Power Allocation in Cooperative NOMA MU-MIMO Beamforming Based on Maximal SLR Precoding for 5G

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Abstract — Cooperative Non-orthogonal multiple access (NOMA) is an effective solution to prevent the degradation in performance of the far users, by allocating less power to users with better channel conditions. The challenge for the base station is to decide how to allocate the power among the individual information waveforms, so we proposed cooperative NOMA in downlink MU-MIMO beamforming based on the signal to leakage ratio (SLR), to achieve power domain between the superposition users signal. We aim to minimize the total transmit power by exploiting the solution of the maximal signal to leakage ratio (maximal-SLR) for each user to find the minimum transmit power per user. sequentially, the best user's channel will assigned in the first-time slot channel because there is a better channel for each user when the precoder with less transmits power. Order Successive Interference Cancellation (OSIC) and Maximum-likelihood (ML) estimator method are employed at the receiver. Rician fading channels are considered as second-time slot channel. Bit error rate (BER) performance evaluations show that the minimizing the total transmitted power in cooperative NOMA beamforming based on maximal-SLR scheme (MinP-NOMA-MaxSLR) (proposed scheme) is outperforming cooperative NOMA beamforming based maximal-SLR (NOMA-MaxSLR).

Index Terms—NOMA, Beamforming, signal-to-leakage ratio, cooperative NOMA, OSIC.

I. Introduction

Multiple accesses in 5G mobile networks is a developing research topic since it is significant for the next generation network to possess step with the growth of mobile data and multimedia traffic [1]. Non-orthogonal multiple access (NOMA) has an active solution and attention as a promising candidate for 5G multiple access [2]. The benefit of the NOMA idea is the ability to squeeze the user with better channel conditions into a channel that is occupied by a user with worse channel conditions [3].

To imagining the idea of NOMA. We consider a base station BS communicate easily with a group of mobile users because they are nearest to BS and enjoy with the best communication channel, while hardly communicate with far mobile users because they have worst channel conditions. The NOMA suggest [5] the nearest mobile users cooperate with the far mobile users to prevent the degradation in performance of the far users and exploit the spectral more efficiently compared with orthogonal MA, the benefit of cooperative communication in NOMA systems is that the nearest users employed successive interference cancelation OSIC to send the information of the far users. The challenge for the base station is to decide how to allocate the power among the individual information waveforms. Based on this issue we introduce another scenario of cooperative NOMA in downlink MU-MIMO beamforming that considers one base station BS and multiple users, to encourage each user with little power and best channel to cooperate by employing OSIC. More explicitly, we proposed additional features to achieve power domain between the superposition users signal in BS of cooperative NOMA system, by applying maximal-SLR in BS. The maximal-SLR problem is constraint by total transmitted power. Where by solving the maximal-SLR problem we can find the minimum transmit power for each user because the maximal-SLR is the parameter that each user shall achieve using as little transmits power and minimum-leakage-based precoding vector (minimum information leakage from the desired user). Sequentially the best channel will be assigned in the first-time slot depending on minimum power for each user. Because there is a better channel for each user when the precoder with less transmit power. OSIC is employed in each user to exploit the leakage power. Rician fading channels are the inter-user channel between cooperative users. These procedures will enhance system performance. Because the base station will transmit less power over the best channel in the first time slot, as well as the applying of OSIC in the second time slot with different levels of power will improve the reliability of NOMA users without draining the users' batteries. The reason for using the maximal-SLR technique instead of SINR that the SINR-constrained power minimization solutions are applicable to the user with a single antenna due to their coupled nature of SINR constraints, that is, the SINR of each user is determined not only by its own precoding matrix but also by all other user's precoding matrices. Therefore, the SLNR is suggested as an optimization metric for linear precoder design [7]. Because each user's

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SLNR is only determined by its own precoding matrix and not by other user's precoding matrices, this metric transforms a coupled optimization problem into a completely decoupled one, for which a closed-form solution is available. To improve system BER performance the beamforming based on the maximal signal to leakage ratio (maximal-SLR) was suggested by [8].

In this paper, we introduce a technique to minimize the total transmitted power of cooperative NOMA in downlink MU-MIMO beamforming based on the maximal signal to leakage ratio (MinP-NOMA-MaxSLR). The proposed scheme aims to:

- Minimize each user transmitted power satisfy signal-to-leakage ratio constraint, by exploiting the solution of the maximal signal to leakage ratio problem.
- Minimize the total transmit power satisfy signal-to-leakage, by encourage each user with little power and best channel to cooperate. because there is a better channel for each user when the precoder with less transmit power.
- Achieve power domain between the superposition users signal that operates in the same band and at the same time.
- Detect the power of interference signals that have an impact on the other users which is also considered as a utility power for other users. Ordered Successive Interference Cancellation (OSIC) detection [9] detection and maximum-likelihood (ML) estimator method are used at each user receiver.
- Improve the reliability of NOMA users without draining the users' batteries.

