This article has been accepted for publication in a future proceedings of this conference, but has not been fully edited. Content may change prior to final publication. Citation information: DOI10.1109/GCWkshps52748.2021.9682080, 2021 IEEE Globecom Workshops (GC Wkshps)

Power Optimization Analysis using Throughput Maximization in MISO Non-Orthogonal Multiple Access System

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***Abstract*— This paper analyzes the power optimization for a downlink multi-input single-output non orthogonal multiple access (MISO-NOMA) system. Power coefficients are optimized in order to maximize the sum throughput of the system users based on the total transmitted power and Quality of service (QoS) constraints. First, we formulate a simple expression for Signal to interference noise ratio (SINR) for each user in MISO-NOMA system, then an analysis for the optimization problem and the considered constraints to prove the concavity of the objective function is presented. Lagrange function and Karush-Kuhn–Tucker (KKT) optimality conditions are utilized to derive the optimal power coefficients. Simulations are conducted and optimization solver is used to investigate the improvement achieved when power coefficients are optimized compared to fixed power scheme. Simulation results are conducted in terms of sum-rate, outage probability, SIC error and users' individual rates. Results revealed that optimized power scheme is more satisfactory than fixed power scheme for far user than near user and both schemes are superior compared to conventional orthogonal multiple access (OMA) scheme.**

***Keywords*—MISO-NOMA, Optimization, KKT conditions, GA solver, SIC error**

I. INTRODUCTION

Conventionally, Orthogonal multiple access (OMA) schemes have been utilized in numerous wireless systems to support each user in a distinct orthogonal resource frame. On the other hand, OMA may not be the best adequate scheme for running vast networks which involve diverse quality of services (QoS) [1]. This may be justified by the restricted degrees of freedom (DoF), where users with high channel gain are given assistance first compared to users with low channel conditions who have to postpone for channel access [2]. In order to attain this demands of DoF and QoS needed for cellular networks, non-orthogonal multiple access (NOMA) supported by practical successive interference cancellation (SIC) at the receiver was appeared as a encouraging multiple access technique for fifth generation (5G) networks. In order to achieve high spectral efficacy and enormous connectivity in 5G, Power domain NOMA (PD-NOMA) is one of the multiple access candidates' schemes, since it deals with signals that have substantial distinction in power levels, so it is designated to split up the high-energy signal at the receiver and then remove it to leave only the intended signal [3]. The incorporation of NOMA and multiple antenna techniques [4] is sufficient to enhance system performance, hence analyzing multiple input single output (MISO) based NOMA system can be supportive towards characterizing the significant reinforcement in the achievable user's data rates. In [5], authors have introduced a closed-form lower bound for the ergodic capacity for downlink MISO-NOMA system. Optimal power assigned to every user is found in order that user rate constraints are fulfilled. In order to determine the maximum number of users such that user-rate constraints are met, an algorithm is derived. Authors concluded that users' number decreases while increasing the minimum rate requirements or raising channel gain gap between users. Clustering and power consumption in a multi-cluster MISO-NOMA system were investigated in [6]. In order to lower the total transmit power, a two-layer user clustering algorithm is proposed to group users into multiple clusters where each cluster contain 2 users. In the first layer, the algorithm is directed in choosing cluster heads according to intensity of the path gains, whereas in the other layer the technique is responsible to couple each cluster head with a tail user. Authors have demonstrated numerical results to validate the effectiveness of the presented clustering algorithm in multi-user MISO-NOMA network. In [7], an iterative power distribution algorithm is considered for a power minimization in a multi-cell MISO-NOMA system. Throughout every iteration, base station (BS) is responsible for updating power transmitted for each user according to the channel status and inter-cell interference plus noise value at user terminals. The algorithm showed performance enhancements and simulation results emphasized that the examined algorithm with MISO-NOMA system can substantially outperform OMA technique based power controlled mechanism. Sum-rate maximization in multi-user MISO-NOMA downlink system based simultaneous wireless information and power transfer (SWIPT) was examined in [8]. Authors introduced a mixture user pairing beamforming procedure where two users with dissimilar channel gains are chosen to accomplish user pairing to augment the realizable sum rate and consequently expand energy harvesting capability. Authors have utilized low- intricacy iterative algorithm, on the basis of sequential convex approximation technique to solve the formulated sum throughput problem which classified as mixed-integer nonconvex optimization problem. Systematic results verified the superiority of the hybrid scheme over the non user-pairing schemes. In [9], under assumption of statistical channel state information (CSI), authors have deduced a closed form formula for outage probability in downlink MISO-NOMA system when two antennas are considered at the base station. Outage formulas have been derived based on PDF and CDF of the distribution ratio for the beamforming. Outage probability was simulated versus several power allocation scenarios to validate the reliability of the outage probability results. In [10], energy efficiency maximization problem for a MISO- NOMA system based clustering is investigated on the basis of non-ideal channel state information, total power transmitted and minimum user rate constraints. In order to transform the resultant non-linear optimization problem into a subtractive form, authors have utilized an iterative algorithm which make use of Taylor series and Dinkelbach's method. Two types of zero forcing (ZF) schemes were also presented to alleviate the inter-cluster interference. Simulation results illustrated that increasing the quantity of clusters will also increase the inter-cluster interference while full-Zero forcing scheme proved to be the best candidate to provide a better performance when energy efficiency is measured.

