Retraction

Retraction: Analysis of Power Allocation for Non-Orthogonal Multiple Access (J. Phys.: Conf. Ser. 1916 012059)

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This article (and all articles in the proceedings volume relating to the same conference) has been retracted by IOP Publishing following an extensive investigation in line with the COPE guidelines. This investigation has uncovered evidence of systematic manipulation of the publication process and considerable citation manipulation.

IOP Publishing respectfully requests that readers consider all work within this volume potentially unreliable, as the volume has not been through a credible peer review process.

IOP Publishing regrets that our usual quality checks did not identify these issues before publication, and have since put additional measures in place to try to prevent these issues from reoccurring. IOP Publishing wishes to credit anonymous whistleblowers and the Problematic Paper Screener [1] for bringing some of the above issues to our attention, prompting us to investigate further.

[1] Cabanac G, Labbé C and Magazinov A 2021 arXiv:2107.06751v1

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Analysis of Power Allocation for Non-Orthogonal Multiple Access

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Abstract. Most multiple access schemes provide orthogonal access to the users in time, frequency, code and space, this is not true for NOMA where each user operates in the same band and at the same time where they are distinguished by their power levels. It uses superposition coding at the transmitter such that the successive interference cancellation (SIC) receiver can separate the users both in the uplink and in the downlink channels. The users in (NOMA) are classified based on power, while in Orthogonal Multiple Access (OMA) it is classified based on time, frequency, and code. The NOMA system contains a power-delay tradeoff and hence power efficiency becomes critical for Ultra-Reliable Low Latency Communication (URLLC), especially where a huge number of devices are battery-powered. Combining these considerations, we simulate Dynamic Power Allocation (DPA) for power domain non-orthogonal multiple access (PD-NOMA) with user mobility. For small and clumsy battery-powered IoT devices, power efficiency becomes critical. Further, flexibility is also important to communicate with diverse machine-type devices as well as human users while meeting a variety of quality of service (QoS) requirements. The performance of the DPA is compared with Static Power Allocation under user mobility.

1. Introduction

The fifth generation is the forthcoming revolution of mobile technology which has a huge array of innovative features like speed up to 10 gigabits per second, 100 times greater number of devices, faster response time, virtually 0 latency, ubiquitous connectivity, larger data volume per unit area (high system spectral efficiency). NOMA in 5G serves multiple users using the same time and frequency resources, which is the primary reason for adopting it. One of the imperative techniques used here is Power Domain multiplexing. There are two types of multiple access techniques. One is OMA and the other one is NOMA. In the OMA technique, systems are orthogonal to each other. Some of these techniques are TDMA, FDMA, CDMA, OFDMA. Due to high traffic volume, OFDMA could not fully satisfy the spectral efficiency and power utilization. By considering those difficulties the NOMA technique has been proposed. In this technique, the individual user is allowed to occupy the whole spectrum and multiplexed from one another in the power domain. With SIC the weakest signal is extracted by removing the
strongest signal. NOMA offers 30% more throughput than OFDMA. It gives higher spectral efficiency due to multiple users on the same frequency and time. In this project, the NOMA technique and dynamic power allocation of users are explained very clearly. The basic principle of NOMA in uplink and downlink is presented and the proposed NOMA with multiple antennas is implemented [1]. The NOMA is presented and power allocation factor is included and the coverage region for fixed BS is calculated [2]. An original analysis of NOMA and the Rayleigh fading coefficients are calculated and a new evaluation technique is proposed with NOMA spectral efficiency [3]. A multiple access technology for subcarrier and a novel utility function is introduced [4] and the non-convexity problem is sorted using a two-step iterative method. The Non-orthogonal multiple access (NOMA) for 5G networks is represented and spectrum efficiency (EE-SE) of NOMA and OFDMA techniques are compared, and the simulated results were with respect to energy and spectrum efficiency [5]. A theoretical analysis of spectral efficiency of closed-form of NOMA in Nagakami is proposed and a fading index is introduced [6]. Two different power allocation schemes are introduced, one is based on channel information, and the other strategy on pre-defined QoS for each user is introduced and potential gain of NOMA is analyzed [7]. A non-orthogonal multiple access (NOMA) that has a capability for a 5G system is proposed [8] and a new cooperative NOMA is introduced and analyzed, and the outage probability and diversity were plotted. Existing NOMA for 5G is studied and the current challenge is identified as energy consumption and proposed a novel energy-efficient NOMA is obtained [9]. NOMA is considered with SIC at receiver [10] and adopts LTE and multi-user power allocation, signaling overhead, SIC error propagation, performance in high mobility scenarios, and combination with multiple-input multiple-output (MIMO) are simulated. A new signal-based theory is introduced in NOMA [11] and a massively concurrent NOMA(MC-NOMA) and the channel capacity of multi-user MIMO is analyzed and simulations are performed.