Bit error rate (BER) performance evaluations show that the minimizing the total transmitted power in cooperative NOMA in downlink MU-MIMO beamforming based on maximal-SLR (MinP-NOMA-MaxSLR) proposed scheme, is outperforms cooperative NOMA beamforming based maximal-SLR (NOMA-MaxSLR).

The remainder of this paper is organized as follows. In section II, we introduce the system of cooperative NOMA in downlink MU-MIMO beamforming based on the maximal signal to leakage ratio (MinP-NOMA-MaxSLR). The suggestion algorithm for minimizing the total transmitted power is introduced in section III which includes solving the Signal-to-Leakage Ratio (SLR) maximizing problem (P1) then solving of the total power minimization problem (P2) which depends on solving (P2). The results are used to compare the BER performance of the minimizing the total transmitted power of cooperative NOMA in downlink MU-MIMO beamforming based on maximal-SLR (MinP-NOMA-MaxSLR) with cooperative NOMA in downlink MU-MIMO beamforming based maximal-SLR (NOMA-MaxSLR) are drawn in section IV.

II. System Model

NOMA exploits the power domain to transmit multiple signals over the same frequency and time domain and performs SIC at the receivers to decode the corresponding signals. Therefore, we consider cooperative NOMA in downlink MU-MIMO beamforming based on maximal signal to leakage ratio (maximal-SLR) to achieve power domain between the superposition users signal, the proposed scheme consist of single BS performs power control and beamforming to U users. The BS assumed to be equipped with M antennas, and each of the cooperative users is assumed to be equipped with N_u antennas. The system is shown below in Fig. 1.

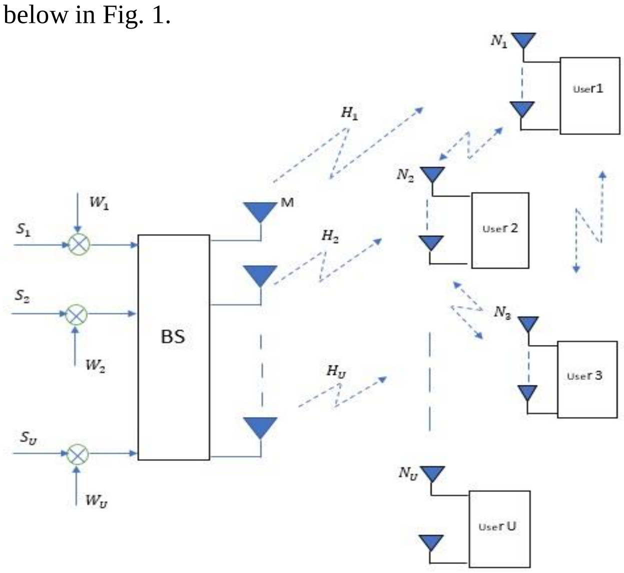

Fig. 1. Cooperative NOMA downlink MU-MIMO system.

In a cooperative NOMA approach, each user, in addition, to maximize its performance, minimizes the negative impact of its action on the performance of the other users by exploiting the power of leakage signal for his partner as a useful power, Moreover the beamforming vector for each user will be exploited to control and minimize the total transmitted power. The strategy of cooperative approach is, in first time slot the BS transmits a superposition of the individual messages i.e., $w_i s_i$, to all users after mapped by QPSK over the less effect Rayleigh fading channels (best channel), then the chosen users employ OSIC to retransmitted the partner data in second time slot over Rician fading channel with m-mean and unit-variance independent and identically distributed (i.i.d) complex Gaussian random variables. The received signal at ith is given by:

$$y_i = H_i w_i s_i + H_i \sum_{u=1,u\neq i}^{U} w_u s_u + n_i \tag{1}$$

$\mathbf{y}_i \in C^{N_i \times 1}$ is the received signal at ith user. The intended data signal for user i is the s_i. The intended data signal for user u is the s_u, n_i is the additive white Gaussian noise vector that its entries are independent and identically distribution (i.i.d.) with zero mean and variance σ_i^2 . $w_i \in \mathrm{C}^{M \times 1}$ is the beamforming vector and power allocation for the ith user. $w_u \in \mathrm{C}^{M \times 1}$ is the beamforming vector and power allocation for uth user. While H_i is represented by,