II. SYSTEM MODEL

In this work, downlink MISO-NOMA system is analyzed, where all users encounter diverse channel gains. In this paper, MISO-NOMA cell is inspected where a single base station with two antennas is considered to serve two users simultaneously on the same resources and each user device has a single antenna. In NOMA system , each user receives the composite signal transmitted from base station (BS) which include targeted and interfering signals transmitted via same time-frequency slot, therefore multiplexing of several signals using diverse power levels is demanding to discriminate signals and to enhance successive interference cancellation (SIC) process at each user's receiver [10]. In downlink NOMA, users that characterized by high channel gain are mostly assigned low power level while users with weak channel gain are given high power portions. For each transmission, we can classify each user according to its distance from BS. We denote the closest user as near user and the farthest one or user at the cell edge is considered as far user. In this work, a Rayleigh fading channel with zero mean is assumed for communication paths between each antenna at the BS and users in the cell. According to that, channel gain for each link can mathematically be represented as $h_{ni}\sim(0,d_{ni}^{-k})$ and $h_{fi}\sim\left(0,d_{fi}^{-k}\right)$, where h_{ni} is the channel gain between i^{th} transmitting antenna at the BS and near user equipment, while h_{fi} is the channel gain between i^{th} transmitting antenna at the BS and far user device [11]. In this paper, k represents the path loss exponent and we assumed that that the distance between each antenna at BS and near user is nearly the same, which implies that $d_{ni}^{-k}\approx d_n^{-k}$, similarly we can assume that the distance between each antenna at BS and far user is nearly the same, which indicate that $d_{fi}^{-k}\approx d_f^{-k}$ [12]. Additive white Gaussian noise (AWGN) power is denoted as σ^2. Without loss of generality, we can assume that $|h_{ni}|^2 > \left|h_{fi}\right|^2$ and channel state information (CSI) is identified. Total transmitted power from BS to users is denoted as P_t. As indicated before, each receiver has the capability to perform SIC to remove signals related to other users with weak channel conditions. Whereas signals from users with strong channel gains cannot be taken away and handled as interference. Each antenna at the base station can transmit the superposition coded signal x which can be written as [7][11]

$$x=\sqrt{P_t}\left(\sqrt{\alpha_f}x_f+\sqrt{\alpha_n}x_n\right) \qquad (1)$$

Where α_f and α_n are the power coefficients for far user and near user respectively, while x_f and x_n represent the desired messages related to far and near user respectively. Therefore, the received signal at far user can be formed as [11]

$$y_f=xh_{f1}+xh_{f2}+z_f \qquad (2)$$

Where h_{f1} is the fading channel between far user and 1st antenna at BS and h_{f2} is the fading channel between far user and 2nd antenna at same BS, while z_f is AWGN noise samples for far user with zero mean and σ^2 variance. Likewise, the signal received at near user can be written as

