Power Allocation Scheme for Non-Orthogonal Multiple Access System

R. Seetharaman *, M. Tharun1, S. Gayathri2, K. Anandan3

1Department of ECE, CEG Campus, Anna University, Chennai-600025, India
2Department of EEE, CEG Campus, Anna University, Chennai-600025, India
3PS Division of E & E, TUV SUD South Asia Pvt Ltd, Chennai-600041, India

*Corresponding author email: rseetharamanece@gmail.com, rseetharamanece@annauniv.edu

Abstract. Since there exists a principal power-defer tradeoff in the NOMA framework, power proficiency additionally becomes basic for Ultra-Reliable Low Latency Communication (URLLC), particularly where countless gadgets are battery-fueled. Joining these contemplations, we reproduce Dynamic Power Allocation (DPA) for power area non-symmetrical different access (PD-NOMA) with client versatility. The exhibition of the DPA is contrasted and Static Power Allocation under client versatility. The characterization of clients in (NOMA) depends on power, while it depends on schedule, recurrence and code in Orthogonal Multiple Access (OMA). Since there exists an essential force defer tradeoff in the NOMA framework, power effectiveness likewise becomes basic for Ultra-Reliable Low Latency Communication (URLLC), particularly where countless gadgets are battery-controlled. Consolidating these contemplations, we reenact Dynamic Power Allocation (DPA) for power area non-symmetrical numerous entrance (PD-NOMA) with client portability. Force effectiveness becomes basic particularly for little and cumbersome battery-controlled IoT gadgets. Further, adaptability is additionally critical to speak with different machine-type gadgets just as human clients while meeting an assortment of nature of administration (QoS) prerequisites. The presentation of the DPA is contrasted and Static Power Allocation under client portability.

1. Introduction

The fifth era is the approaching unrest of portable innovation which has an immense exhibit of creative components like accelerate to 10 Gigabits each second, multiple times more gadgets, Faster reaction time, Virtually '0' inertness, Ubiquitous network, bigger information volume per unit region (high framework otherworldly proficiency). One of the basic methods utilized here is Power Domain multiplexing. In remote correspondence data transmission and time are the two characterizing provisions of a channel. Clients can approach channels through numerous entrance procedures. There are two sorts of different access methods. One is OMA and the other one is NOMA. In the OMA procedure, frameworks are symmetrical to one another. A portion of these procedures are TDMA, FDMA, CDMA, OFDMA. Because of high traffic volume, OFDMA couldn't completely fulfill the ghastly productivity and force use. By considering those challenges the NOMA method has been proposed. In this procedure, the individual client is permitted to involve the entire range and multiplexed from each other in the force space. With SIC the most vulnerable sign is extricated by eliminating the most grounded signal. NOMA offers 30% more throughput than OFDMA. It gives higher ghastly productivity because of various clients on a similar recurrence and time. In this venture, the NOMA strategy and dynamic force allotment of
clients are clarified unmistakably. The essential standard of NOMA in uplink and downlink is introduced and the proposed NOMA with numerous receiving wires is executed [1]. The NOMA is introduced and power assignment factor is incorporated and the inclusion district for fixed BS is determined [2]. A unique examination of NOMA and the Rayleigh blurring coefficients are determined and another assessment method is proposed with NOMA ghostly productivity [3]. In a different access innovation for subcarrier and a clever utility, capacity is presented, and the non-convexity issue is arranged utilizing a two-venture iterative strategy [4]. The Non-symmetrical various access (NOMA) for 5G organizations is addressed and range proficiency (EE-SE) of NOMA and OFDMA strategies are thought about, the recreated the outcomes concerning energy and range effectiveness [5]. A hypothetical examination of ghostly productivity of shut type of NOMA in Nagakami is proposed and a blurring file is presented [6]. Two distinctive force distribution plans are presented, one depends on channel data, and the other procedure on pre-characterized QoS for every client is presented and the expected addition of NOMA is dissected [7].

In the Non-symmetrical different access (NOMA) that has an ability for a 5G framework is proposed and another helpful NOMA is presented and broke down the blackout likelihood and variety are plotted. Existing NOMA for 5G is contemplated and the current test is recognized as energy utilization and proposed a clever energy-proficient NOMA. Here another sign-based hypothesis is presented in NOMA and a greatly simultaneous NOMA(MC-NOMA) and the channel limit of multi-client MIMO is examined and reproductions are performed.

