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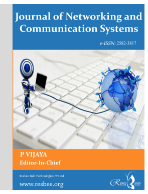

Power Allocation in MIMO-NOMA System using Improved CCS and PSO Algorithm

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Abstract: In the multiple access issues, Non-Orthogonal Multiple Access (NOMA) obtains a hopeful solution and accomplishes the 5G networks requirements by intensification the QoS, such as enormous connectivity and energy effectiveness. Therefore, the Non-Orthogonal Multiple Access is expanded with the Multiple Input Multiple Output (MIMO) system to attain the power allocation of multiple users with the layered transmission. By exploiting the adopted Improved Chaotic Crow search (CCS)-and Particle Swarm Optimization (PSO) approach called Improved CCS-PSO, the optimal power allocation with the layered transmission is performed by the MIMO-NOMA system. In the MIMO-NOMA system, the developed optimization approach is obtained by utmost sum rate by power allocation at multiple layers of users. In addition, exploiting the CSI derives the closed-form expression for the average sum rate at the transmitter side. The Channel State Information (CSI) permits users to assign powers at multiple layers to improve the average sum rate. The adopted optimal power allocation approach performance is shown via the minimum Bit Error Rate (BER) and enhanced energy, spectral power, and attainable rate.

Keywords: BER, CSI, NOMA, MIMO, Power Allocation.

Nomenclature

Abbreviations	Descriptions
5G	fifth generation
NOMA	Non-Orthogonal Multiple Access
CCS	Chaotic Crow search
PA	Power Allocation
SIC	Successive Interference Cancellation
DK	Dinkelback method
BER	Bit Error Rate
PSO	Particle Swarm Optimization
MIMO	Multiple Input Multiple Output
KKT	Karush-kuhn-Tucker
BS	Base Station
OMA	Orthogonal Multiple Accesses
WS	Weighted Sum
SQP	Sequential Quadratic Programming
CSI	Channel State Information
SWIPT	Simultaneous Wireless Information and Power Transfer
QoS	Quality of Service
LEDs	Light-Emitting Diodes
VLC	Visible Light Communication
HC	Hill Climbing
SE	Spectrum Efficiency
MOO	Multi-Objective
NLP	Nonlinear Programming
NLGRPA	Normalized Logarithmic Gain Ratio Power Allocation
DL	down-link
EE	Energy Efficiency
SIC	Successive Interference Cancellation

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1. Introduction

Data traffic is exponentially growing in arising of the high growth of communication technologies. In 2030, it is highly expected the data traffic will be reduced 10 times than in 2020. There is an imperative requirement for novel technologies to raise the communication systems throughput in face of present circumstances of scarce spectrum resources. The NOMA can create superior exploitation of the spectrum resources with the evolution of the OMA as the 5G candidate technology. In order to differentiate the signals, the NOMA uses the diverse among signals as well as a channel that can be multiplexed using the multiple signals. Using SIC, interference in superimposed signals can be evaded in the receiving end. Many studies exhibit high diverse among the signals channel gains at the transmitting end. Most studies mainly concentrated on the NOMA regarding user matching as well as power allocation and the main contribution is to frequently enhance the fairness of user, energy effectuality as well as energy effectuality.

In NOMA, the MIMO application is highly effective due to the exploitation of the MIMO approach which presents a minimum error rate as well as maximum data rate via the spatial diversity as well as multiplexing gain correspondingly. For downlink as well as uplink a new MIMO-NOMA model transmission uses the idea of signal alignment. A novel MIMO-NIMO uplink the implementation model with the cancellation of the group interference is exhibited in the studies which to be highly superior strategies that the OMA transmission as well as alignment of the signal [12]. In some studies, it was exhibited analytically and via experimentations the MIMO-NOMA betterment with the existing OMA-based MIMO system regarding the sum of channel ability as well as in correspondent with the summation of ergodic capacity [11]. In addition, the ergodic capacity maximization of the MIMO-NOMA system with limitation of utmost transmitted power as well as least rate of the feebler user was developed by exhibiting its betterment with existing MIMO-NOMA. In MIMO-NOMA systems in order to abandon inter-cluster interference, a linear beamforming approach was proposed for the inter-cluster as well as intra-cluster PA to increase the entire ability of the cell, and a dynamic PA solution was developed. Using the linear optimization model the total power utilization was minimized by mobile users grouping was examined to integrate optimized beam forming vectors as well as coefficients of energy allocation for a MIMO-NOMA cluster [9]. In the NOMA system, a significant manner of using the MIMO approach was taken into consideration therefore a novel idea of pre-coding, as well as recognition of matrices for MIMO-NOMA systems as well as its performance, was verified [2]. The NOMA system is very useful for the reason of enhancing the performance of the system which needs to be integrated with several technologies such as deep learning [14] [15], device-to-device as well as cognitive radio.