$$\mathrm{H}_i = \begin{bmatrix} \mathrm{h}_i^{(1,1)} & \dots & \mathrm{h}_i^{(1,\mathrm{M})} \\ \vdots & \ddots & \vdots \\ \mathrm{h}_i^{(\mathrm{N}_u,1)} & \dots & \mathrm{h}_i^{(\mathrm{N_u},\mathrm{M})} \end{bmatrix} \quad (2)$$

where $h_i^{(n,m)}$ represents the channel coefficient that effects on the propagation signal between *m*th transmitter array antenna of BS and *n*th receiver array antenna of the *i*th user.

At the user's receiver, the Ordered Successive Interference Cancellation (OSIC) detection employed, which used as linear detection instead of using the complexity of hardware implementation. Where each of user represent the group of receivers, each of which used to detect one of the parallel data streams that received by own use antennas, on other words detected signal in each antenna is subtracted from the received signal, therefore, the result is user signal and the signal that contain low amount of interference, which can used as a leakage single to combine with second user signal. In our suggestion cooperative scheme, the ML detector is employed to estimate the received superposition NOMA signal. Then the remaining superposition NOMA signal from detection is subtracted from the received signal. After estimation, the remaining NOMA signal in the first stage is formed by subtracting it from the NOMA received signal, the block diagram of proposed scheme is shown in Fig. 2.

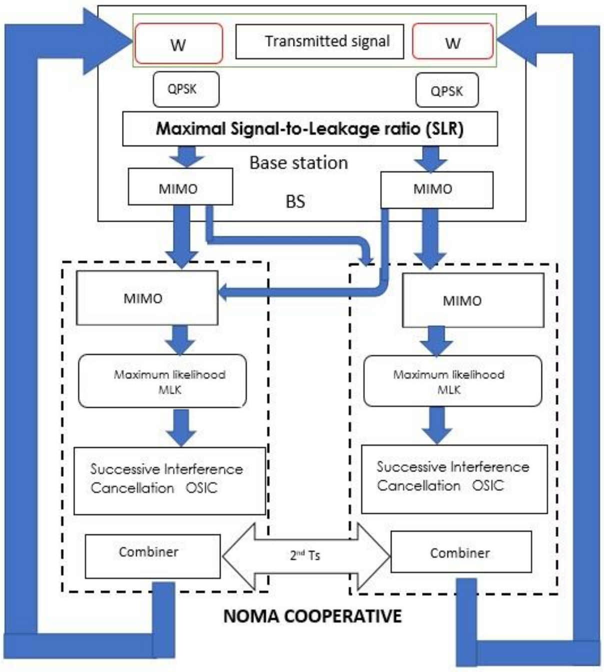

Fig. 2. Block diagram of minimizing the total transmitted power in cooperative NOMA beamforming based on maximal-SLR (MinP-NOMA-MaxSLR) proposed scheme.

There are total transmission power constraints at the transmitter, which can be described as $(\|\beta_i s_i\|^2) \leq P_i$, where β_i, is a constant to meet the total transmitted power constraint and it is given as [9]:

$$\beta = \sqrt{\frac{N_T}{Tr(H^{-1}(H^{-1})^H)}} \quad (3)$$

Generally, In cooperative NOMA MU-MIMO. $\hat{s} = w\, s$, where the received symbols are preceded with pre-equalization weight w, [9]

where $w = \beta H^{-1}$

The transmitted signal to *u*th user at second time slot is:

$$\hat{s}_{u-i-2nd} = w s_{u-i-1st} \quad (4)$$

where $s_{u-i-1st}$ represent the leakage signal from *i*th user which detected by *u*th user at first time slot. The received signal at the second time slot in *i*th user is given by:

$$y_{u-i-2nd} = H_{u-i-2nd}\,\hat{s}_{u-i-2nd} + n_i \quad (5)$$

where $H_{u-i-2nd}$ represent the inter-user channel between *u*th user and the *i*th user and n_i is the AWGN in *i*th user. The maximum ratio combiner (MRC) will be used to combine the desired signal $\widehat{s}$ (which detected by its self as its own signal at first time slot) with $\hat{s}_{u-i-2nd}$. By using MRC scheme after first and second time slot and employed Maximum-likelihood (ML) estimator, the signal of *i*th user will be:

$$s_i = \widehat{s}_i + \sum_{u=1,\ u\neq i}^{U} \hat{s}_{u-i-2nd}$$

$$s_i = \widehat{s}_i + \sum_{u=1,\ u\neq i}^{U} \frac{H^*_{u-i-2nd}}{||H_{u-i-2nd}||^2}\, y_{u-i-2nd} \quad (6)$$

