Maximizing signal to leakage ratios in MIMO BCH cooperative beamforming scheme

Mohammed Fadhil[1], Nor Fadzilah Abdullah[2], Mahamod Ismail[3], Rosdiadee Nordin[4], Cebrail Ciftlikli[5]
Musaab Al-Obaidi[6]
[1,2,3,4]Centre of Advanced Electronic and Communication Engineering (PAKET),
Universiti Kebangsaan Malaysia, Malaysia
[5,6]Faculty of Engineering, Erciyes University, Turkey

Article Info

ABSTRACT

Beamforming (BF) technique in cooperative multiple input multiple output (MIMO) antenna arrays improves signal to noise ratio (SNR) of the intended user. The challenge is to design transmit beamforming vectors for every user while limiting the co-channel interference (CCI) from other users. In this paper, we proposed cooperative beamforming based on Signal-to-Leakage Ratio (SLR) to exploit the leakage power as a useful power in the second time slot after user cooperation, for this purpose successive interference cancellation (SIC) is employed in each user to separate the leakage signal from the desired signal. Without increasing the complexity, Maximizing Signal-to-Leakage Ratio (SLR) subject to proposed power constraint instead of a unity norm is the way to achieve extra leakage power. To reduce the erroneous, Bose–Chaudhuri–Hocquenghem (BCH) codes employed in Beamforming of (SIC) cooperative scheme BF(CS-SIC-BCH). Maximum-likelihood (ML) estimator method is used at each user receiver. Simulation results show that the performance of the proposed scheme BF (CS-SIC-BCH) over Rayleigh and Rician fading channel is significantly better than the performance beamforming based on SLR in Non-cooperative system. More specifically to achieve a BER of about 10^{-4} the required SNR for the proposed scheme is about 1 dB less than the Non-cooperative system.

Corresponding Author:

Mohammed Fadhil,
Centre of Advanced Electronic and Communication Engineering (PAKET),
Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia.
Email: mohammedfadhilm@gmail.com

1.   INTRODUCTION

Multiple antenna systems improve the spectral efficiency without increasing power or bandwidth, theoretically, the capacity increases with the number of antennas deployed. MIMO technique also gained a considerable amount of interest as technique to increase the data rate through spatial multiplexing or enhance the quality of transmission through the exploitation of diversity [1]. In multiuser MIMO downlink communications [2], a base station communicates with several co-channel users in the same frequency and time slots. Therefore it is necessary to design a transmitter that able to suppress co-channel interference (CCI) because co-channel interference consider as major limitation factor for the system capacity. The focus of this paper is on spatial diversity techniques in a downlink wireless communication system, where a base station (BS) could simultaneously serve multiple users, which required to deployed beamforming [3-4] at BS to suppress CCI to end users and maximize overall capacity.

Many techniques have been adopted to suppress the CCI. For example in [5], the pre-processing of the signal at the BS was employed to completely cancel the CCI at the receiver for each user, while in [6] the block-diagonalization was proposed. Both [5] and [6] restricted to use transmitting antennas to be greater

than the sum of all receiving antennas. In [7] the space-time block codes (STBC) have been porposed to design the precoder as a way to suppress CCI, this way also requires a large number of antennas at BS. Other works [8-11] have been employed the zero forcing (ZF) at the receiver as a schemes for perfectly canceling the CCI for each user which also resited by the number of transmit antennas at the BS. Some researchers suggested iterative algorithms to solve the optimization problem in multiuser to cancel the CCI [12-13]. Other schemes based on optimaztion techniques to maximize the output signal-to-interference plus-noise ratio (SINR) [14-15] which also impose to restriction on the number of transmit antennas to be greater than the number summation of all users' antennas.

Due to the complexity that results from coupled nature of the solving optimization problem of maximizing the alternative so-called signal-to-interference noise ratio (SINR) [16], an alternative scheme based on the concept of signal leakage, have been suggested for designing transmit beamforming vectors. More explicitly co-channel interference (CCI) define as the interference of other users on the desired user, while the leakage defines as the interference caused by the signal intended for a desired user on the remaining users. Sequentially, the leakage is a measure of how much signal power leaks into the other users. Several studies based on maximizing the signal-to-leakage-and-noise ratio (SLNR) for designing the beamforming vector suggested [17-18] which leads to a decoupled optimization problem and admits an analytical closed-form solution. Moreover, the solution of the leakage scheme does not restrict by the number of Bs and users antennas. Another scheme of the signal to leakage SLR with absent of additive to noise power term suggested by [19] which aims to design beamforming vector and enhance the bit error performance.