The major objective of this paper is to introduce an optimization approach that obtains the utmost sum rate in the MIMO-NOMA system by allocating powers to users at multiple layers. In addition, by exploiting the CSI which exists at the transmitter side, the closed-form expression is derived. Moreover, this optimization Improved CCS-PSO approach is exploited to improve the utmost average sum rate.

2. Related Works

In 2020, Yin Lu et al [1], developed a minimum complexity user matching as well as allocation of power model. Initially, users by means of higher channel correlations were coordinated as well as the residual users were coordinated regarding the channel difference. Moreover, the objective model was formed to increase the throughput of a system when promising QoS users. Ultimately, in the KKT by means of the objective model circumstances being resolved the power allocation metrics were attained. The experimentation outcomes specify the adopted model possess a benefit over the existing MIMO-NOMA model.

In 2021, Mujtaba Ghous et al [2], worked on the cell edge user performance analysis with equalizer design as well as precoder in a two-user supportive MIMO-NOMA system. In the MIMO-NIMO system, the data rate equality, as well as superior performance of cell edge user, was important problems, therefore this paper develops a method to reform the problem. Finally, the power allocation coefficients were updated with the aid of beamformers by using the SWIPT protocol. Specifically, a user at the cell-center act as an important role to aid the cell edge user as well as relay operation which was powered by a hybrid power dividing SWIPT protocol. Therefore, the signal to interference and Noise ratio downlink MIMO-NOMA system was formulated by taking into consideration of diverse correlation matrics regarding the indefinite eigenvalues.

In 2021, Jaime L. Jacob et al [3], worked on power proportion allocation for each user in DL MIMO NOMA systems. SIC approach was developed to get better users' signals by means of utmost differences among channel gains. In the developed optimization model, at first, the least total power, as well as power proportion factor for each active user was attained. Subsequent to this, the utmost system EE, total power equivalent data rate, and power-proportion distribution beside users, as well as clusters, was ascertained in particular circuitry power utilization.

In 2021, Jaime L. Jacob et al [4], investigated the trade-off among EE and SE in DL MIMO NOMA systems in equivalent-rate constraint. The utmost fairness of NOMA-MIMO system was obtained while it was ensured similar data rate for all active users in system. The trade-off of SE-EE was devised as a MOO issue. The optimization issue was resolved by exploiting mainly ∊-Constraint (∊-C) scalarization approach integrated by means of NLP approaches, as SQP and DK approaches. The adopted iterative-analytical ∊-C-SQP, as well as ∊-C-DK techniques, was capable to attain the best EE-SE solutions at the Pareto frontier.

In 2020, Heran Wang et al [5], worked on the enhancement of the attainable summation rate of indoor NOMA to help MIMO VLC downlink networks. Here, an effectual minimum computational complexity power allocation scheme called NLGRPA was developed, in that optical channel information of each and every transmitter LEDs was used as well as correctly ordered to assure competent power allocation.

3. System and Power Model

In this section, the MIMO-NOMA system model is discussed by exploiting the layered transmission model [11]. The BS in the MIMO-NOMA system maintains 2 users to exploit the similar time slot as well as frequency band by exploiting the NOMA in the downlink transmissions. The BS is linked to E count of antennas so that each user in the BS is linked to A count of antennas. Assume that user-1 is available considering BS, wherein user-2 is adequately despite BS, as cell edge user). M_i indicates the chancel matrix that is computed from the BS to the user i. c_i represents for user i signal vector with the size $[A \times 1]$. In order to exploit the coded series the signal vector c_i is modeled. Hence, $\{c_i(e)\}$ indicates the coded series, wherein $c_i(e)$ represents e^{th} signal vector. For our expedient, the time index e was eradicated. The signal vector received by the user i is indicated as,

