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# Improved Dynamic Power Allocation Scheme for Massive Connectivity in NOMA System

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**ABSTRACT**

In a wireless network, the radio resources are allocated to the users based on the Orthogonal Multiple Access (OMA) technique. The performance of the network can be improved by introducing non-Orthogonal multiple access (NOMA) whenever the number of users increases tremendously. There is much scope in improving the outage probability, bit error rate (BER), high spectral efficiency and latency. To improve this, Non-Orthogonal Multiple Access (NOMA) technique has been discussed in this paper with fair power allocation technique. The effect of fixed power and dynamic power allocation has been discussed and compared, the Bit error rate (BER) and achievable rate have been analyzed and compared. The NOMA uses Successive interference cancellation (SIC) at the receiver for decoding the individual user's data which is a complex process. The effect of imperfect SIC has also been evaluated and analyzed. In dynamic Power allocation technique higher power is devoted to the far users due to which the near user goes into outage. A new technique has been proposed to reduce the outage power while taking the target rate and SNR of each user into consideration. The results show an improvement in outage probability in comparison with the state of art technique.

## 1. INTRODUCTION

The multiple access techniques not only allow the users to establish a wireless connection between the networks and the users but also let the users to access the shared resources at the same time. During the evolution of wireless communication from the first generation to the fourth generation, the demand and success of orthogonal multiple access (OMA) were quite high, OMA techniques like Frequency division multiple access (FDMA), Time division multiple access (TDMA), code division multiple access (CDMA) and orthogonal frequency division multiple access (OFDMA) contributed a lot [1, 2], in these techniques the signals of multiple users were mapped into orthogonal resources either in the time domain or in Frequency domain for multi-user access with minimal inter-user-interference.

In the Fifth generation (5G) of mobile communications, the demand for the IoT devices will rise tremendously with time, similarly, the number of Vehicle to Vehicle (V2V) communicating devices will also increase, which will demand for the very low latency and highly reliable network. It would make it difficult for the OMA techniques to fulfil these demands [3, 4]. The 5G network has some set of requirements as prescribed by the International Telecommunication Union (ITU), these are, massive connectivity, ultra-low latency, and very high data rate [5-7].

The escalating demands for massive connectivity with higher data rates and diversity in deployments have put power domain (PD) NOMA as much sought technology for 5G, it has been recognized as a promising multiple access technique to improve the capacity and user multiplexing of Uplink as well as Downlink cellular systems [8]. The 3rd Generation partnership Project (3GPP) has worked effectively in NOMA in LTE-Advance for down link communication [9] and New Radio (NR) as for uplink communication [10]. The NOMA is receiving major attentions from Researchers, academics and standard sectors for implementation of future wireless devices and deployments. NOMA is broadly classified into Power and Code Domain NOMA [11]. In Power Domain NOMA (PD-NOMA) users are multiplexed in power domain. Here users with poor channel conditions are allocated more power at transmitter as compared with users having good channel conditions and this is done to avoid the poor channel users from going into outage. Unlike PD-NOMA, the Code domain NOMA (CD-NOMA) uses specific low density spreading code sequences which are non-orthogonal and having low cross-correlation for all the users during multiplexing. This paper focuses on implementation of power domain NOMA. Many studies have been conducted so far and have found that power domain NOMA can be implemented effectively to fulfil the essential demands of 5G technologies. NOMA can be further implemented, to improve the performance of other contemporary wireless technologies, like multiple-input multiple-output (MIMO) [12], Cognitive radio (CR) [13], millimeter wave [14], cooperative [15] and energy harvesting (EH) techniques [16].

Power domain NOMA uses superposition coding and successive interference cancellation (SIC) during transmission and reception respectively [17]. Where the signals are decoded successively according to the power of the transmitted signal. In downlink NOMA, the base-station (BS) transmits the signals to randomly deployed multiple users over a common resource. Each user then retrieves its own information employing SIC and removing the interferences taking the power order of the signals into account. In this process the non-overlapping frequency sub-bands and time slots are assigned to each user without any interference. Since the time and frequency are linearly related with channel capacity, this improves the channel capacity compared to much popular OMA technique and thus NOMA has higher achievable data rate then OMA [18]. It has already been proved in literature [19] that the power allocation techniques in NOMA make it outperform the OMA for multi-user in terms of capacity. The power allocation techniques of NOMA completely depend upon the distance at which the users are located from the BS. In such scenario channel state information (CSI) plays a vital role. It is expected that the BS should have perfect instantaneous channel state information (CSI), but it is not a realistic assumption in deployment of wireless system.