Following the [19], we proposed beamforming based on signal-to-leakage-ratio (SLR) in successive interference cancellation (SIC) cooperative scheme. We aim to exploit the leakage power as a useful power instead of ignoring it. More explicitly we use SIC [20] as a technique to separate the desired signal from the leakage signal and isolate the leakage to use again as a useful power from the second cooperative user. Sequentially we update the power constraint of the Maximal Signal-to-Leakage Ratio (SLR) problem instead of a unity norm to achieve extra leakage power. To reduce the erroneous, Bose–Chaudhuri–Hocquenghem (BCH) codes [21] employed in Beamforming of (SIC) cooperative scheme BF(CS-SIC-BCH). Maximum-likelihood (ML) estimator method is used at the each user receiver. The drawback of the proposed scheme is the cooperation which means exchange of information.This leads to the requirement of more resources for transmission and additional delays.

Simulations of the system are carried out over Rayleigh (in the NLOS environment) and Rician fading channel (in the LOS environment). Results of simulation demonstrate that the performance of the beamforming based on SLR in SIC cooperative scheme BF(CS-SIC-BCH) (proposed scheme) outperforms beamforming based on SLR of Non-cooperative schemes [19] at high SNRs.

The remainder of this paper is organized as follows. In section 2, we introduce the system model for downlink multiuser MIMO beamforming schemes. The optimization of transmitting beamforming is formulated in section 3 whereas Signal-to-Leakage Ratio (SLR) Maximining is described in section 4. All these then used in sub-section 4.1 and 4.2 to formulate the proposed scheme to maximize the Signal-to-Leakage Ratio (SLR) by updating the optimization of transmit beamforming constraint. The describing of BCH coding techniques are presented in section 5, while proposed downlink cooperative scheme for two cooperative users is presented in section 6. In section 7, the channel model for the first and second time slot is described. The results are used to compare the BER performance of the beamforming based on SLR in SIC cooperative scheme BF(CS-SIC-BCH) with beamforming based on SLR of Non-cooperative system are drawn in section 8.

2. MULTIUSER MIMO BEAMFORMING

In downlink MU-MIMO beamforming [19], a base station (BS) equipped with M antennas communicates with U Multi-antenna users. Each user received and transmit the signal independently using N_U antenna, the total users' antennas $N_T = \sum_{u=1}^{U} N_u$ as shown in Figure 1. In a wireless communication network, the typical system assumes that $N_T \geq M$ in independent channels of flat fading. The intended data signal for user u is the scalar s_u, so the transmitted symbol vector to U users is:

$$S = [s_1, s_2, \dots, s_u]^T \tag{1}$$

While the precoding matrix is defined as,

$$W = [w_1, w_2, \dots, w_u] \tag{2}$$

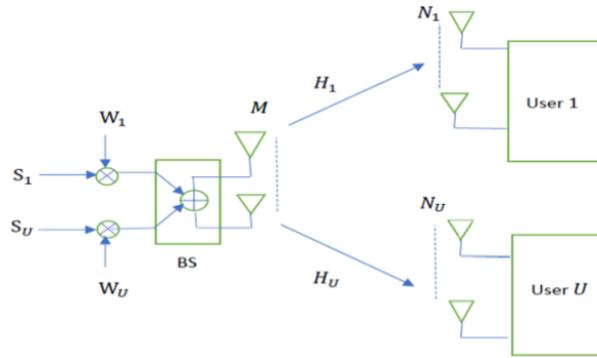Where $w_u \in C^{M \times 1}$ is the beamforming vector for uth user.