2. System model

The wireless channel is affected by multipath and blurring. These types of channels are available to capture the effects of wading and to deal with the situation. Among these types the Rayleigh weld model is used when there is no line of sight (LOS) between the sender and the receiver. The multipath elements have minimal fading effects such as reflection, distribution, distribution and shadow formation. So in our approach all the existing end-to-end results are considered. The effect you have when each transferred component has a different reduction and phase change due to multipath transfer is analyzed. In the proposed route a downlink (BS) transmission channel for two users is considered. User 1 is as far / weak as remote BS transfer. User 2 is the closest / most powerful user. Let d1 and d2 indicate the range of users from Base Station. BS has two different messages x1 on user 1 (remote user), and x2 on user 2 (next to user), A1 and u2 are long and close user power allocation features respectively (α1 + α2 = 1). To encourage user impartiality, more power is given to the remote user and less power to the nearest user. The presentation of the NOMA scheme is shown in Figure 1 and the internal blocks of the program are shown in Figure 2.
3. Proposed NOMA achievable capacity for far user

The achievable capacity for far users and near users is respectively given by equations (1) and (2)

\[ R_f = \log_2 \left( 1 + \frac{|h_f|^2 \alpha_f}{|h_f|^2 \alpha_f + \sigma^2} \right) \]  \hspace{1cm} (1)

\[ R_n = \log_2 \left( 1 + \frac{|h_n|^2 \alpha_n}{\sigma^2} \right) \]  \hspace{1cm} (2)

\( R_n \) is obtained after removing the interference from far user transmission by successive interference cancellation (SIC).

\( \alpha_n \) is assumed to be power allocation coefficient for the near user

\( \alpha_f \) is assumed to be power allocation coefficient for the far user

\( h_n \) = Rayleigh fading coefficient for the near user

\( h_f \) = Rayleigh fading coefficient for the far user
P=Total transmit power
\[ \sigma^2=\text{Noise power, } \alpha_n+\alpha_f=1, \alpha_f>\alpha_n \]

Let \( R^* \) denote the target rate of the far user. Our goal is to choose \( \alpha_n \) and \( \alpha_f \) such that \( R_f \) is greater than or equal to \( R^* \) as in equation (3)

Let \( R_f = R^* \) (3)

Taking logarithmic power on both sides of Equation (2) then, we derive as in equation (4-10)

\[ 2^{R^*} - 1 = \frac{|h_f|^2 P \alpha_f}{|h_f|^2 P \alpha_n + \sigma^2} \]

In Equation (4), \( \xi \) is represented as \( \xi = 2^{R^*} - 1 \).

where \( \xi \) is the target SNR for the far user who has target rate \( R^* \).

Since \( \alpha_n + \alpha_f = 1 \) (5)

\[ \frac{|h_f|^2 P \alpha_f}{|h_f|^2 P \alpha_n + \sigma^2} = \xi \]

\[ |h_f|^2 P \alpha_f = \xi (|h_f|^2 P(1-\alpha_f) + \sigma^2) \]

\[ \alpha_f \left( |h_f|^2 P + \xi |h_f|^2 \right) = \xi \left( |h_f|^2 + \sigma^2 \right) \]

\[ \alpha_f = \frac{\xi (|h_f|^2 + \sigma^2)}{|h_f|^2(\alpha + \xi)} \]

\[ \alpha_f = \min \left( 1, \frac{\xi (|h_f|^2 + \sigma^2)}{|h_f|^2(\alpha + \xi)} \right) \]

4. Simulation results.

4.1. Simple NOMA system with AWGN consideration
4.1.1 Downlink: In the downlink, the signal is transmitted from the base station to the near user and the far user. In the proposed model the length of the data is initialized. The user data for the far and near users are generated using random number generation. The transmission is carried out by BPSK modulation. The SNR is fixed for data length. The superposition coding is implemented in the transmitter to find \( x \) as in Equation (10). The AGWN is added for both near and far users. The demodulation is applied to retrieve the near and far user. Obtained user data is again modulated as \( x_1 \) and is changed into a BPSK signal. The estimated output is demodulated to obtain \( x_2 \). In Equation (10) the Simple NOMA without including the path loss model is represented. The received signal is represented by equations (11) and (12).
In Equation (12), $w$ is the AWGN with zero mean and variance $\sigma^2$. The results are plotted by comparing received data and bit error rate and plotted as in Figure 3. User 2 has a slightly higher BER than user 1, especially in the low SNR regime. This is because the near user has to do SIC. While performing SIC, near user must estimate far user’s data from received data. If this estimate is wrong, then this error will reflect in the decoding of its own information because the wrong data would be subtracted from received data. In other words, the near user must decode both the far user's data and his own data correctly.

\[
x = \sqrt{a_1}x_1 + \sqrt{a_2}x_2
\]

(11)

\[
y_i = h_i x + w
\]

(12)