In power-area multiplexing, various clients are assigned diverse force coefficients as indicated by their divert conditions to accomplish a high framework execution. Specifically, different clients' data signals are superimposed on the transmitter side. On the beneficiary side, progressive obstruction undoing (SIC) is applied for translating the signs individually until the ideal client's sign is acquired, giving a decent compromise between the throughput of the framework and the client's reasonableness. In code-area multiplexing, various clients are assigned various codes and multiplexed throughout a similar time-recurrence asset. Despite the fact that code-space multiplexing can possibly improve unearthly proficiency, it requires a high transmission transfer speed and isn't effectively pertinent to the current frameworks. Then again, power-area multiplexing has a straightforward execution as impressive changes are not needed on the current organizations. Likewise, it doesn't need extra data transmission to work on ghostly productivity.

2. System model

Non-symmetrical different access is arising as a promising innovation for 5G with its prevalent phantom productivity and client decency [8]. We are considering a downlink transmission station (BS) for the two users. User 1 is far/weak as he is far away from the transmitting BS. User 2 is the near/strong users. Let $d_1$ and $d_2$ denote their distances from the Base Station. The BS has two distinct messages $x_1$ to user 1 (far user), and $x_2$ to user 2 (near user). $\alpha_1$ and $\alpha_2$ are the power allocation factors for the far and the near user respectively ($\alpha_1 + \alpha_2 = 1$). In NOMA, to advance client decency, more force is given to the far client and less capacity to close client. The objective is to explain the advantages of NOMA over symmetrical numerous entrance (OMA, for example, OFDMA embraced by Long-Term Evolution (LTE)) [9].

To get the outage probability, we have set the same target rate for both near and far users. It very well may be considered that to be limit is expanded, the blackout likelihood likewise increments on the grounds that the higher the edge esteem, the more will be the odds of the rate falling underneath the edge and more will be blackout likelihood. The correlation between blackout likelihood and SNR of dynamic force portion, the blackout likelihood diminished with an increment in SNR.

In the downlink, the base station communicates the sign for the close to client and the far client.
In our proposed model instate the length of the information. The client information for the all over clients are produced utilizing irregular number age. The transmission is done by BPSK adjustment. The SNR is fixed for information length. The superposition coding is executed in the transmitter to discover the capacity achievable rate for both far user and near user [10]. The AGWN is added for both all over clients. The demodulation is applied to recover the all over client. Gotten client information is again tweaked as x₁ and is changed into a BPSK signal. The assessed yield is demodulated to acquire x₂. The outcomes are investigated by looking at got information and bit blunder rate.

3. NOMA system with Rayleigh Fading Channel
The advancement of remote interchanges and the web of things (IoT), non-symmetrical various access (NOMA) has been considered as one of the successful plans to meet the quickly developing client access necessities and the NOMA system is modeled with the Rayleigh fading channel [11]. 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 h₁ and h₂. h₁ and h₂ are coefficients of standardized complex Gaussian irregular variable with zero mean and difference. A two-client downlink agreeable non-symmetrical different access (NOMA) short-parcel correspondence network is researched in level Rayleigh blurring channels, where a focal client helpfully transfers the signs expected to a phone edge client [12]. The force of the transmitter in the liners scale is estimated and framework transfer speed is determined. The commotion level is additionally set concerning transfer speed. The SNR esteems for the all over client are determined and the reachable objective rates are additionally registered. The blackout likelihood for the comparing objective rate is determined. The graphical outcomes are plotted for Transmitter power Vs Sum Rate as displayed in Figure 1. Far client has a lower limit (i.e., attainable information rate) than close to client, particularly when the communicate power is high. This is on the grounds that the far client performs direct unraveling without eliminating the close to client's information. However, close to client enjoys the benefit of eliminating far user's information utilizing progressive obstruction retraction.

For dynamic power allocation, our only aim is to maximize the sum rate. For sum-rate maximization (SR maximization) the following constraint must be satisfied. When the sum of rates of users 1 and user 2 is greater than or equal to the sum rate and when the channel coefficient of user 1 is greater than the channel coefficient of user 2 then lower power is allocated to the far user (i.e., user 1) and higher power is allocated to near user (i.e., user 2) and the splitting factor gets the values accordingly based on channel coefficients. Similarly, when the channel coefficient of user 2 is greater than the channel coefficient of user 1 then higher power is allocated to the far user (i.e., user 1) and lower power is allocated to the near user (i.e., user 2) and the splitting factor gets the values accordingly based on channel coefficients. For each iteration, the condition checks if the current sum of the individual rates of user 1 and user 2 is greater than or equal to the previously stored sum rate, then the sum rate will get updated. Therefore, at the end of the iteration, the sum rate variable will store the maximum sum rate for the corresponding transmit power.