Figure 1. Multi-user beamforming system

The transmitted vector will result from multiplying, the beamforming vector by the data symbol would be:

$$X = \sum_{u=1}^{U} w_u s_u = WS \tag{3}$$

The transmitted signals WS $\in C^{M \, x1}$ are broadcasting over all channels between BS and users denoted as:

$$H = [\, H_1{}^T, H_2{}^T, \dots, H_U{}^T]^T \tag{4}$$

where $H_u \in C^{N_u \, x \, M}$ is the channel coefficients between N_u received antennas of uth user and M antennas of BS as:

$$H_u = \begin{bmatrix} h_u^{(1,1)} & \cdots & h_u^{(1,M)} \\ \vdots & \ddots & \vdots \\ h_u^{(N_u,1)} & \cdots & h_u^{(N_u,M)} \end{bmatrix} \tag{5}$$

where $h_u^{(n,m)}$ represents the channel coefficient that effect on the propagation signal between mth transmitter array antenna of BS and nth receiver array antenna of the uth user. Thus, the received signals by the receivers' antennas:

$$y = [\, y_1{}^T, y_2{}^T, \dots, y_U{}^T]^T = HWS + n \tag{6}$$

By considering $\mathbf{y}_i \in C^{N_i \, x \, 1}$ as the signal, which is received at the ith recipient, whilst for the additive noise is denoted by $n \in C^{UN_i \, x \, 1}$. When we have considered, each user separately, we will find the received signal at an ith recipient as:

$$y_i = H_i \sum_{u=1}^{U} w_u s_u + n_i$$

$$= H_i w_i s_i + H_i \sum_{u=1,u\neq i}^{U} w_u s_u + n_i \tag{7}$$

The H_i vector has complex Gaussian variables Components with (unit–variance) and (zero-mean). Moreover, the components of the additive noise n_i have distribution as $N(0,\sigma_i^2)$ and is temporarily white and spatially. To describe the proposed scheme clearly, as following we review the original SLR based precoding scheme [19] in section 4.0.

3.   TRANSMIT BEAMFORMING OPTIMIZATION

One of the main steps to enhance system performance is transmitting beamforming optimization. According to [22] the maximizing of some arbitrary utility function $f(\text{SINR}_1, ., \text{SINR}_U)$ can strictly be increasing in the SINR of each user, and the total transmit power is restricted by P. Mathematically speaking is,

$$\max f(\text{SINR}_1, \ldots, \text{SINR}_U)$$

$$\text{subject to } \sum_{u=1}^{U} \|w_u\|^2 \leq P \tag{8}$$

4.   MAXIMIZING SIGNAL TO LEAKAGE RATIO

In this work, the single user maximum-likelihood SINR is considered, as shown in equation (9). Using SINR in (9) for $i = \{1. \ldots U\}$ as an optimization objective function for determining the $\{ w_i \}_{i=1}^{U}$ will lead a problem with U coupled variables $\{w_i\}$[19].

$$\text{SINR}_i = \frac{\|H_i w_i\|^2}{\sigma^2 + \frac{\sum_{u=1, u \neq i}^{U} \|w_i^* \widetilde{H}_i^* \widetilde{H}_i w_u\|^2}{\|H_i w_i\|^2}} \tag{9}$$

For the above reason in design of the beamforming coefficients $\{w_i\}$ SLR are suggested in [19], which result in a full characterization of the optimal solutions in terms of generalized eigenvalue problems. Where SLR is the ratio of the power of the desired signal $\|H_i w_i\|^2$ to the power of the interference caused by this user i on the signal received by user u, $\|H_u w_i\|^2$.

$$SLR = \frac{\|H_i w_i\|^2}{\sum_{u=1, u \neq i}^{U} \|H_u w_i\|^2} \tag{10}$$

4.1. Problem statement (P1):

By maximizing SLR to compute maximum beamforming (w_i^o) for each user according to [19].

$$w_i^o = arg \ \ max \ \frac{\|H_i w_i\|^2}{\sum_{u=1, u \neq i}^{U} \|H_u w_i\|^2}$$

$$\text{subject to} \ \ \|w_i\|^2 = 1 \ \ i = \{1, \ldots U\} \tag{P1}$$

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 to SLR in (P1). It's easy to say that for w_i, $i = \{1. \ldots U\}$ the U is decoupled optimization problems comparing with equation (9).