The time gap between the transmission and the channel estimation by the BS is also considerable which determines the target rate and CSI formats like precoding matrix indicator, rank indicator channel quality etc. The exact channel gain calculation in such a scenario is not easy to estimate in 4G and 5G. Therefore, it is difficult to accommodate the Downlink (DL) transmission at respective target rate. In NOMA system, the cochannel interference is very high, as same time, frequency and spreading codes are shared by the multiple users. Therefore, it is little difficult for the users in the system to work together. Furthermore, the system is classified into subgroups, NOMA is implemented into these subgroups where orthogonal bandwidth resources is allocated between these groups [20].

Mounchili and Hamouda [21] has used the fixed power allocation to analyze the performance of the 2-user NOMA system, there are some of the ranges of these power allocation coefficient value where the user goes into outage with the higher achievable rate. To study and predict this behavior, we have evaluated the outage for all dynamic values of power allocation coefficients. It is necessary that power allocation for all the randomly deployed users in downlink NOMA should be made fair by taking the required achievable target rate along with proper user pairing scheme. Allocation need not to be done on the channel gain values.

In this paper, an Improved dynamic power allocation technique has been proposed for randomly deployed users in downlink NOMA, the target rates and outage of the individual user have been taken into consideration for power allocation in real time deployment instead of channel gain values. The residue free novel technique has been proposed to prevent the user from outage, instead of fixed power allocation (FPA) which creates inefficient use of transmitted power, the dynamic power allocation (DPA) technique has been used.

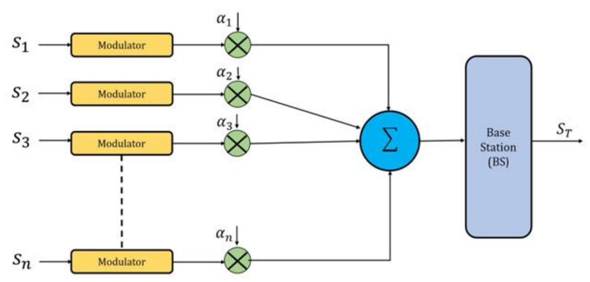


**Figure 1.** The representation of NOMA for Uplink

The performance of both FPA and DPA has been compared.

This paper is organized as follows. Section II describes the system model along with the proposed method for residue free and fairness in NOMA using both FPA and DPA. The performance of the NOMA has been evaluated and results has been discussed in Section III. The Section IV gives the concluding remarks.

## 2. NOMA STRUCTURE AND SYSTEM MODEL

### 2.1 Uplink NOMA

Consider a power domain NOMA method shown in Figure 1. for Uplink with N number of users located on some random locations in a circular disc. The signal power received from the N users will be given by $P_n = \alpha_n P_T$; $where \sum_{n=1}^{n=N} \alpha_n = 1$, $P_T$ is the total received power and the value of $\alpha_n$ is for all users, n=1, 2…N. $\alpha_n$ is the power allocation coefficients for the individual users. $P_n$ represents the power distributed among all N users. The α is allocated in such a fashion that $\alpha_1 \geq \alpha_2 \geq \cdots \geq \alpha_N$, where $\alpha_1$ is allocated to the user farthest from the base station (BS) and $\alpha_N$ to the user nearest to the Base station so that $P_1 \geq P_2 \geq \cdots \geq P_N$. Consider that the base station is located at the centre of a circular disc and radius is $\mathcal{R}_\mathcal{D}$. The channel denoted by the $n^{th}$ user and the base station is $h_n$ and $h_n = \frac{\hat{g}_n}{\sqrt{1+d_n^a}}$, where $\hat{g}_n$ is the Rayleigh Fading gain of the channel, $a$ is path loss factor and $d_n$ denotes the distance between the user and the base station. Without loss of generality, the channel is given as $|h_1|^2 \leq |h_2|^2 \leq \cdots \leq |h_n|^2$, according to the NOMA protocol, the base station will send $\sum_{n=1}^{n=N} \sqrt{\alpha_m P}\, S_n$, where P is the transmission power, $S_n$ is the message signal for the $n^{th}$ user and $\alpha$ are the power allocation coefficients.

### 2.2 Downlink NOMA

The downlink NOMA as shown in Figure 2 includes the signal reception and decoding.