For optimal power allocation along with sum-rate maximization, we should also ensure user fairness is maintained. For sum-rate maximization along with user fairness, the following constraints must be satisfied. The first condition is to maximize the sum-rate which implies the sum of rates of users 1 and 2 must be greater than or equal to the sum rate and the second condition mentioned is to ensure user fairness which implies that the individual rates of user 1 and user 2 must be greater than or equal to the minimum rate (1 bps/Hz). When these conditions are satisfied then the channel coefficients are checked. So, when the channel coefficient of user 1
is greater than the channel coefficient of user 2 then lower power is allocated to the far user (i.e., user 1), and higher power is allocated to near user (i.e., user 2) and the splitting factor gets the values accordingly based on channel coefficients. Similarly, when the channel coefficient of user 2 is greater than the channel coefficient of user 1 then higher power is allocated to far user (i.e., user 1) and lower power is allocated to the near user (i.e., user 2) and the splitting factor gets the values accordingly based on channel coefficients. Therefore, at the end of the iteration, the sum rate variable will store the maximum sum rate for the corresponding transmit power.

If any of the above conditions fail, let’s say suppose if the sum-rate maximization condition fails, the maximum sum rate will be retained. But if the user fairness condition fails i.e., in some cases the individual rate may be less than 1 bps/Hz. This happens when transmit power is low. So, we will be trying two techniques to maximize the sum-rate only.

1. Dividing the power equally between two users.
2. Dividing the power based on channel condition, i.e., High transmitting power is given to the user with weak channel conditions, and low transmitting power is given to the user with strong channel conditions. Once both the rates fall below 1 bps/Hz, we focus only on maximizing the sum rate as we know that user fairness could not be achieved for very low transmit power. So, using the above two techniques we calculate the sum rate in both cases and adopt the technique that gives the maximum sum rate. It was observed that the maximum sum rate was achieved when power was divided equally between the two users.

![Figure 1. Transmit Power vs Sum Rate characteristics](image-url)
The progressive obstruction crossing out is defective at the numerical degree of useful investigation. Consequently, the proposed NOMA is thinking about the flawed and tracking down the debased execution. SIC is great if the close to client precisely translates the far client's information and deducts it from got information by SIC. At the point when it is flawed, the far client's information isn't totally taken out, and still, the buildup of far client's information is available. We can see that flawed SIC detrimentally affects the information pace of the solid client/the client who performs SIC. Attainable information rate corrupts as SIC blunder increments. The presentation examination of the downlink NOMA (DL-NOMA) framework in presence of progressive obstruction wiping out (SIC) blunder over Rayleigh blurring channels is dealt with productively [13].

4. Dynamic Power allocation in NOMA system
SIC is performed at the base station and the received signal at the BS in the uplink. The received signal at BS is represented as Equation (1).

\[
y = h_r(P_\beta S_1)^{1/2} + h_r(P_\beta S_2)^{1/2}
\]

Likewise, \(w\) is the AWGN with zero mean and fluctuation \(\sigma_2\). Signal \(S_1\) is decoded and the subsequent client signal \(S_2\) is treated as commotion. Then, at that point the beneficiary takes away the decoded from the got signal. Force levels are distinguished as \(P_1 = P_\beta\) and \(P_2 = P_\beta\). The force designation coefficient is \(\alpha = P_1/P_2\) and reaches. The BER for the close to (client 2) is lower when \(\alpha_r < 0.1(\alpha_r > 0.9)\) than when \(\alpha_r = 0.8(\alpha_r = 0.2)\). Anyway, would we be able to pick \(\alpha_r < 0.1\) and \(\alpha_r > 0.9\)? The far (client 1) has extremely high BER in this system. The channel gain can be accomplished by multi-transporter transmission and increments with the number of subcarriers [14]. Assuming we need the two clients to reasonably profit from NOMA, the ideal system to work is \(\alpha_r \in [0.5,1]\) and \(\alpha_r \in [0,0.5]\). This implies an exceptionally huge force is designated to the close to (client 2). Consequently, he has an exceptionally low BER. As \(\alpha_r = 0\) and \(\alpha_r = 1\), the close to (client 2) information is ruling and henceforth, the far (client 1) cannot straightforwardly decipher his sign.