When we considered the single-user maximum-likelihood the SINR will be written as shown in equation (7). Using SINR in (7) for $i = \{1. . . . \mathrm{U}\}$ as an optimization objective function for determining the $\{\mathrm{w_i}\}_{i=1}^{\mathrm{U}}$ will lead a problem with U coupled variables $\{\mathrm{w}_i\}$.

$$\mathrm{SINR}_i = \frac{||\mathrm{H}_i\mathrm{w}_i||^2}{\sigma^2 + \frac{\sum_{\mathrm{u}=1,\mathrm{u}\neq i}^{\mathrm{U}} ||\mathrm{w}_i^*\bar{\mathrm{H}}_i^*\bar{\mathrm{H}}_i\mathrm{w_u}||^2}{||\mathrm{H}_i\mathrm{w}_i||^2}} \quad (7)$$

For the above reason, the design of the Beamforming coefficients $\{\mathrm{w}_i\}$ was suggested [8], where an optimization criterion based on generalized eigenvalue problems, which produced maximization of the signal-to-leakage ratio (SLR) [8]. So, in the next section, we will use SLR which is the ratio of the power of the desired signal $||\mathrm{H}_i\mathrm{w}_i||^2$ to the power of the interference caused by this user *i* on the signal received by user *u*, $||\mathrm{H}_u\mathrm{w}_i||^2$.

III. Minimizing Total Transmitted Power Algorithm in NOMA

A. *Problem Statement (P1): Maximal Signal to Leakage Ratio (Maximal-SLR) Subject To Power Constraint*

By maximizing SLR to compute maximum beamforming $(\mathrm{w}_i^{\mathrm{o}})$ for each user according to [8].

$$\mathrm{w}_i^{\mathrm{o}} = \arg\ \max \frac{||\mathrm{H}_i\mathrm{w}_i||^2}{\sum_{u=1,u\neq i}^{\mathrm{U}} ||\mathrm{H}_u\mathrm{w}_i||^2} \quad (8)$$

$$\text{subject to} \quad ||\mathrm{w}_i||^2 = \mathrm{w}_i^{\mathrm{H}}\mathrm{w}_i \leq \mathrm{P}_i/\,\mathrm{E}_i,$$

where the maximizing the SLR subject to total transmission power constraints (P_i) at the transmitter, which can be described as $E(\|w_i s_i\|^2) \leq P_i$. The symbol s_i satisfies the power constraint as $E_i = E(|s_i|^2) = 1$.

Where $||H_i w_i||^2$ represents the required signal power of user i, while $\sum_{u=1,\ u\neq i}^{U} ||H_u w_i||^2$ represents the total leakage power from the total power of user i as interference on the other users. By carefully looking at expression (8). It's easy to say that for w_i , $i = \{1. . . . U\}$, the U is decoupled optimization problems comparison with equation (7).

$$\mathrm{SLR} = \frac{||H_i w_i||^2}{||\tilde{H}_i w_i||^2} = \frac{w_i^* H_i^* H_i w_i}{w_i^* \tilde{H}_i^* \tilde{H}_i w_i} \tag{9}$$

the general solution of equation (8) which is solved by [8] is obeyed to the Rayleigh-Ritz method [10]. sequentially the solving of (9) is given below:

$$\frac{w_i^* H_i^* H_i w_i}{w_i^* \tilde{H}_i^* \tilde{H}_i w_i} \leq \lambda_{\max}\left(H_i^* H_i, \tilde{H}_i^* \tilde{H}_i\right) \tag{10}$$

where $\lambda_{\max}$ represent the largest generalized eigenvalue. Equality occurs if w_i is proportional to a generalized eigenvector that corresponds to the largest generalized eigenvalue, written compactly as

$$w_i^o \propto \mathrm{maxgen.\,eigenvector}\left(H_i^* H_i, \tilde{H}_i^* \tilde{H}_i\right) \tag{11}$$

B. *Problem Statement (P2) Power Minimization Subject To SLR Constraint*

The transmit beamforming can be optimized to maximize some performance utility metric, which is generally a function of the SLR.

$$\min_{w_1 \ldots w_U} \sum_{i=1}^{U} \|w_i\|_2^2 \tag{12}$$

$$\text{subject to} \quad SLR_i \geq \gamma_i^o$$

The parameter γ_i^o, is the largest SLR threshold that each user shall achieve at the optimum of (P2), using as little transmits power as possible. The γ_i^o parameter can, for example, describe the SLR required for achieving certain data rates. The value of the γ_i^o parameter is constant in (P2) and clearly impact the optimal beamforming solution [11].