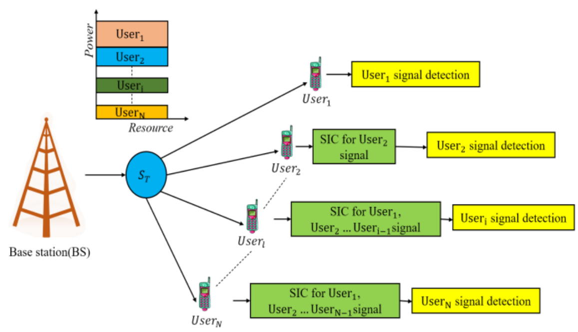


**Figure 2.** The System model of Downlink NOMA

From the uplink model shown in the Figure 1, the signal received at the $n^{th}$ user is given by

$$y_n = h_n S_l + \eta_w = h_n \sum_{l=1}^{N} \sqrt{\alpha_l P} S_l + \eta_w \quad (1)$$

where, $\eta_w \sim \mathcal{CN}(0, \sigma^2)$ is additive white Gaussian noise (AWGN) with zero mean and variance of $\sigma^2$, to retrieve the message at the user side the received signal needs to do successive Interference Cancellation (SIC), therefore the $n^{th}$ user will detect its corresponding message after removing $(n-1)^{th}$ users starting with $l^{th}$ user's message, $l < n$ after removing the message from successive users. During the whole process of SIC then the message of other $l$ users shall be treated as the noise at the $n^{th}$ user. The achievable data rate to the $n^{th}$ user is given by

$$R_n = \log_2(1 + \frac{\rho|h_n|^2\alpha_n}{\rho|h_n|^2\sum_{l=n+1}^{N}\alpha_l + 1}) \tag{2}$$

Such that $R_{i\to n} \geq \widetilde{R_i}$, where $\rho$ represents the transmit SNR, $\widetilde{R_i}$ is the target data rate of the $i^{th}$ user and $R_{i\to n}$ is the rate for the $n^{th}$ user to detect the $i^{th}$ user's message, $i \leq n$, i.e., $R_{i\to n} = \log_2\left(1 + \frac{\rho|h_n|^2\alpha_i}{\rho|h_n|^2\sum_{j=i+1}^{N}\alpha_i+1}\right)$, the rate at the $N^{th}$ user is $R_M = \log_2(1 + \rho|h_M|^2\alpha_M)$. The Instantaneous Signal to Interference Noise ratio (SINR) for the $n^{th}$ user to detect the $j^{th}$ user, $j \leq n$, with $j \neq N$ is given by

$$SINR_n = \frac{\rho|h_n|^2\alpha_n}{\rho|h_n|^2\sum_{l=n+1}^{N}\alpha_l + 1} \tag{3}$$

where $\rho = \frac{P}{\sigma^2}$ represents the Signal to noise ratio (SNR). Hence the SINR for the *N-th* user is represented by $SINR_N = \rho|h_N|^2\alpha_N$. Figure 2 also demonstrates the process of Successive Interference Cancellation (SIC) for a downlink NOMA network, the superimposed transmitted signal of multiple users is transmitted from the BS where each user is having different allocated power coefficients based upon their channel conditions. SIC is an iterative process that is carried until each user's signal is retrieved successfully. Since the user has poor channel conditions are provided with higher transmission power compared with the user with good channel conditions. To recover the user with maximum power the signals of subsequent users are considered as noise and are retrieved without any SIC, however, to recover the other user's message the SIC process needs to be performed.

Therefore, the sum rate can be written as

$$R_{sum}^{NOMA} = \sum_{n=1}^{N}\log_2(1 + SINR_n) \tag{4}$$

$$\begin{aligned} &= \sum_{n=1}^{N-1}\log_2\left(1 + \frac{\rho|h_n|^2\alpha_n}{\rho|h_n|^2\sum_{l=n+1}^{N}\alpha_l + 1}\right) + \log_2(\rho|h_N|^2\alpha_N) \\ &= \sum_{n=1}^{N-1}\log_2\left(1 + \frac{\alpha_n}{\sum_{l=n+1}^{N}\alpha_l + \frac{1}{\rho|h_n|^2}}\right) + \log_2(1 + \alpha_N\rho|h_N|^2) \end{aligned} \tag{5}$$