$$y_n=xh_{n1}+xh_{n2}+z_n \qquad (3)$$

Similarly, h_{n1} and h_{n2} represent the channel links between near user and 1st & 2nd antenna at the BS respectively. Also, here z_n is a another AWGN noise samples for near user with zero mean and σ^2 variance. Since far user is characterized by cell edge with weak channel condition, where his own signal x_f is allocated more power by the base station where $\alpha_f>\alpha_n$. Therefore, far user can directly decode his desired message x_f from received signal y_f, based on treating x_n term as interference. The composite received signal at far user can simply expressed as [11]

$$y_f=\sqrt{P_t}(\sqrt{\alpha_f}x_f+\sqrt{\alpha_n}x_n)(h_{f1}+h_{f2})+z_f$$
$$y_f=\sqrt{P_t\alpha_f}x_f\left(h_{f1}+h_{f2}\right)+\sqrt{P_t\alpha_n}x_n\left(h_{f1}+h_{f2}\right)+z_f \qquad (4)$$

The 1st term in (4) denotes the desired signal for far user , while the 2nd term represents the interference term from near user. Based on (4) The achievable bit rate for far user can be written from as [8][12]

$$R_f=\log_2\left(1+\frac{\left|h_{f1}+h_{f2}\right|^2P_t\alpha_f}{\left|h_{f1}+h_{f2}\right|^2P_t\alpha_n+\sigma^2}\right) \qquad (5)$$

Traditionally, near user has good channel status with each antenna at the BS, hence his signal x_n allocated less power $\alpha_n<\alpha_f$, and the received signal at the near user can be written as

$$y_n=xh_{n1}+xh_{n2}+z_n$$
$$y_n=\sqrt{P_t\alpha_n}x_n(h_{n1}+h_{n2})+\sqrt{P_t\alpha_f}x_f(h_{n1}+h_{n2})+z_n \qquad (6)$$

The 1st term in (6) denotes the near user anticipated signal, while the 2nd term is the interference term from far user. Also, it can be noticed from (6), that the interference term is dominant because of the more power allocated to far user, so at the receiver side of near user, direct decoding for the far user signal x_f must be firstly performed. At near user receive side, the SINR γ_{fn} between far user and near for direct decoding x_f can be written as [12]

$$\gamma_{fn} = \frac{|h_{n1} + h_{n2}|^2 P_t \alpha_f}{|h_{n1} + h_{n2}|^2 P_t \alpha_n + \sigma^2} \tag{7}$$

After SIC, the near user achievable rate to decode its own desired signal x_n can be formed as

$$R_n = \log_2\left(1 + \frac{|h_{n1} + h_{n2}|^2 P_t \alpha_n}{\sigma^2}\right) \tag{8}$$

III. OPTIMIZATION PROBLEM CHARACTERIZATION

In this section, the aim is to maximize the sum throughput based on optimizing the power coefficients for each user according to the inspected channel condition. The sum of the aforementioned achievable rates for the two users in the MISO-NOMA system is

$$R_{sum} = R_n + R_f \tag{9}$$

The constraints and objective function accounted for our optimization problem in this system can be introduced as follows:

1. Total power constraint

The assigned power for every user in the cell is a portion of the total power P_t transmitted from BS, hence the assigned power percentage for every user device must follows [7][11]

$$\sum_{x=1}^{N} \alpha_x \leq 1 \tag{10}$$

where α_x is the power allocation fraction for the x^{th} user in the N-user MISO-NOMA network.

2. Quality of service (QoS) constraint

$$\log_2(1 + \delta_n) \geq R_{min} \tag{11}$$

where R_{min} is the minimum transmission rate and δ_n is the signal to interference noise ratio for n^{th} user.

This condition can be clarified in several ways [12][13], assume we have $R_{m\to k}$ which is the rate of user k to detect the signal of user m where $1 \leq k \leq m$. When user k is not capable to detect the message of user m , this can be denoted as $R_{m\to k} < R_m$. The complement of this event can be written as

$$\frac{|h_k|^2 P_t \alpha_m}{|h_k|^2 P_t \sum_{i=1}^{m-1} \alpha_i + \sigma^2} > (2^{R_m} - 1) \tag{12}$$

Which can be rewritten as

$$|h_k|^2 \rho \left(\alpha_m - (2^{R_m} - 1) \sum_{i=1}^{m-1} \alpha_i\right) > (2^{R_m} - 1) \tag{13}$$

Where ρ now is the signal to noise ratio and R_m is the minimum target rate for m^{th} user.