We are exploiting the solution of the maximal signal to leakage ratio w_i^o problem solved in Problem Statement (P1) to minimize the total transmit power. Because larger SLR threshold γ_i^o is the parameter that each user shall achieve using little transmits power as possible. Specifically, the value of the maximal signal to leakage ratio for each user (w_i^o) $i = \{1. . . . U\}$, that solved by the Problem Statement (P1) will be used to allocate the power of each user, where γ_i^o will be used as a knowing constraint for minimizing the total transmit power problem in Problem Statement (P2). Then we used the channel of the minimum value of transmitted power for each user to find the total transmitted power. because only there is a better channel for each user when the precoder with less transmit power which satisfies SLR constraints, the square norm $\|w_i\|_2^2$ is the power allocated for transmission to user i.

A summary of proposed minimizing the total transmitted power **Algorithm** is given below:

- Step 1: Find the maximum value of signal-to-leakage ratio (w_i^o), $i = \{1. . . . U\}$, for each user separately from solving problem statement (P1) equation (8).
- Step 2: Find the transmitted power of each user $p_i = w_i = \|w_i\|_2^2$ which is the second norm of the maximal value of signal-to-leakage ratio w_i^o that solved by problem statement (P1).
- Step 3: Then we find (by numerically searching) the minimum value of transmitted power for each user separately, which satisfy (SLR) constraint of problem statement (P2) of equation (12). because the large SLR γ_i^o parameter that each user shall achieve using as little transmit power as possible
- Step 4: following step 3, we find the channel of the minimum value of transmitted power for each user numerically. Because there is only a better channel for each user when the precoder with less transmit power which satisfies SLR constraints. Where for user i , we have multiple paths (channels) and each path has certain and precoding as, $w_i = \{w_{i1}. . . . w_{in}\}$
  Where n is the number of channels of user i.
- Step 5: Apply the channels of the minimum value of transmitted power for each user (better channel for each user) in simulation to find the total minimum transmitted power.

The Proposed **Algorithm** for minimizing the total transmitted power in cooperative NOMA MU-MIMO beamforming based on maximal-SLR (MinP-NOMA-MaxSLR) shown below in Fig. 3.

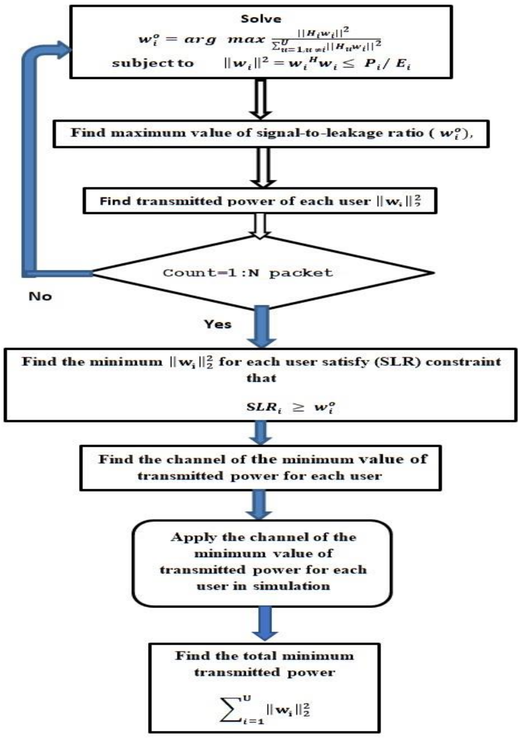

Fig. 3. Proposed Algorithm for minimizing the total transmitted power in cooperative NOMA MU-MIMO beamforming based on maximal-SLR (MinP-NOMA-MaxSLR).

IV. Simulation Results

The proposed cooperative NOMA in downlink MU-MIMO scheme introduced in section II is simulated using Matlab codes. Simulation considers two channel types which are first and second-time slot channels. In first time slot channel, the BS broadcast a superposition of individual signals to multi-users receiver over less effect Rayleigh fading channel with zero-mean, in second time slot channel (inter-user channels), the best users' channel cooperates with each other over Rician fading channel with m-mean and unit-variance independent and identically distributed (i.i.d) complex Gaussian random variables. The summary of parameters is shown in Table I. The BER performance of all the systems described are evaluated at BER 10^{-5}. An acceptable BER performance for voice communications is 10^{-4} [7], [8]. The BER performance of the minimizing the total transmitted power in cooperative NOMA MU-MIMO beamforming based on maximal-SLR (MinP-NOMA-MaxSLR) proposed scheme, compared with the Noncooperative MU-MIMO beamforming based on SLR (NonCoop-MaxSLR) [8] is shown in Fig. 4. The abbreviations used in the simulation results are listed in Table II.