To compare the individual performance of NOMA and OMA techniques, we consider them at a very high SNR, i.e., $\rho \to \infty$, the sum rate can be represented as

$$R_{Sum}^{NOMA} \approx \sum_{n=1}^{N-1}\log_2\left(1 + \frac{\alpha_n}{\sum_{l=n+1}^{N}\alpha_l}\right) + \log_2(\rho|h_N|^2) \approx \log_2(\rho|h_N|^2) \tag{6}$$

whereas in OMA Techniques, the achievable data rate of the n-th user can be given as

$$R_n^{OMA} = \alpha_n\log_2\left(1 + \frac{\beta_n\rho|h_n|^2}{\alpha_n}\right) \tag{7}$$

where, $\beta_n$ and $\alpha_n$ are the power coefficients and the parameters associated with the specific resource of $User_n$ respectively. The sum rate can be written as

$$R_{Sum}^{NOMA} = \sum_{n=1}^{N}\alpha_n\log_2\left(1 + \frac{\beta_n\rho|h_n|^2}{\alpha_n}\right) \tag{8}$$

Let us assume if FDMA, one of the OMA is used, then the total bandwidth and power will be equally divided among the users. Hence $\alpha_n = \beta_n = 1/N$, the sum rate can be given by

$$R_{Sum}^{OMA} = \sum_{n=1}^{N}\frac{1}{N}\log_2(1 + \rho|h_n|^2) \tag{9}$$

where, $\rho \to \infty$, the above equation can be written as

$$R_{Sum}^{NOMA} \approx \sum_{n=1}^{N}\frac{1}{N}\log_2(\rho|h_n|^2) \tag{10}$$

channel condition $|h_1|^2 \leq |h_2|^2 \leq \cdots \leq |h_N|^2$, the sum rate can be written as

$$R_{Sum}^{OMA} \approx \sum_{n=1}^{N}\frac{1}{N}\log_2(\rho|h_n|^2) \leq \sum_{n=1}^{N}\frac{1}{N}\log_2(\rho|h_N|^2) \tag{11}$$

$$= \log_2(\rho|h_N|^2) \approx R_{Sum}^{NOMA} \tag{12}$$

$$\text{Therefore the } R_{Sum}^{NOMA} \geq R_{Sum}^{OMA} \tag{13}$$

### 2.3 Power allocation to near and far users

Let us assume a scenario where two users are located at two different locations as shown in Figure 3 such that the power allocation coefficient to the near user is $\alpha_{near}$ and to the far user is $\alpha_{far}$ in a Rayleigh channel with channel coefficients as $h_n$ and $h_f$ respectively.

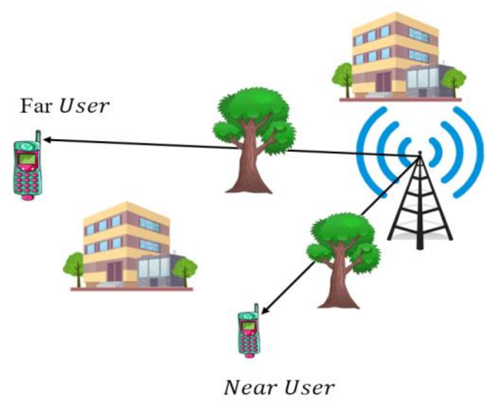


**Figure 3.** Illustration of two user NOMA model

The target rate for the far-user is given by $R_{Tar}$ such that $R_{far} \geq R_{Tar}$, where $R_{far}$ is the achievable rate of the far user. Hence, we can write this as

$$\log_2\left(1+\frac{\alpha_{far}P|h_f|^2}{\alpha_{near}P|h_f|^2+\sigma^2}\right) \geq R_{Tar} \tag{14}$$

$$1+\frac{\alpha_{far}P|h_f|^2}{\alpha_{near}P|h_f|^2+\sigma^2} \geq 2^{R_{Tar}} \tag{15}$$

$$\frac{\alpha_{far}P|h_f|^2}{\alpha_{near}P|h_f|^2+\sigma^2} \geq \rho_{far} \tag{16}$$

where, $\rho_{far}$ is the SINR for the far user whose target rate is $R_{Tar}$ and $\rho_{far} = 2^{R_{Tar}} - 1$.

$$\alpha_{far}P|h_f|^2 \geq \rho_{far}(\alpha_{near}) \tag{17}$$

Since $\sum_{n=1}^{N} \alpha_n = 1$, for two users we can write $\alpha_{far} + \alpha_{near} = 1$, therefore it can be written as:

$$\alpha_{far}P|h_f|^2 \geq \rho_{far}\left\{(1-\alpha_{far})P|h_f|^2+\sigma^2\right\} \tag{18}$$

$$\alpha_{far} \geq \frac{\rho_{far}\left(P|h_f|^2P+\sigma^2\right)}{P|h_f|^2(1+\rho_{far})} \tag{19}$$

Power allocated to the near user will be $(1-\alpha_{far})$.