To realize (13) and avoid that m^{th} user being in outage and can satisfy the minimum rate, the following condition must be satisfied

$$\alpha_m > (2^{R_m} - 1) \sum_{i=1}^{m-1} \alpha_i \tag{14}$$

3. Sum rate Maximization

Based on the above-mentioned constraints in (10) & (11) and sum rate expression and the fact that we have 2 antennas at the base station and single antenna at each user in a cell, the objective function can be generally defined as [13][14]:

$$\max_{\alpha} R_{sum} = \sum_{k=1}^{N} \log_2\left(1 + \frac{|h_{k1} + h_{k2}|^2 P_t \alpha_k}{|h_{k1} + h_{k2}|^2 \sum_{j=1}^{k-1} P_t \alpha_j + \sigma^2}\right) \tag{15}$$

such that

$$\sum_{x=1}^{N} \alpha_x \leq 1 \tag{16}$$

$$\alpha_k \geq 0 \ \forall k = 1,2,\ldots,N \tag{17}$$

$$\log_2(1 + \delta_n) \geq R_{min} \tag{18}$$

IV. CONVEXITY ANALYSIS

In this section, the analysis is restricted to two users (N = 2). The optimization problem for MISO-NOMA system and can be reformulated as follows

$$\max_{\alpha} \quad R_{Sum} = R_n + R_f \tag{19}$$

$$S.t.$$

$$(2^{R_m} - 1) \leq |h_{k1} + h_{k2}|^2 \rho \left(\alpha_m - (2^{R_m} - 1) \sum_{i=1}^{m-1} \alpha_i\right) \tag{20}$$

$$\alpha_n + \alpha_f - 1 \leq 0 \tag{21}$$

$$\alpha_n , \ \alpha_f \geq 0 \tag{22}$$

Where $m = 1,2$. The target rate for far user R_f can be shown as

$$R_f = \log_2\left(1 + \frac{\left|h_{f1} + h_{f2}\right|^2 P_t \alpha_f}{\left|h_{f1} + h_{f2}\right|^2 P_t \alpha_n + \sigma^2}\right) \tag{23}$$

The target rate for near user after SIC R_n can be written as

$$R_n = \log_2\left(1 + \frac{|h_{n1}+h_{n2}|^2 P_t \alpha_n}{\sigma^2}\right) \tag{24}$$

According to the analysis above, and assuming that $R_m = R_f$ the constraints can be represented as follows:

$$C_1(\alpha) = (2^{R_f} - 1) - \rho |h_{k1} + h_{k2}|^2 \left(\alpha_f - (2^{R_f} - 1)\alpha_n\right) \tag{25}$$

$$C_2(\alpha) = \alpha_n + \alpha_f - 1 \tag{26}$$

Since both $C_1(\alpha)$ & $C_2(\alpha)$ are linear in terms of α , then $C_1(\alpha)$ & $C_2(\alpha)$ are convex. The objective function in (15) is considered as nonlinear optimization problem, hence we need to find $\frac{\partial R_{Sum}}{\partial \alpha_i}$ and $\frac{\partial^2 R_{Sum}}{\partial \alpha_i^2}$ to prove if the objective function either convex or concave. After some mathematical handlings, we can derive a general formula for the first derivative for the objective function in (15) terms of α as follows:

$$\frac{\partial R_{Sum}}{\partial \alpha_i} = \frac{1}{ln2}\left(\frac{|h_{i1}+h_{i2}|^2 P_t}{|h_{i1}+h_{i2}|^2 P_t \sum_{j=1}^{i}\alpha_j + \sigma^2}\right)$$

$$-\frac{1}{ln2}\sum_{k=1}^{N-i}\left\{\left(\frac{\left(\left|h_{(i+k)1}+h_{(i+k)2}\right|^2 P_t\right)^2 \alpha_{i+k}}{\left(\left|h_{(i+k)1}+h_{(i+k)2}\right|^2 P_t \sum_{j=1}^{i+k}\alpha_j + \sigma^2\right)}\right)\times \left(\frac{1}{\left(\left|h_{(i+k)1}+h_{(i+k)2}\right|^2 P_t \sum_{j=1}^{i+k-1}\alpha_j + \sigma^2\right)}\right)\right\} \tag{27}$$