4.2 NOMA system with Rayleigh Fading Channel

The NOMA system is modeled with the Rayleigh fading channel. The near and far users are fixed with the distance value. The power and path loss exponent values are assigned as per the model. Rayleigh fading coefficients are generated as $h_1$ and $h_2$. $h_1$ and $h_2$ are coefficients of normalized complex Gaussian random variable with zero mean and variance. The power of the transmitter in the linear scale is measured and system bandwidth is calculated. The noise level is also set with respect to bandwidth. The SNR values for the near and far user are calculated and the achievable target rates are also computed. The outage probability for the corresponding target rate is calculated. The graphical results are plotted for transmitter power vs achievable capacity and transmitter power versus outage probability as shown in Figure 4 and Figure 5. Far user has a lower capacity (i.e., achievable data rate) than near user, especially when the transmit power is high. This is because the far user performs direct decoding without removing the near user's data. But near user has the advantage of removing far user's data using successive interference cancellation.
4.3. Imperfect SIC consideration

The successive interference cancellation is imperfect at the mathematical level of practical analysis. Hence the proposed NOMA is considering the imperfect and finding the degraded performance. In NOMA, the near user first performs SIC to decode the signal for the far user, since the channel gain of the near user is higher than that of the far user. The decoded signal is then subtracted from the received signal of the near user and the resultant signal is used to decode the signal for the near user. For the far user, SIC is not executed, and the signal is directly decoded. SIC is perfect if the near user exactly decodes the far user's data and subtracts it from received data by SIC. When it is imperfect, the far user's data is not completely removed, and still, the residue of far user's data is present. We can see that imperfect SIC has a detrimental effect on the data rate of the strong user: the user who performs SIC. Achievable data rate degrades as SIC error increases and is plotted in Figure 6.

Figure 4. Transmit Power vs Achievable Capacity

Figure 5. Transmit Power vs Outage probability
4.4. Choice of Power allocation coefficients in NOMA

4.4.1 Uplink. At the base station and the received signal at the BS in the uplink, SIC is performed. The received signal at BS is represented as in Equation (13).

\[ y = h_1 \sqrt{P_{\beta_1}S_1} + h_2 \sqrt{P_{\beta_2}S_2} \]  

The BS decodes the signals of the two stages with the help of SIC. Signal S1 is decoded and the second user signal S2 is treated as noise. Then the receiver subtracts the decoded from the received signal. Power levels are identified as \( P_1 = P_{\beta_1} \) and \( P_2 = P_{\beta_2} \) (2, 7). The power allocation coefficient is \( \alpha = P_1/P_2 \) and ranges (0-1). The BER for the near user (user 2) is lower when \( \alpha_1 < 0.1 (\alpha_2 > 0.9) \) than when \( \alpha_1 \approx 0.8 (\alpha_2 \approx 0.2) \). The far user (user 1) has very high BER in this regime where \( \alpha_1 < 0.1 \) and \( \alpha_2 > 0.9 \). If we want both users to fairly benefit from NOMA, the ideal regime to operate is \( \alpha_1 \in [0.5, 1] \) and \( \alpha_2 \in (0, 0.5) \) towards the left end of the plot, \( \alpha_1 \approx 0 \) and \( \alpha_2 \approx 1 \) as shown in Figure 7. This means a very large power is allocated to the near user (user 2). Therefore, he has a very low BER. As \( \alpha_1 \approx 0 \) and \( \alpha_2 \approx 1 \), the near user's (user 2) data is dominating and hence, the far user (user 1) will not be able to directly decode his signal.

4.5 Dynamic Power Allocation in NOMA

Our fair PA gives priority to the weak/far user. That is, the power allocation coefficients are calculated so that the far user's target rate is met. Only after meeting the target rate of far user, all the remaining
available power is allocated to the near user. We can immediately see that fixed PA is performing very poorly and its outage probability saturates to all the time when $R^* > 1.5$. In other words, the receiver is always in outage if we use fixed PA with $R^* > 1.5$. This is because, fixed PA neither exploits the instantaneous CSI, nor takes the target rate requirements into account. But our fair PA has lower outage probability because $\alpha_n$ and $\alpha_f$ are dynamically adjusted based on target rate requirement and CSI. The results are shown in Figure 8.

Figure 8. Target rate of far user vs outage probability

5. Conclusion

The dynamic power allocation method for the Non-Orthogonal multiple access scheme was explained and the proposed model analyzed the different aspects of NOMA using separate methods. Hence the system model considers the Rayleigh fading channel and varying the fading coefficients. Thus, the result proved the far user has a lower achievable rate than the near user because of successive interference cancellation (SIC). In our proposed work, the near user performs the imperfect SIC cancellation of the signal by subtracting the far user data from the received signal. Our paper focuses on power allocation for NOMA and introduced the power allocation factor and limitation of the fixed power allocation. Hence our new proposal dynamically allocates the power for the far user and the target rate. By analyzing the Channel State Information, dynamic power allocation coefficients are determined. Dynamic power allocation has a lower outage probability than the static power allocation method. Hence the achievable rate is changing dynamically by maintaining the target rate at the expected value. Our proposed work is further extended by considering more than two users. User mobility is also an important factor to be considered for future enhancement of the proposed work. The height is varied and adjusted to different ranges in future work.

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