Our reasonable PA offers need to the frail/far client. That is, the force designation coefficients are determined to such an extent that the far client's objective rate is met. The proposed streamlining structure limits the drawn-out time-normal send power use while diminishing the lining delay and ensuring the base time-normal information rates [15]. Solely after gathering the objective pace of far client, all the excess accessible force is apportioned to the close to client. We can quickly see that decent PA is performing ineffectively and its blackout likelihood soaks to constantly when \(R^* > 1.5\). All in all, the collector is consistently in blackout on the off chance that we utilize fixed PA with \(R^* > 1.5\). This is on the grounds that, fixed PA neither adventures the immediate CSI, nor considers the objective rate necessities. In any case, our reasonable PA has lower blackout likelihood Bit Error Rate (BER) result for Binary Phase Shift Keying (BPSK) random power allocation technique and dynamic power allocation technique is shown in Figure 2 and Figure 3 we can observe that near user has slightly higher BER than far user. This is because the near user must decode both the far user's data and its own data correctly. Any error in decoding a far user's data or its own data will impact its BER. That is why near user
experiences higher BER than far user. We can observe that the random power allocation technique gave lower error rates. However, user fairness and maximum sum-rate were achieved in optimal power allocation technique and this wasn’t present in random power allocation techniques. On the grounds that $\alpha_n$ and $\alpha_f$ and progressively changed dependent on track rate necessity and CSI.

![Figure 2. BPSK Random power allocation](image1)

![Figure 3. BPSK Dynamic power allocation](image2)

![Figure 4. QPSK Random power allocation](image3)

![Figure 5. QPSK Dynamic power allocation](image4)

Bit Error Rate (BER) result for Quadrature Phase Shift Keying (QPSK) random power allocation technique and dynamic power allocation is shown in Figure 4 and Figure 5. The error rate for QPSK random power allocation technique was similar to that of the BPSK random power allocation technique. But in QPSK random power allocation technique the BER becomes negligible only for higher SNR values compared to BPSK random power allocation. The error rates for random and optimal power allocation techniques were similar but as in the case of BPSK, the optimal power allocation technique split power between the two users in such a way that the sum-rate was maximized and the rate of neither of the users was allowed to fall below a specified threshold, thus ensuring user fairness. Another common feature in both BPSK and QPSK transmission schemes was that data transmitted with high power was received with lower error rates than the data that was transmitted with low power. It could also be observed that BPSK performs better than QPSK in terms of error rate but QPSK is better in terms of the amount of information transmitted. Hence there is a tradeoff between lower error
rates and higher information rates and we need to choose accordingly.

In the case of random power allocation, when the transmit power is increased gradually, it can be asserted that outage probability decreases. Moreover, the outage probability of a far user is much less when compared to the outage probability of a near user since more power is allotted to the far user than to a near user. In the case of Dynamic power allocation, when the transmit power is increased gradually, it can be observed that the outage probability of both users decreases and overlaps to a certain extent. The outage probability of the far user is only slightly less than the outage probability of the near user since the power allocation is done dynamically using an optimal power allocation algorithm.

In the case of random power allocation, we can observe that when the threshold rate increases gradually the outage probability starts increasing as the number of times the achievable rate falling below the threshold rate increases with an increase in the threshold rate. Except for low threshold rates, both the users seem to follow the same trend. When higher rates are reached, the outage eventually becomes zero for both the users. In the case of Dynamic power allocation, we can observe that the trend is quite different from that of random power allocation. When the threshold rate increases keeping the transmit power constant, the outage probability also increases. For the far user, distance plays an important role so its outage probability is quite high when compared with that of the near user but when compared with random both users fare quite well as in this case the outage never reaches even when the threshold rate is 10 bps/Hz.

5. Conclusion
In this paper, we clarified the unique force assignment strategy for the Non-Orthogonal various access plot. In this manner, the proposed model dissected various parts of NOMA utilizing separate strategies. Henceforth the framework model considers the Rayleigh blurring channel and changing the blurring coefficients. In this manner, the outcome demonstrated the far client has a lower attainable rate than the close to client due to progressive impedance retraction (SIC). In our proposed work, the close to client plays out the flawed SIC abrogation of the sign by taking away the far client information from the got signal. Our paper centers around power designation for NOMA and presented the force assignment factor and limit of the decent force portion. Henceforth our new proposition powerfully dispensing the force for the far client and the objective rate is acquired. By breaking down the Channel State Information, dynamic force allotment not really settled. Dynamic force portion has a lower blackout likelihood than the static force designation technique. Subsequently the feasible rate is changing powerfully by keeping up with the objective rate at the normal worth. Our proposed work is additionally stretched out by thinking about multiple clients.