4.2. Proposed scheme (P2):

Follow the general optimization of transmit beamforming constraint in equation (8) and [23], we update the SLR constrain in (P1) to be; $\|w_i\|^2 = w_i^H w_i \leq P_i / E_i$. Where P_i / E_i is transmission power constraint at the transmitter i, which can be described as $E(\|w_i s_i\|^2) \leq P_i$. The symbol s_i satisfies the power Constraint as $E_i = E(|s_i|^2) = 1$.

The reason for this updating is the drawback of the constraint in problem statement (P1) is when each user has multiple data streams, the effective channel gain for each stream can be severely unbalanced. If power control or adaptive modulation and coding cannot be applied, the overall error performance of each user will suffer significant loss [24]. So by updating the constraint, of (P2), we get (P2) as following:

$$w_i^o = arg \ \ max \ \frac{\|H_i w_i\|^2}{\sum_{u=1, u \neq i}^{U} \|H_u w_i\|^2}$$

$$\textit{Subject to} \ \ \ \|w_i\|^2 = w_i^H w_i \leq P_i / E_i \tag{P2}$$

It is noted that the norm of w_i is irrelevant to the final solutions, or in other words, the norm of w_i can be forced to be any value to achieve the best value for w_i under the power constraint. By substituting $\widetilde{H}_i = \sum_{u=1,u \neq i}^{U} H_u$ into objective function of (P2), we can obtain;

$$SLR = \frac{||H_i w_i||^2}{||\widetilde{H}_i w_i||^2} = \frac{w_i^* H_i^* H_i w_i}{w_i^* \widetilde{H}_i^* \widetilde{H}_i w_i} \tag{11}$$

Our updating depends on that the general solution of (P2) which is solved by [19] is obeyed to the Rayleigh–Ritz method [25] which satisfyingly any constraint without effect on the general solution. So, following [19] the solution of (11) will be:

$$\frac{w_i^* H_i^* H_i w_i}{w_i^* \widetilde{H}_i^* \widetilde{H}_i w_i} \leq \lambda_{max}\left(H_i^* H_i, \widetilde{H}_i^* \widetilde{H}_i\right) \tag{12}$$

where λ_{max} is the largest generalized eigenvalue. According to the SLR criterion, the precoding matrix w_i is designed based on the following metric;

$$w_i^o \propto max\,gen.\,eigenvector\left(H_i^* H_i, \widetilde{H}_i^* \widetilde{H}_i\right) \tag{13}$$

At user i, maximum-likelihood (ML) detection scheme will be used to estimate (s_i) from the received signal as following [19]

$$\widetilde{y}_i = \frac{w_i^* H_i^*}{||H_i w_i||^2} y_i \tag{14}$$

then

$$\widetilde{y}_i = s_i + \frac{w_i^* H_i^* \sum_{u=1,u \neq i}^{U} H_i w_u s_u}{||H_i w_i||^2} + \frac{w_i^* H_i^*}{||H_i w_i||^2} n_i \tag{15}$$

5. BCH CODING TECHNIQUE

The BCH encoder block creates a BCH code with message length $K_{BCH}=5$ and codeword length $N_{BCH}=15$. The input must contain exactly K_{BCH} elements. The output is a vector of length N_{BCH} must have the form $2^{\wedge}((M_{BCH}-1))$, where M_{BCH} is an integer greater than or equal to 3. For a given codeword length N_{BCH}, only specific message lengths K_{BCH} are valid for a BCH code.

The BCH decoder block recovers a binary message vector from a binary BCH codeword vector. For proper decoding, the first two parameter values in this block should match the parameters in the corresponding BCH encoder block. The input is a binary codeword vector and the first output is the corresponding binary message vector. If the BCH code has message length K_{BCH} and codeword length N_{BCH}, then the input has length N_{BCH} and the first output has length K_{BCH}. If the input is frame-based, then it must be a column vector. The second output is the number of errors detected during decoding of the codeword. A negative integer indicates that the block detected more errors than it could correct using the coding scheme. The sample times of all input and output signals are equal.