### 2.4 Imperfectness in NOMA

We have assumed in our previous discussions that the SIC perfectly cancels out the individual signal at the receiver however it is quite complex to subtract the decoded signal from the signal received without getting any error. In Figure 3 the received signal at the far user and the near user can be given as

$$y_{far} = h_f S_l + \eta_f \tag{20}$$

$$y_{near} = h_n S_l + \eta_n \tag{21}$$

If we assume for two user scenario which can be extended to any number of users, the above equations can be written as

$$y_{far} = h_f\big(P(\sqrt{\alpha_{far}}S_1 + \sqrt{\alpha_{near}}S_2)\big) + \eta_f \tag{22}$$

$$y_{near} = h_n\big(P(\sqrt{\alpha_{far}}S_1 + \sqrt{\alpha_{near}}S_2)\big) + \eta_n \tag{23}$$

where, $S_l = P(\sqrt{\alpha_{far}}S_1 + \sqrt{\alpha_{near}}S_2)$; is the superimposed signal transmitted from BS and $\eta_f$ and $\eta_n$ are respectively the white Gaussian noise with zero mean and $\sigma^2$ variance.

Since, $\alpha_{far} > \alpha_{near}$, the far user will go with direct decoding and the near user have to go SIC to decode its data, hence at the near user, the decoded data of the far user is subtracted from the received signal which can be given asideally, we expect a perfect SIC and get $y_{near} = h_n P\sqrt{\alpha_{near}}S_2$, however, it is very difficult to get a perfect SIC instead we get an imperfect SIC and thus the signal received and decoded at near user contains some residue of the signal of the far user, which can be given as $y_{near} \approx \sqrt{\epsilon}h_n P\sqrt{\alpha_{far}}S_1 + h_n P\sqrt{\alpha_{near}}S_2$; where $\sqrt{\epsilon}h_n P\sqrt{\alpha_{far}}S_1$ is the residual term from the far user. $\epsilon$ is the residue component from far user left out due to imperfect SIC. Due to this Imperfect SIC, a residue of far user's power is present as the interference, due to which the achievable rate gets reduced and is given by

$$y_{near} = h_n\big(P(\sqrt{\alpha_{far}}S_1 + \sqrt{\alpha_{near}}S_2)\big) + \eta_n - h_n P\sqrt{\alpha_{far}}S_1 \tag{24}$$

$$R'_{near} = \log_2\left(1+\frac{|h_n|^2 P\alpha_{near}}{\epsilon|h_n|^2 P\alpha_{far}+\sigma^2}\right) \tag{25}$$

### 2.5 Power allocation to avoid outage

In this model the users go in outage whenever the target rate is much higher than the achievable rate, therefore to avoid outage we have simulated the results taking Eq. (14) into account. whenever the far user has achieved its target rate, as calculated in Eqns. (14-19); $\frac{\rho_{far}\left(P|h_f|^2P+\sigma^2\right)}{P|h_f|^2(1+\rho_{far})}$ greater than unity, instead of limiting the $\alpha_{far}$ to one, set $\alpha_{far}$ to zero, which will lead to an increase in the $\alpha_{near}$ value automatically and thus the near usercan be restricted from entering into outage. Which will lead to a better and efficient fair power allocation for both near user and the far user.

## 3. RESULTS AND DISCUSSION

In this section the performance of different estimations for NOMA has been assessed, the results have been illustrated by taking the different performance parameters into account. In Figure 4, a comparison between the capacity of NOMA with respect to OMA has been done and in Figure 5. BER of both the users have been compared.

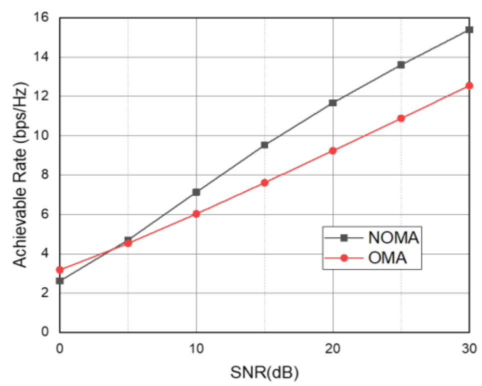


**Figure 4.** Comparison between the capacity of NOMA and OMA

The Simulation has been done for two users; however, it can be extended up to any number of users, here each user is located at a distance as shown in Table 1, under a Rayleigh fading channel with a bandwidth of 1MHz and power allocation coefficients to both users are $\alpha_1 = 0.8$ and $\alpha_2 =$

0.2. From the plot in Figure 4, it is observed that the OMA has good performance compared with NOMA at low SNR value, this is because NOMA suffers from interference at low SNR; however, the NOMA outperforms the OMA significantly at higher SNR Values where it offers high capacity with minimal resources as compared to OMA.