5.1 Discussion
The essential justification taking on NOMA in 5G owes to its capacity of serving various clients utilizing similar time and recurrence assets. One of the basic procedures utilized here is Power Domain Multiplexing. NOMA takes advantage of superposition coding at the transmitter and progressive impedance dropping (SIC) at the collector, subsequently multiplexing clients in the force space. NOMA is essentially not quite the same as other different access plans which give symmetrical admittance to the clients either on schedule, recurrence, code or space. In NOMA, every client works in a similar band and simultaneously where they are recognized by their force levels. NOMA utilizes
superposition coding at the transmitter to such an extent that the progressive obstruction wiping out (SIC) beneficiary can isolate the clients both in the uplink and in the downlink channels. NOMA can be a reasonable innovation for 5G organizations that can further develop energy proficiency and otherworldly effectiveness beating existing Orthogonal Frequency Multiple entrance strategy (OFDMA) and can oblige a colossal tally of Machine-to-Machine specialized gadgets.

5.2 Future work
A key feature of NOMA is that users with better channel conditions have prior information about the messages of other 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.

References
[1] Khales, FA., Hodtani, GA.: An evaluation of the coverage region for downlink Non-Orthogonal Multiple Access (NOMA) based on Power Allocation Factor. Iran Workshop on Communication and Information Theory, 1-5 (2017).
[2] Sedtheetorn, P., Chulajata, T.: Spectral efficiency evaluation for non-orthogonal multiple access in Rayleigh fading. 18th International Conference on Advanced Communication Technology (ICACT), 747-750 (2016).
[3] Baghani, M., Parsaeefard, S., Derakhshani, M., Saad, W.: Dynamic Non-Orthogonal Multiple Access and Orthogonal Multiple Access in 5G Wireless Networks. IEEE Transactions on Communications, 67(9), 6360-6373 (2019).
[4] Selvam, K., Kumar, K.: Energy and Spectrum Efficiency Trade-off of Non-Orthogonal Multiple Access (NOMA) over OFDMA for Machine-to-Machine Communication. Fifth International Conference on Science Technology Engineering and Mathematics, 523-528 (2019).
[5] Chulajata, T., Sedtheetorn, P.: Theoretical analysis on spectral efficiency of non-orthogonal multiple access in Nakagami fading. IEEE International Conference on Control System, Computing and Engineering, 146-149 (2015).
[6] El-Sayed, MM., Ibrahim, AS., Khairy, MM.: Power allocation strategies for Non-Orthogonal Multiple Access. International Conference on Selected Topics in Mobile & Wireless Networking, 1-6 (2016).
[7] Ding, Z., Peng, M., Poor, HV.: Cooperative Non-Orthogonal Multiple Access in 5G Systems IEEE Communications Letters, 19(8), 1462-1465 (2015).
[8] Selvam, K., Kumar, K.: Green Point Energy-efficient Analysis of Non-Orthogonal Multiple Access (NOMA) over OFDMA. International Conference on Emerging Trends in Information Technology and Engineering, 1-5 (2020).
[9] Benjebbour, A., Saito, Y., Kishiyama, Y., Li, A., Harada, A., Nakamura, T.: Concept and practical considerations of non-orthogonal multiple access (NOMA) for future radio access. International Symposium on Intelligent Signal Processing and Communication Systems, 770-774 (2013).
[10] Stoica, R., De Abreu, GTF., Hara, T., Ishibashi, K.: Massively Concurrent Non-Orthogonal Multiple Access for 5G Networks and Beyond. IEEE Access, 7, 82080-82100 (2019).
[11] Yin Y, Peng Y, Liu M, Yang J, Gui G. Dynamic user grouping-based NOMA over Rayleigh fading channels. IEEE Access. 2019 Aug 9;7:110964-71.
[12] Lai X, Zhang Q, Qin J. Cooperative NOMA short-packet communications in flat Rayleigh fading channels. IEEE Transactions on Vehicular Technology. 2019 Apr 22;68(6):6182-6.
[13] Jain M, Soni S, Sharma N, Rawal D. Performance analysis at far and near user in NOMA
based system in presence of SIC error. AEU-International Journal of Electronics and Communications. 2020 Feb 1;114:152993.

[14] Liu F, Petrova M. Dynamic power allocation for downlink multi-carrier NOMA systems. IEEE Communications Letters. 2018 Jul 3;22(9):1930-3.

[15] Choi M, Kim J, Moon J. Dynamic power allocation and user scheduling for power-efficient and delay-constrained multiple access networks. IEEE Transactions on Wireless Communications. 2019 Jul 26;18(10):4846-58.