6. SYSTEM MODEL

In our proposed downlink cooperative systems model, two cooperative users $U=2$, with N antenna array for each user communicate with M antenna base station (BS). The cooperative scheme involves two steps as shown in Figure 2. In the first time slot, the data is decoded on the transmitter side, where binary sequences K_{BCH}-bits long are generated by a pseudo-random generator block which is the input to the BCH encoder block. The encoder block maps k_{BCH}-bits of the sequence into N_{BCH} bits of the sequence. The N_{BCH} represent the data signal for user u is the s_u. The data signal s_u are passed on the QPSK modulator, then each user data modulated perform beamforming as $w_u s_u$, The Gaussian-like (AWGN and Rayleigh) channel block is designed to introduce a fading effect and add noise to the modulated signal as shown in (7). In the second time slot, each user retransmitted the data to his partner [26]. Due to the complexity of hardware implementation which used for linear detection, we suggested the SIC method for improving the detection performance with low complexity.
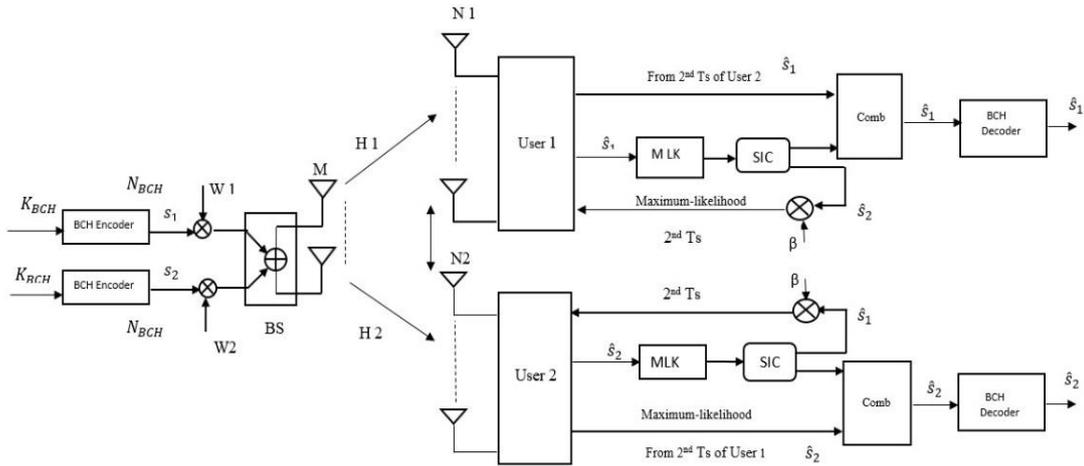
Figure 2. Beamforming cooperative scheme between two users employing SIC signal detection and ML estimation

The basic idea of SIC [20] is that user signals are successively decoded by ML detector to estimate s_i from the received signal. After one user's signal is decoded, it is subtracted from the combined signal before the next user's signal is decoded. When SIC is applied, one of the user signals is decoded, treating the other user signal as an interferer, but the latter is then decoded with the benefit of the signal of the former having already been removed. Mathematically speaking the remaining signal y_i, is,

$$\widetilde{y}_i = y_i - H_i s_i.$$

More explicitly at the first time slot, ML estimation and SIC detection is used, where the (SIC) will be used to detect the interference symbols, where each user recognizes and identifies its own signal (desired signal) from other user signals which are known as the leakage signal, then the leakage signals for first and second users are transmitted to his partner at the second time slot. By using proposed scheme, we can exploit the power of leakage signal to get more productive power by combining the desired signal (which is detected by each user) with leakage signal (which detected by the second user). In other words, combining the own user signal with the interference signal coming from his partner as shown in Figure 2.

When the inter-user channel (the channel between users) is taken into account, more power will be allocated for cooperation. In simple words, to take advantage of the leaked signal, we have reintroduced the signal that leaked from the original signal to its real destination.

There are total transmission power constraints at the transmitter, which can be described as $E(\|\beta_i s_i\|^2) \leq P_i$, β_i is a constant to meet the total transmitted power constraint and it is given as [26]:

$$\beta = \sqrt{\frac{N_T}{Tr(H^{-1}(H^{-1})^H)}} \tag{16}$$

Generally, in multi user cooperative, and according to [26]. $\hat{s} = w\,s$. Where the received symbols are preceded with pre-equalization weight w, Where $w = \beta H^{-1}$.