$$a_i = M_i(c_1 + c_2) + b_i,\ i \in \{1,2\} \tag{1}$$

wherein, $b_i \sim F(0, E_o G)$ represents the background noise vector for the user i. Because of higher-scale fading, the magnitude of M_1 element is higher than magnitude of M_2 element. Therefore, power allocated to user1 is lesser than power allocated with user2. Suppose that $X[c_i] = 0$. The power level, as well as power difference, is exploited in the transmission of NOMA to improve spectral efficiency. At user1 c_2 is decoded as it possesses utmost transmission power. The acquired signal subsequent to receiving c_2 via SIC is indicated as,

$$\overline{a_1} = M_1 c_1 + b_1 \tag{2}$$

At user 1, power of c_1 is lesser than the power of c_2, therefore c_2 is decoded. Basically, the BS possess large count of antennas than the user, $E > A$. So that, by exploiting the precoding matrix, the BS is precoded with the size of $[E \times A]$, that is indicated as, K. Therefore, the effectual channel matrix is represented as, $M_i K$ with the size of $[A \times A]$ the matrix. Suppose that $E = A$, and M_i represents a composite channel matrix. The users are divided into diverse subgroups by exploiting the power difference of the channel correlation as well as users. In the layered transmission model, each and every user carries sequence by sequence decoding via SIC. Therefore, user decoding complexity is lesser in the layered transmission model. For MIMO detection, the layered transmission model does not exploit any joint however it exploits the power allocation to raise the attainable rate. $c_{j;i}$ indicates the j^{th} element of c_i. The $\{c_{j;i}(e)\}$ represents the channel sequence of the j^{th} channel encoder. At each layer, symbol sequence is independently decoded. Eq. (3) represents the CT factorization for M_i, wherein, T_i denotes upper triangular matrix with the dimension of $[A \times A]$ C_i implies $A \times A$ orthogonal matrix.

$$M_i = C_i T_i \tag{3}$$

$$p_i = C_i^M a_i \tag{4}$$

$$p_i = T_i(c_1 + c_2) + \overline{b_i} \tag{5}$$

wherein, $\overline{b_i} = C_i^M b_i$. Thus, a layer j, the element p_i is stated in eq. (6). $\tilde{b}_{j;i}$ specifies j^{th} element of $\tilde{b}_i$ $d_{j,g;i}$ specifies $(j,g)^{th}$ element of T_i.

$$p_{j;i} = \sum_{g=j}^{A} d_{j,g;i}\left(c_{j;1} + c_{j;2}\right) + \tilde{b}_{j;i} \tag{6}$$

Eq. (6) represents the standard formulation for the element p_i at layer j so that the standard formulation is enhanced by exploiting the coefficient of power allocation as stated in eq. (7). By augmenting the coefficient of power allocation of each layer, ensued element is stated in eq. (7), β_j specifies the coefficient of power allocation.

$$p_{j;i} = \sum_{g=j}^{A} .\beta_j \left[d_{j,g;i}\left(c_{j;1} + c_{j;2}\right) + \tilde{b}_{j;i}\right] \tag{7}$$

In the MIMO-NOMA system, power allocation is carried out with a layered transmission model. The coded sequence is forwarded at a coherence time in the block fading channels. Consider, $\lambda_j = \left|d_{j,j;1}\right|^2$ and $\delta_j = \left|d_{j,j;2}\right|^2$. Moreover, signal powers are represented as $B_j = X\left[\left|c_{j;1}\right|^2\right]$ and $C_j = X\left[\left|c_{j;2}\right|^2\right]$. Here, $X\left[\left|\tilde{b}_{j;i}\right|^2\right] = E_0 = 1$ for normalization purposes.

$$f_j = \min\{\lambda_j, \delta_j\} \tag{8}$$

Hence, eq. (9) represents the attainable sum rate and eq. (10) indicates the coefficient of power allocation. Therefore, the eq. (11) and (12) represent the adopted attainable sum rate.

