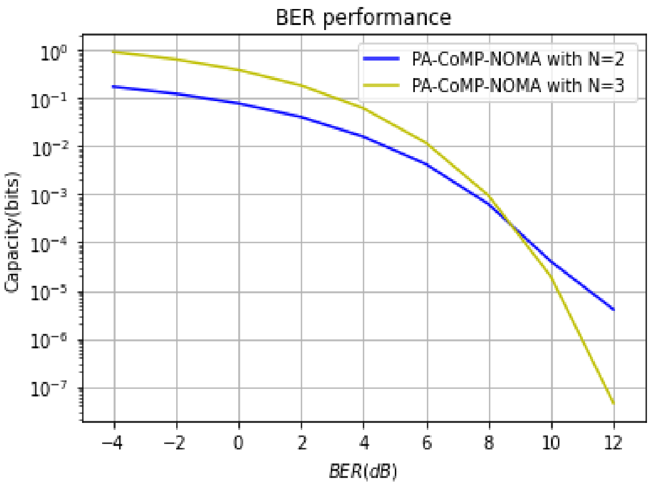

Fig. 5. Channel Capacities for PA-CoMP-NOMA.

Fig. 6 shows the execution time of the proposed model. Compared with the existing MBER model, the proposed method takes less time. The proposed method achieves 23.45 (s) for the execution of each performance. Table 2 shows the quantitative analysis of the execution time of the proposed model and the comparison with the existing models.

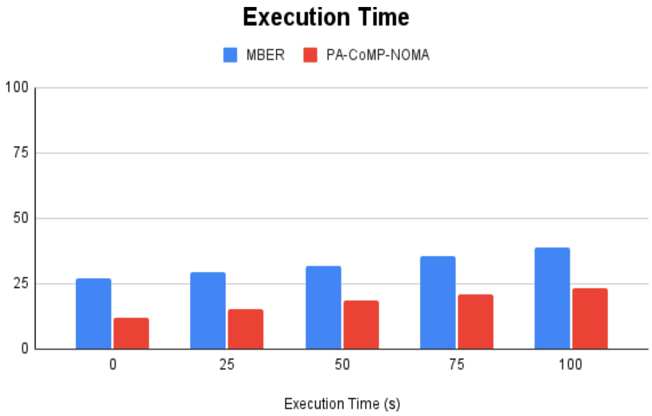

Fig. 6. Execution time.

Table 2. Performance analysis.

Execution time for MBER (in s)	25.0	30.2	32.6	34.4	43.8
Execution time for PA-CoMP-NOMA (in s)	13.8	16.2	18.9	21.7	23.5

5. Conclusion

In this paper, we present the development of a power adaptive NOMA with coordinate multi-point, where the energy parameters for different users are selected considering the average error probability for all users. We have demonstrated the improvement of BER for a variety of users. To use the proposed method, the BER efficiency has been experimentally demonstrated. Computational complexity is the major limitation in this important work, which will lead and promote future growth in this field. The proposed PA-CoMP-NOMA improves the performance of BER and increases the power allocation and channel capacity. Compared to the existing MBER system, the proposed method requires less execution time. It also works with SISO and CoMP models. By using both systems, the proposed model performs all parameter metrics efficiently.

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The authors declare no funding applied.

Conflicts of Interest

The authors declare they have no conflicts of interest to report regarding the present study.

Data Availability Statement

Available Based on Request. The datasets generated and/or analyzed during the current study are not publicly available due to the extension of the submitted research work. They are available from the corresponding author upon reasonable request.

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