Also, the second derivative for objective function in terms of α_n and α_f can be formulated as follows:

$$\frac{\partial^2 R_{Sum}}{\partial \alpha_n^2} = -\frac{1}{ln2}\left\{\left(\frac{(|h_{n1}+h_{n2}|^2 P_t)^2}{(|h_{n1}+h_{n2}|^2 P_t \alpha_n + \sigma^2)^2}\right) - \left(\frac{\left(\left|h_{f1}+h_{f2}\right|^2 P_t\right)^3 \alpha_f \left[2\left(\left|h_{f1}+h_{f2}\right|^2 P_t \alpha_n + \sigma^2\right) + \left|h_{f1}+h_{f2}\right|^2 P_t \alpha_f\right]}{\left(\left|h_{f1}+h_{f2}\right|^2 P_t(\alpha_n+\alpha_f) + \sigma^2\right)^2 \left(\left|h_{f1}+h_{f2}\right|^2 P_t(\alpha_n) + \sigma^2\right)^2}\right)\right\} \tag{28}$$

$$\frac{\partial^2 R_{Sum}}{\partial \alpha_f^2} = -\frac{1}{ln2}\left\{\left(\frac{\left(\left|h_{f1}+h_{f2}\right|^2 P_t\right)^2}{\left(\left|h_{f1}+h_{f2}\right|^2 P_t(\alpha_n+\alpha_f) + \sigma^2\right)^2}\right)\right\} \tag{29}$$

Instead of using a Hessian matrix to prove that the objective function is convex or concave, and since our objective function is function of two variables we can apply and check the following conditions [16]

$$\frac{\partial^2 R_{Sum}}{\partial \alpha_n^2} < 0 \tag{30}$$

$$\frac{\partial^2 R_{Sum}}{\partial \alpha_f^2} < 0 \tag{31}$$

$$\left(\frac{\partial^2 R_{Sum}}{\partial \alpha_n^2}\frac{\partial^2 R_{Sum}}{\partial \alpha_f^2} - \left(\frac{\partial^2 R_{Sum}}{\partial \alpha_n \partial \alpha_f}\right)^2\right) > 0 \tag{32}$$

Based on our objective function and after some mathematical simplifications the above conditions (30)(31)(32) have been verified and consequently the objective function is strictly concave and has a unique global maximum.

Lagrange function and the KKT necessary conditions can be applied to obtain optimum power coefficients [16][17]:

$$\mathcal{L}(\alpha_n, \alpha_f, \mu_1, \mu_2) = R_{Sum} - \mu_1 C_1(\alpha) - \mu_2 C_2(\alpha) \tag{33}$$

where μ_1 & μ_{1_2} are Lagrange multipliers.

- Optimality condition can be formulated as follows:

$$\frac{\partial R_{Sum}}{\partial \alpha_f} - \mu_1 \frac{\partial C_1(\alpha)}{\partial \alpha_f} - \mu_2 \frac{\partial C_2(\alpha)}{\partial \alpha_f} = 0 \tag{34}$$

$$\frac{\partial R_{Sum}}{\partial \alpha_n} - \mu_1 \frac{\partial C_1(\alpha)}{\partial \alpha_n} - \mu_2 \frac{\partial C_2(\alpha)}{\partial \alpha_n} = 0 \tag{35}$$