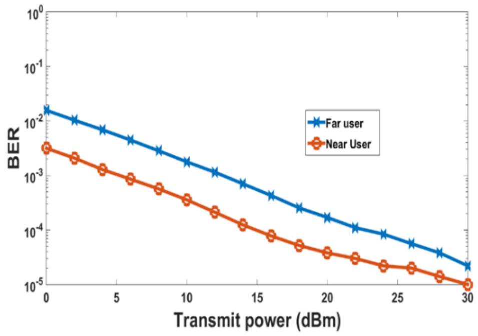


**Figure 5.** BER of near user and far user in NOMA

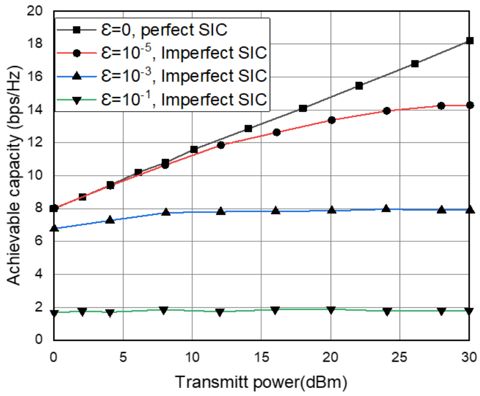


**Figure 6.** Effect of imperfect sic and perfect sic in downlink NOMA

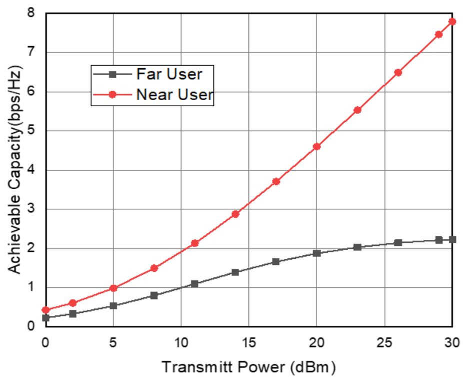


**Figure 7.** The capacity comparison of near and far user in NOMA

**Table 1.** Parameter used for simulation

| Parameter | Value |
|---|---|
| **Distance of far user from BS** | 200 m |
| **Distance of near user from BS** | 100 m |
| **Bandwidth** | 1 MHz |
| $\boldsymbol{\alpha_{far}}$ | 0.8 |
| $\boldsymbol{\alpha_{near}}$ | 0.2 |
| **Modulation technique used** | QPSK |
| $\boldsymbol{\eta}$ | 4 |

The simulation parameters are shown in Table 1. The simulation is carried for a Rayleigh fading channel having channel coefficients with a condition $|h_{far}|^2 < |h_{near}|^2$, with variance $d_i^{-\eta}$ and mean zero; where $d_i$ is the distance of the i-th user from the base station and $\eta$ is the path loss component. The superimposed transmitted signal is given by $S_l = P(\sqrt{\alpha_{far}}S_1 + \sqrt{\alpha_{near}}S_2)$ for the two users.

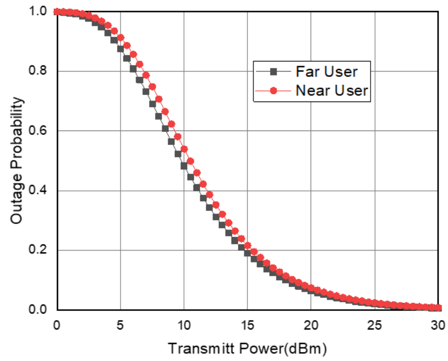


**Figure 8.** Outage probability of near and far users in NOMA

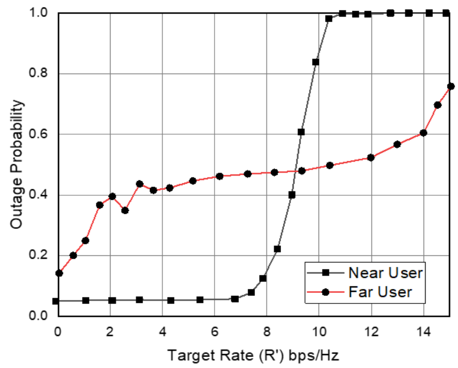


**Figure 9.** Dynamic power allocation for near and far user in NOMA

The BER for the far user is higher than that of the near user since it is located at a greater distance from the near user, therefore, suffers higher interference than the near user.