TABLE I: Simulation Parameters

Parameters	Definition
Modulation mode	QPSK
No. of input data	10000
BER compassion Point	10^{-5}
Downlink channel	Rayleigh
Inter-user channels	Rician
SNR of inter user channel	5 – 20
Number of users (U)	3,4
Number of antenna for BS (M)	5,6
Number of antenna for each use (N)	2,3,4
Rician channel factor (K_{Rician})	5 – 30
Beta (β)	0.1 – 0.5

TABLE II: Simulation Abbreviations

Parameters	Definition
minimize total transmitted power in cooperative NOMA MU-MIMO beamforming based on maximal-SLR	(MinP-NOMA-MaxSLR)
Cooperative NOMA MU-MIMO beamforming based on maximal-SLR	(NOMA-MaxSLR)
Non-cooperative MU-MIMO beamforming based on Maximal-SLR [8]	(NonCoop-MaxSLR)
No. of transmitted antenna	T
No. of received antenna	R
SNR of inter-user channels	SNRdBin
Factor of the Rician channel	KdB

A. *Comparison with Other Research*

Fig. 4, shows, the comparison of bit error ratio (BER) performance between the proposed scheme (MinP-NOMA-MaxSLR) and Non-cooperative MU-MIMO beamforming based on maximal-SLR system (NonCoop-MaxSLR) [8] with assigned antenna in BS with M = 5 and each user assigned with N= 3, in Rician inter user channel SNR= 20 with K_Rician= 25 and β = 0.1. The result demonstrates that the performance of (MinP-NOMA-MaxSLR) is better than (NonCoop-MaxSLR). More specifically, to achieve a BER of about 10^{-5} the required SNR for the (MinP-NOMA-MaxSLR) is about 2 dB less than the (NonCoop-MaxSLR) [8].

On the other hand, Fig. 5, shows the comparison between proposed scheme (MinP-NOMA-MaxSLR), (NOMA-MaxSLR) and (NonCoop-MaxSLR)[8] with the assigned antenna in BS with M = 6 and each user assigned with N=3, in Rician inter user channel SNR= 20 with K_Rician= 25 and β = 0.1.

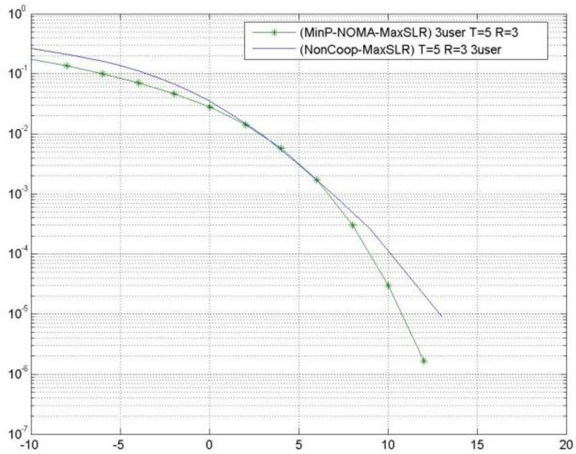

Fig. 4. BER performances of the (MinP-NOMA-MaxSLR) and (NonCoop-MaxSLR) with BS M = 5 antenna and 3user, each with N= 3, in Rician inter user channel SNR= 20 with k = 25 and β = 0.1.

The result demonstrates in Fig. 5, that the performance of (MinP-NOMA-MaxSLR) is better than Both (NOMA-MaxSLR) and (NonCoop-MaxSLR). More specifically, to achieve a BER of about 10^{-4} the required SNR for the (MinP-NOMA-MaxSLR) is about 7.5 dB less than the (NonCoop-MaxSLR) [8]. Also, to achieve a BER of about 10^{-4} the required SNR for the (MinP-NOMA-MaxSLR) is about 4 dB less than the (NOMA-MaxSLR).