- slackness conditions can be represented as follows

$$\mu_1\left((2^{R_f}-1) - \rho|h_{k1}+h_{k2}|^2\left(\alpha_f - (2^{R_f}-1)\alpha_n\right)\right) = 0 \tag{36}$$

$$\mu_2(\alpha_n + \alpha_f - 1) = 0 \tag{37}$$

- Lagrange multipliers need to satisfy the following

$$\mu_1 \geq 0,\ \mu_2 \geq 0 \tag{38}$$

In the following steps, the Lagrange multipliers μ_1 & μ_2 should be proved to be positive. After performing the derivative, both (34) & (35) can be written as

$$\frac{\partial R_{Sum}}{\partial \alpha_f} + \mu_1 \rho |h_{k1}+h_{k2}|^2 - \mu_2 = 0 \tag{39}$$

$$\frac{\partial R_{Sum}}{\partial \alpha_n} - \mu_1 \rho |h_{k1}+h_{k2}|^2 (2^{R_f}-1) - \mu_2 = 0 \tag{40}$$

From (39) μ_1 & μ_2 and be related as follow

$$\frac{\partial R_{Sum}}{\partial \alpha_f} + \mu_1 \rho |h_{k1}+h_{k2}|^2 = \mu_2 \tag{41}$$

substitute (41) in (40)

$$\frac{\partial R_{Sum}}{\partial \alpha_n} - \mu_1 \rho |h_{k1}+h_{k2}|^2 (2^{R_f}-1) - \left(\frac{\partial R_{Sum}}{\partial \alpha_f} + \mu_1 \rho |h_{k1}+h_{k2}|^2\right) = 0$$

$$\frac{\partial R_{Sum}}{\partial \alpha_n} - \frac{\partial R_{Sum}}{\partial \alpha_f} = \mu_1 \rho |h_{k1}+h_{k2}|^2 2^{R_f} \tag{42}$$

Based on the aforementioned assumption in the system model that $|h_{ni}|^2 > \left|h_{fi}\right|^2$, and based on the derived formula $\frac{\partial R_{Sum}}{\partial \alpha_i}$ and after some mathematical simplifications, the left-hand side of (42) can be easily proved to be positive. Therefore, the right-hand side of (42) $\mu_1 \rho |h_{k1}+h_{k2}|^2 2^{R_f}$ must be also positive and since $\rho|h_{k1}+h_{k2}|^2$ is larger than zero and 2^{R_f} is a positive constant, this implies that $\mu_1 > 0$. Also, we need to check the sign of μ_2 and this can be easily deduced as follows: it is clearly shown from (27) that $\frac{\partial R_{Sum}}{\partial \alpha_f}$ is positive and since μ_1 has verified to be positive and $\rho|h_{k1}+h_{k2}|^2$ is positive by inspection, hence this concludes that $\mu_2 > 0$. Now both μ_1 & μ_2 has been proved to be positive, so the examined constraints are feasible [16][17] and the closed form expressions for α_n & α_f can be deduced from the slackness conditions as follows:

$$\alpha_n = \left(\frac{\rho|h_{n1}+h_{n2}|^2 - (2^{R_f}-1)}{\left(2^{R_f}\right)\rho|h_{n1}+h_{n2}|^2}\right) \tag{43}$$

$$\alpha_f = 1 - \alpha_n = 1 - \left(\frac{\rho|h_{n1}+h_{n2}|^2 - (2^{R_f}-1)}{\left(2^{R_f}\right)\rho|h_{n1}+h_{n2}|^2}\right) \tag{44}$$

V. SIMULATION RESULTS

In this section, system simulation is implemented to evaluate the effectiveness of embedding the proposed optimized scheme in MISO- NOMA compared to the fixed power allocation (FPA) scheme in a single cell. Simulation environment is mainly comprised of single base station (BS) with 2 antennas serving two users each has one receiving antenna and simulation has conducted over 10^5 random channel generations. In fixed power allocation (FPA) scheme we set $\alpha_n = 0.25$ while $\alpha_f = 0.75$. The links among each user and the antennas at BS is implemented as small scale fading with Rayleigh distribution, which is flat through each transmission time slot and varies in next time slots, independently. The path loss exponent is assumed 4 and the transmitted signals are modulated using binary phase shift keying (BPSK). The applied transmitted power is varying from -10 to 40 dBm according to examined metric. The system bandwidth is B = 1 MHz, the noise spectral density $N_0 = -174$ dBm and R_{min} is chosen as 3 bps/Hz. Genetic algorithm (GA) solver is used to resolve the formulated objective function after inequality constraints matrix and upper and lower bounds are defined. Power allocation coefficients are calculated using interior point method. The interior point method is used as a standard optimization technique for solving non-linear problem, which solves it iteratively to obtain power factors [18]. MISO system based TDMA is used as a conventional OMA scheme for benchmark comparison.