$$Y(B_1, C_1, \ldots\ldots B_A, C_A) = \sum_{j=1}^{A} \log_2\left(1 + \frac{f_j C_j}{f_j B_j + 1}\right) + \log_2\left(1 + \lambda_j B_j\right) \tag{9}$$

$$\beta_j = \beta_{max} \sum_{g=1}^{j} \lambda_g \qquad 10)$$

$$Y = \left[\sum_{j=1}^{A} \log_2\left(1 + \frac{f_j C_j}{f_j B_j + 1}\right) + \log_2\left(1 + \lambda_j B_j\right) + \beta_j\right] \tag{11}$$

$$Y = \left[\sum_{j=1}^{A} \log_2\left(1 + \frac{f_j C_j}{f_j B_j + 1}\right) + \log_2\left(1 + \lambda_j B_j\right) + \beta_{max} \sum_{g=1}^{j} \lambda_g\right] \tag{12}$$

$\left[\underset{B,C,\beta}{\mathrm{Max}}.Y\right]$ represents maximum power allocation of each layer; $B, C \in x$, wherein, c represents a coded sequence of a user in every layer. Therefore, eq. (9) represents the standard sum rate and the eq. (12) indicates the adopted attainable sum rate.

4. Power Allocation using an Improved CCS-PSO Model

In this section, the adopted model for power allocation with a layered transmission model is discussed. The major contribution of the adopted approach is to carry out the power allocation in an optimal manner via the maximization of the attainable rate at each layer. Nevertheless, it assigns power to the user with utmost effectuality in a layered transmission model. By exploiting the CSI available at the transmitter side the closed-form expression is modeled. The CSI permits users to effectually assign powers to diverse layers in a layered transmission model. Fig. 1 demonstrates the schematic model of the adopted Improved CCS-PSO approach in the MIMO-NOMA system.

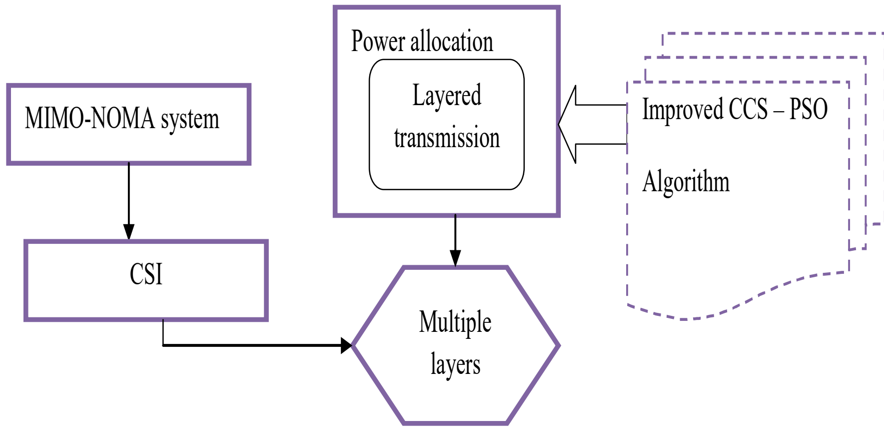


Fig.1. *Schematic model of the adopted Improved CCS-PSO approach in MIMO-NOMA system.*

a) Fitness Function

By exploiting the utmost attainable sum rate the fitness model is calculated. The utmost fitness value starts with the effectual allocation of the powers at diverse layers. The CSI available on the transmitter side is exploited to the model expression of closed form. On the transmitter side, the CSI present is exploited to model the expression of the closed form. In order to resolve the complexity to allocate powers in the MIMO-NOMA system, the proposed optimization Improved CCS-PSO model is presented with a layered transmission model to raise the sum rate. On basis of utmost attainable, this is stated in the eq. (12).

b) Proposed Model

In this paper, the proposed improved CCS-PSO model is exploited [8], the amalgamation of the concepts stated in the binary PSO as well as binary CSA approaches are integrated that ensued into a method that can the increase from their combination, in the improved CCS-PSO model, merely targeting a few chosen crows with optimal foods improves performance of arbitrarily pursuing each crow in conventional CSA.