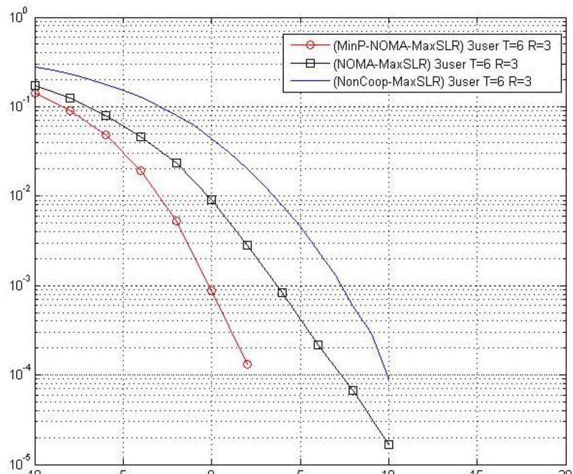

Fig. 5. BER performances of the (MinP-NOMA-MaxSLR), (NonCoop-MaxSLR) and (NOMA-MaxSLR) with BS M = 6 antenna and 3user, each with N= 3anttena, in Rician inter user channel SNR= 20 with k = 25 and β = 0.1.

Fig. 6, shows the comparison between (NOMA-MaxSLR) and proposed scheme (MinP-NOMA-MaxSLR) to select the optimum value of β. where a base station (BS) equipped with M=6 antennas communicates with N =2 in each user. We choose three different value β for the proposed scheme, to make a comparison with (NOMA-MaxSLR), first when β = 0.5, the performance of the (NOMA-MaxSLR), which maximizes the useful power of users and neglects the multi-user interference, has better performance than the proposed scheme (MinP-NOMA-MaxSLR). That is because the effect of multi-user interference is high, which becomes the main factor limiting the system performance. Therefore, in the second-time slot, the users will share the signals with high interference value. While in the second scenario, when β = 0.3 the effect of the interference on sharing signals is reduced. Therefore, the performance of the proposed scheme (MinP-NOMA-MaxSLR) will be improved but still worse than (NOMA-MaxSLR). Whilst for the third scenario, when β = 0.1, noise is the main factor limiting system performance. That is because the proposed scheme (MinP-NOMA-MaxSLR) is making the interference signals turn into useful signals when it detected these signals by using OSIC, and it could get the benefit from the multi-user interference via sharing these signals among users. Therefore, the performance of the proposed scheme will improve.

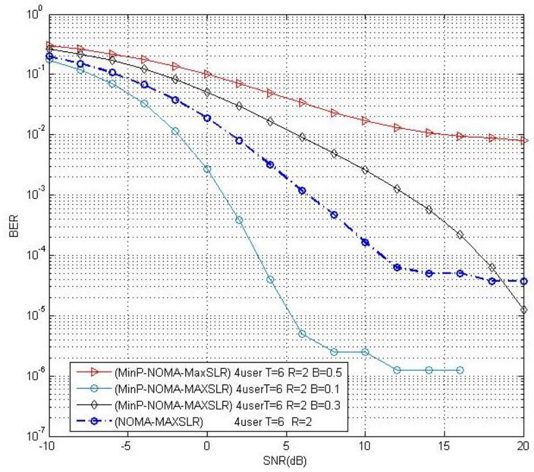

Fig. 6. BER performances of the (MinP-NOMA-MaxSLR) and (NOMA-MaxSLR) with BS M = 6 antenna and 4user, each with N = 2 antenna in Rician inter user channel with k=25 and SNR= 20.

Fig. 7, shows the system performance when the inter-user channel used a line of sight LOS environment (over a correlated realistic Rician fading channel). Where the performance of the proposed scheme (MinP-NOMA-MaxSLR) is better than the performance of (NOMA-MaxSLR). More specifically, in case k = 30 to achieve a BER of about 10^{-4} the required SNR for the proposed scheme (MinP-NOMA-MaxSLR) is about 1 dB less than (NOMA-MaxSLR). It also shows the proposed scheme (MinP-NOMA-MaxSLR) performance is worse than the (NOMA-MaxSLR) when k is decreased. In other words, when the inter user channel LOS is reduced the total proposed system performance will also reduce. It is necessary for these users to identify a suitable partner to obtain optimal performance through knowledge of the inter-user channel characteristics between each user and its' partner.