In Fig.1, Simulation results for MISO-NOMA based power optimization scheme are compared to MISO-OMA in terms of achievable sum rate versus transmitted power. It is clearly noticed that the sum-rate for the MISO-NOMA using GA optimizer shows superiority over MISO-OMA scenario with 12 dB approximately. It can be emphasized that increasing number of antennas at BS in NOMA system-based power optimization has substantial effect in boosting the sum rate compared to OMA scenario.

Fig. 2 demonstrates the outage probability versus transmitted power for far user (FU) and near user (NU) for both MISO-NOMA and MISO-OMA cellular systems. Far user (FU) results indicate an improvement with almost 2dB in outage probability when GA solver is applied compared to NOMA system with fixed power allocation (FPA) scenario. On the other hand, near user (NU) with fixed power allocation (FPA) scheme shows little outage enhancement compared to optimized scenario. This might be justified that both the good channel gain with FPA coefficients are more efficient for near user than optimized scheme. Also, it is worth mentioning that MISO-NOMA system for either FPA scheme or GA optimized scenario is demonstrating better outage probability compared to MISO-OMA for both far and near users.

In Fig. 3, the individual user's rates are simulated versus transmitted power for MISO-NOMA & MISO-OMA systems. For near user (NU) case, both NOMA-GA optimization and NOMA-FPA are always outperforms OMA system for the whole range of power applied. On the other hand, for far user (FU) scenario, it can be noticed that the rate of improvement in bit rate in case MISO-OMA is more satisfactory than MISO-NOMA for high power values. This might be interpreted that increasing signal to noise ratio not always sufficient to attain higher rate for cell edge user with weak channel conditions.

In Fig. 4, simulation results verify the superiority of the NOMA technique either for optimized or fixed power allocation over the OMA technique in terms of the achieved capacity of near user when SIC error is generated by approximately10^{-2}. In this scenario, NOMA fixed power scheme is showing a significant enhancement in near user capacity by at least 3b/s/Hz compared to OMA system. On the Other hand, NOMA based fixed power allocation is showing a noticeable improvement for near user rate compared to optimized scheme. This justify our previous results in fig. 2 and fig. 3 where near user in NOMA system with fixed power coefficients is presenting a little enhancement over the optimized power factors especially when minimum transmission rate R_{min} in the system is increased.