Subsequently, the technique of OBL is used to produce opposite locations of crows as well as exploited to update locations in PSO. This is performed therefore that both approaches can alternately discover search space and not be influenced by consequences generated from each other. In both CSA and PSO one more enhancement is the substitute of the arbitrary variables by chaotic series with 0.7 as primary value.

a. Logistics map : $$q_i^{t+1} = a q_i^t \left(1 - q_i^t\right),\ a = 0.4;\ \ q_i = 0.7 \tag{13}$$

b. Exponential map: $$q_i^{t+1} = q_i^t e^{2\left(1 - q_i^t\right)}\ \ a = 0.4;\ \ q_1 = 0.7 \tag{14}$$

$$C_{t+1} = k * q_i^{t+1} \tag{15}$$

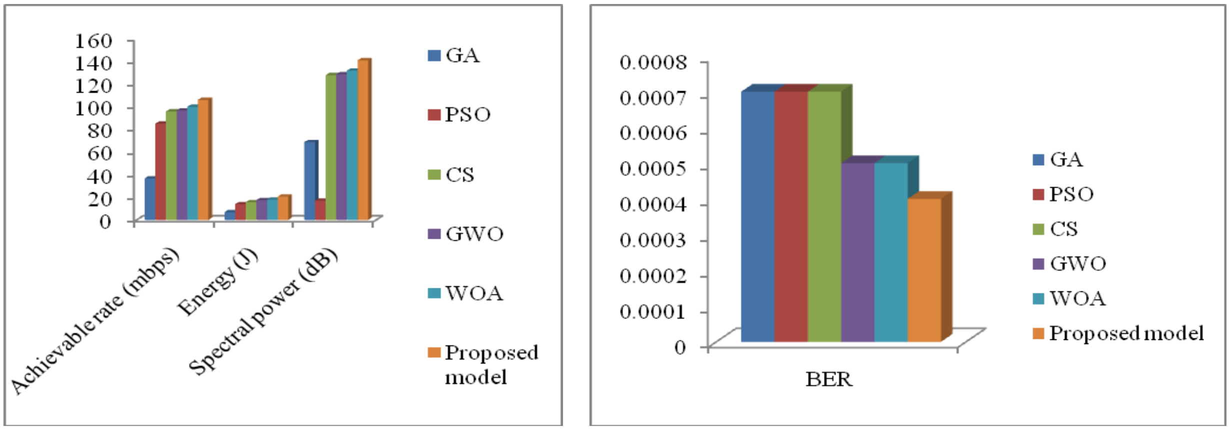
k being an energetic parameter that rules action of q_i^t. While *k step up,* q_i^t passes via the bifurcations, at last leads to chaos.

Furthermore, the improvement of CSA includes exploiting the "tan transformation function (V-shaped) to change agents from a continuous form to binary form" [11] as stated in Eq. (15). If a particular arbitrary count is lesser than this threshold value, present solutions will be altered as well as crow will switch to novel solution ground.

$$V_{shape} = \left| \frac{2}{\pi} \arctan\left(\frac{\pi}{2} q_i^t\right) \right| \tag{16}$$

5. Result and Discussion

The analysis of adopted as well as existing techniques regarding power allocation in the MIMO-NOMA system was described in this section. Here, analysis on basis of evaluation parameters like energy, BER, available rate, as well as Spectral power was described.



(a) (b)

Fig.2. *Analysis of the adopted techniques with the existing techniques*

Fig.2 exhibits a performance analysis of the developed model regarding conventional models on the basis of the 128 transmitting conversation antennas. The performance analysis clearly evident that the rising SNR, and also raises the energy, achievable rate, and spectral power but minimizes the BER.

6. Conclusion

In order to effectually allocate the powers in the MIMO-NOMA system, an adopted model was proposed. In the 5G network, the energy effectuality issue was reinforced by exploiting the adopted model as well as assigning the power effectuality for the MIMO-NOMA system. The performance analysis of the adopted Improved CCS-PSO model was experimented with by exploiting the measures such as a number of admitted users as well as energy. Finally, the adopted optimization approach was evaluated with the conventional models that highly establish minimum BER as well as improved energy, attainable rate as well as spectral power. The attained results evidently demonstrate that the adopted model was better than the conventional models with respect to the optimal power allocation in different layers.

Compliance with Ethical Standards

Conflicts of interest: Authors declared that they have no conflict of interest.

Human participants: The conducted research follows the ethical standards and the authors ensured that they have not conducted any studies with human participants or animals.

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