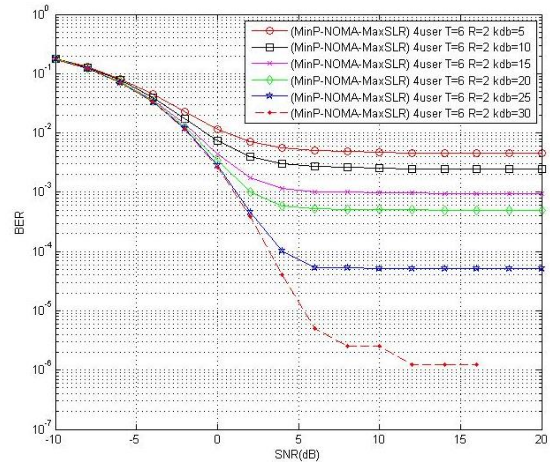

Fig. 7. BER performances (MinP-NOMA-MaxSLR) with BS M = 6 antenna and 4user, each with N = 2 antenna, in LOS environment of inter user channel SNR=20, β = 0.1

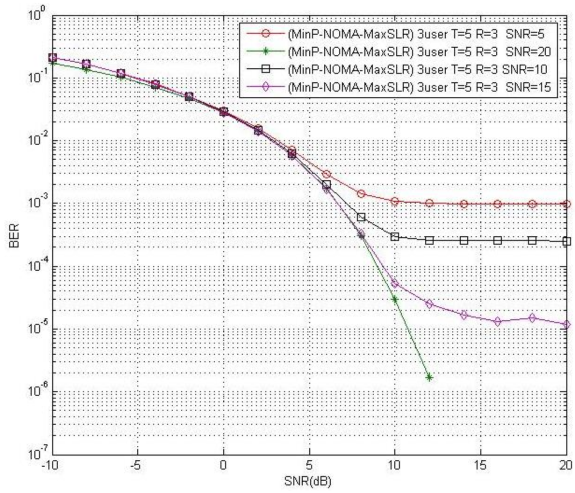

Fig. 8. BER performances of the (MinP-NOMA-MaxSLR) with BS M = 5 antenna and 3 user, each with N= 3, in Rician inter user channel with k = 25 and β = 0.1.

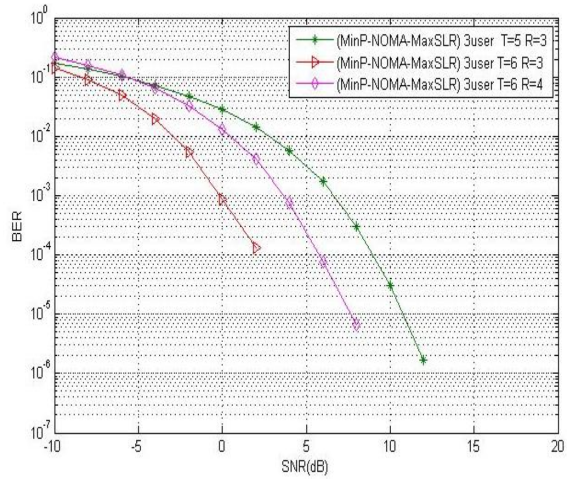

Fig. 9. BER performances of the (MinP-NOMA-MaxSLR) with BS M =5 and 6 antenna and 3user, each with N = 3 and 4 antenna in Rician inter user channel SNR=20, k = 25 and β = 0.1.

Fig. 8, presents the performance of the proposed scheme (MinP-NOMA-MaxSLR) in downlink channels between the BS and the users which have equal value of the SNR in the channel, while the SNR of the inter-user channel equal to 5, 10, 15 and 20 dB. The result shows the performance of the system is enhanced when the inter channel SNR increase.

Fig. 9, shows comparison the BER performance of (MinP-NOMA-MaxSLR) employed multi antenna in both BS and users, where the BS antennas M =5 and 6 while the users antennas N = 3 and 4, the result shows the system has a significant improvement for M = 6 and N=3.

V. Conclusion

In this paper, we proposed cooperative NOMA in downlink MU-MIMO beamforming based on the signal to leakage ratio (SLR) to allocate the power among the individual information waveforms in BS (achieve power domain between the superposition users signal in BS). And to minimize the total transmit power by exploiting the solution of the maximal signal to leakage ratio (maximal-SLR) then encourage the users with the best channel to cooperate. Order Successive Interference Cancellation (OSIC) and Maximum-likelihood (ML) estimator method are employed at the receiver to exploit the leakage power after user cooperation in the second time slot. Rician fading channels are considered as second-time slot channel. Bit error rate (BER) performance evaluations show that (MinP-NOMA-MaxSLR) proposed scheme is outperforming NOMA beamforming based maximal-SLR (NOMA-MaxSLR).

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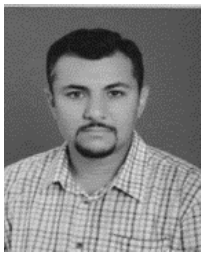

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