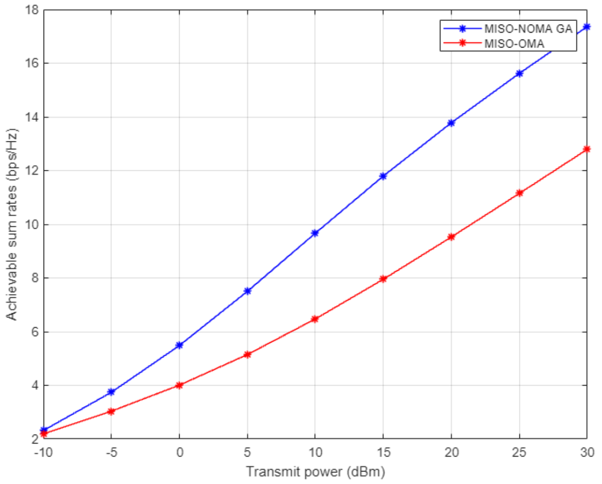

Fig. 1 Sum-rate vs Power for optimized MISO-NOMA and MISO-OMA

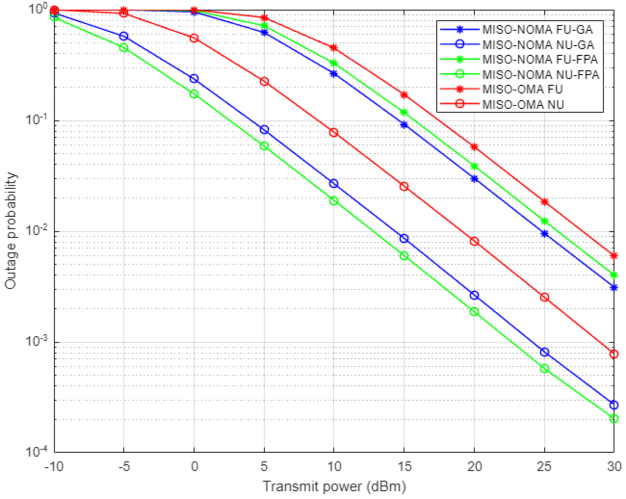

Fig. 2 Outage probability vs Power for MISO-NOMA (optimized & FPA) and MISO-OMA.

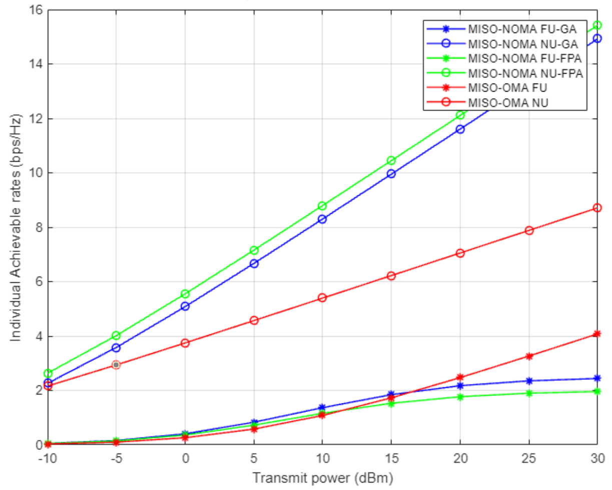

Fig. 3 Individual rates vs Power for MISO-NOMA (optimized & FPA) and MISO-OMA.

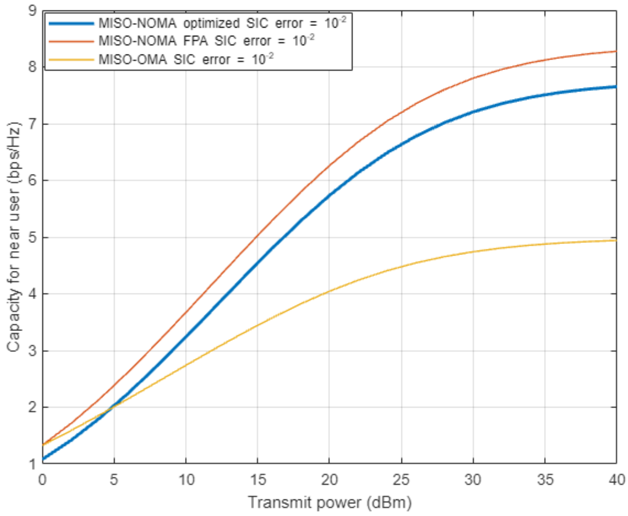

Fig. 4 Capacity for near user vs Power for MISO-NOMA (optimized & FPA) and MISO-OMA based SIC error

VI. CONCLUSION

A downlink MISO-NOMA system is analyzed based on sum-throughput maximization problem with respect to the constraints of total transmitted power budget and minimum transmission rate. In this work we have introduced an elaborated and structured mathematical analysis to demonstrate that the objective function is concave, then, Lagrange function and KKT optimality conditions are applied to derive a simple formula for optimal power coefficients for 2 users in MISO-NOMA network. Genetic algorithm (GA) solver with interior point method has adopted to solve the optimization problem. Different system metrics are utilized such as sum rate, outage probability and SIC error to investigate the enhancement achieved based on the optimized power factors. Simulation results emphasized that MISO-NOMA with optimized power scheme can provide superior sum rate and capacity compared to MISO-OMA. In terms of SIC error and outage probability, results for NOMA near user based fixed power allocation indicated little improvement compared optimized scheme, which implies that channel gain is more sufficient for near user than the allocated power.

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