Due to imperfect SIC, the signal component of one user remains as a residue while decoding other user's information, Which creates interference and reduces the achievable capacity significantly, this can be noted from the Figure 6. When the residue term is absent i.e.; ϵ=0, the achievable capacity is maximum as shown in the graph. For optimal achievable capacity, we need to keep this ϵ value as minimal. The simulation parameter for Figures 4 to 7 has been illustrated in Table 1.

**Table 2.** Simulation parameters for the dynamic power allocations

| Parameter | Value |
|---|---|
| **Distance of far user from BS** | 500 m |
| **Distance of near user from BS** | 250 m |
| **Bandwidth** | 1 MHz |
| **Power transmitted** | 40 dBm |
| $\boldsymbol{\alpha_{far}}$ | dynamic |
| $\boldsymbol{\alpha_{near}}$ | dynamic |
| **Modulation technique used** | QPSK |
| $\boldsymbol{\eta}$ | 4 |

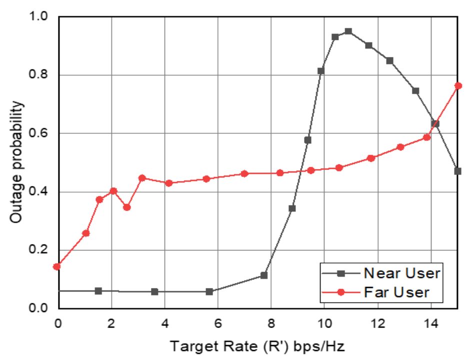


**Figure 10.** Improved dynamic power allocation for near and far user in NOMA

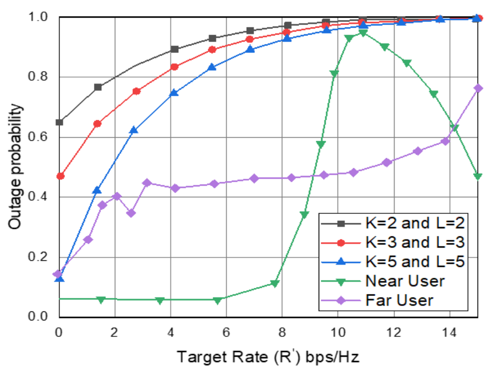


**Figure 11.** Comparison between the proposed DPA in NOMA with the results proposed by Tian et al. [22]

Figure 7 and Figure 8 illustrate the capacity and outage probability which is a function of individual SINR value of the near and far user respectively.

The results show significant improvements in the capacity and outage of the near and far user, the outage probability of near and far user is more or less comparable and reduces significantly with the increase in transmit power.

Figure 9 shows the dynamic power allocation with a target to improve the sum rate and maximize the efficiency, where the value of power allocation coefficients is chosen using the Eq. (19).

The fair power techniques give highest power to the users situated at far location and the remaining is distributed to the subsequent users only after meeting the target rate of far user. The simulation parameters are mentioned in the Table 2.

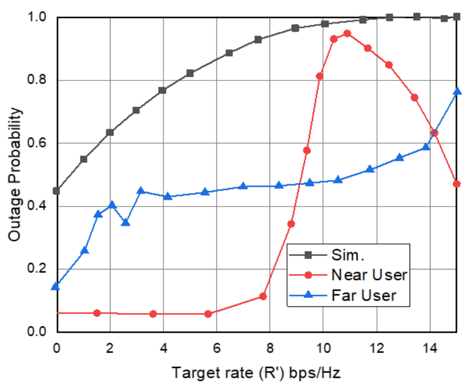


**Figure 12.** Comparison between proposed DPA in NOMA and the result proposed by Do et al. [23]

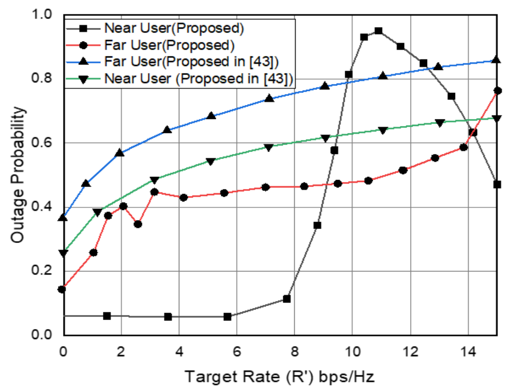


**Figure 13.** Comparison of outage probability vs. target of proposed DPA in NOMA with the results proposed Do et al. [24]

Since the fixed power allocation never harvest the channel state information (CSI) and also does not take the target rate into consideration hence it fails for high target rate of far users, therefore its use is not promoted in most of the applications. In Figure 9, the graph of near user shows sharp transition and goes into outage at a higher rate.

The graph of far user which is getting maximum power does not get into outage even though the sufficient target rate has been achieved. This is uneconomical way of harvesting the power, therefore to modify this an Improvement has been done in power allocation and has been discussed in the section 2.3 to section 2.5. The result of this modification gives tremendous improvement in result which has been illustrated in Figure 10. Here, whenever the near user is about to reach outage the power allocation to the far user is reduced which leads in improvement in near user and stops it from getting outage. Which will lead to a better and efficient fair power allocation for both near user and the far user. Here it can be observed that whenever the near user is about to reach outage the power allocation to the far user is reduced which leads in improvement in near user and prevents it from getting into outage.

The above obtained result has been compared with the results obtained by Tian et al. [22], the authors in the paper have used relay selection in the Cognitive radio (CR) with decode and the forward buffer. The comparison of the result has been illustrated in the Figure 11. The simulation has been done for different values of relays (K) and buffer size (L). From the graph we can say that the NOMA system can outperform the cognitive radio even though the complexity of SIC is high.

In Figure 12, The proposed result has been further compared with the result of literature [23], where the result obtained in the paper has been illustrated with the legend sim. Here at high target rates the users inhabit outage, which is not at all desirable.

Do et al. [24] have proposed a NOMA system assisted with Cognitive radio, the outage probability of the two users have been simulated and compared, the proposed simulation has been illustrated above in Figure 13 and has been compared with our proposed method by us. In Do et al. [24] the outage probability of the both the users are marginally same but have poor performance at higher rates, their performance may degrade at higher number of users and consequently may suffer outage. In our proposed model even though the far users have been given a higher priority but is for momentary, as the

Far users achieves their target rates, we transfer the priority to near users to avoid outage of the near users.

## 4. CONCLUSION

In this paper, Dynamic power allocation analysis has been proposed for NOMA systems based upon the target rate. The performance of the NOMA system has been compared with the traditional OMA system, the imperfect SIC and its effect on performance has been estimated. The outage performance of the near and far user has been compared, the simulation results have been compared with results with the relay based cognitive radio and with fixed power allocation method of the NOMA.The simulation results and plots of the above simulation shows the significant improvement in performance of the NOMA system even though it has lots of complexity.

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## NOMENCLATURE

| | |
|---|---|
| $S_n$ | Message signal of nth user |
| $S_T$ | Superimposed signal from transmitter |
| $P_n$ | Power received at receiver, W |
| $P_T$ | Transmitted power, W |
| $hn$ | Channel coefficient |
| $a$ | Path loss factor |
| $d_n$ | Distance between the user and the base station, m |
| $R_n$ | Achievable data rate to the $n^{th}$ user in NOMA, b/s/Hz |
| $\widetilde{R_\iota}$ | Target data rate of the $i^{th}$ user, b/s/Hz |
| $R_{sum}^{NOMA}$ | Sum rate, b/s/Hz |
| $R_n^{OMA}$ | Achievable data rate to the $n^{th}$ user in OMA, b/s/Hz |
| $R_{Tar}$ | Target data rate of the far user, b/s/Hz |

### Greek symbols

| | |
|---|---|
| $\eta_w$ | Additive white Gaussian noise (AWGN) |
| $\sigma^2$ | Variance of AWGN |
| ρ | Signal to noise ratio (SNR) |
| $\epsilon$ | Residue coefficient |

### Abbreviations

| | |
|---|---|
| OMA | Orthogonal multiple access |
| FDMA | Frequency division multiple access |
| TDMA | Time division multiple access |
| CDMA | Code division multiple access |
| OFDMA | Orthogonal frequency division multiple access |
| SIC | Successive interference cancellation |
| NOMA | Non-Orthogonal Multiple Access |
| CSI | Channel state information |
| FPA | Fixed power allocation |
| DPA | Dynamic power allocation |