The transmitted signal to uth user at second time slot is:

$$\hat{s}_{u-i-2nd} = w s_{u-i-1st} \tag{17}$$

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

$$y_{u-i-2nd} = H_{u-i-2nd}\,\hat{s}_{u-i-2nd} + n_i \tag{18}$$

where $H_{u-i-2nd}$ is the inter-user channel between uth user and the ith user and n_i is the AWGN in ith user. In ith user, maximum ratio combiner (MRC) will be used to combine the desired signal $\hat{s}_i$ (which detected by its self as its own signal at first time slot) with $\hat{s}_{u-i-2nd}$.

By using the MRC scheme after first and second-time slot and employed Maximum-likelihood (ML) estimator, the signal of the ith user will be:

$$s_i = \widehat{s}_i + \sum_{u=1, \ u \neq i}^{U} \widehat{s}_{u-i-2nd} = \widehat{s}_i + \sum_{u=1, \ u \neq i}^{U} \frac{H^*_{u-i-2nd}}{||H_{u-i-2nd}||^2} \, y_{u-i-2nd} \qquad (19)$$

Finally, the received signal for each user is demodulated by the QPSK demodulator. Then the demodulated signals are passed to BCH decoder block to recover the transmitted signal.

7.   CHANNEL MODEL

Due to LOS propagation, the strongest propagation component of MIMO channel corresponds to the deterministic component (also referred to as specular components). On the other hand, all the other components are random components (due to NLOS also referred to as scattering components) [27]. The broadcast channel distribution has been following the Rayleigh channel distribution which is Gaussian distribution with a variance of σ^2 and zero mean. That means there is no component of LOS ($K_{\text{Rician}} = 0$): $\sigma = \sqrt{\frac{1}{K_{\text{Rician}}+1}}$. On the other hand, when there is any component of LOS (For $K_{\text{Rician}} > 0$) the broadcast channel distribution has been following the Gaussian distribution with a variance of σ^2 and mean of q   or Rician distribution when K_{Rician} increases as: $q = \sqrt{\frac{K_{\text{Rician}}}{K_{\text{Rician}}+1}}$, $\sigma = \sqrt{\frac{1}{K_{\text{Rician}}+1}}$. Therefore, in this work, the channel matrix of the MIMO system tends to be described as [27]:

$$H = \sqrt{\frac{K_{\text{Rician}}}{K_{\text{Rician}} + 1}} \, H_d + \sqrt{\frac{1}{K_{\text{Rician}} + 1}} \, H_r \qquad (20)$$

where H_d representing the component of the normalized deterministic channel   matrix,   while H_r representing   the component of random channel matrix, with; $|| H_d ||^2 = N_T M$, $||E\{ |[H_r]_{i,j}|^2\}= 1$, $i = 1: N_T, j = 1: M$ [28], while K_{Rician} is known as factor of the Rician channel which is the relation between the component of the specular power c^2 and the component of scattering power $2\sigma^2$, displayed as:

$$K_{\text{Rician}} = \frac{||H_d||^2}{E\left\{|[H_r]_{i,j}|^2\right\}} = \frac{c^2}{2\sigma^2} \qquad (21)$$

8.   SIMULATION RESULTS

The proposed system presented in section 6 is simulated using Matlab codes. Where the downlink transmitted signal from BS is received by two users as receivers. One of these users will act as a receiver user while the other user will act as a relay user and vice versa. Therefore, there are two channels, first-time slot channel between BS and the receivers (downlink channel) and second-time slot channel between the users (inter-user channels). The downlink channel is simulated as Rayleigh channel with zero-mean, while inter-user channels simulated as Rician fading channel with m-mean and unit-variance independent and identically distributed (i.i.d) complex Gaussian random variables. QPSK signal constellation has been used as a broadcast modulation in all simulations and the results are averaged through several channel investigations. For all receivers, the noise variance per receive antenna is supposed the equal, $\sigma_1^2 = . . . = \sigma_K^2 = \sigma^2$. The summary of parameters is shown in Table 1.

The BER performance of all the systems described is evaluated at BER 10^{-4} . An acceptable BER performance for voice communication is 10^{-4} [19], [24]. The BER performance of the beamforming based on SLR in SIC cooperative scheme BF(CS-SIC-BCH)(proposed scheme), comparing with beamforming based on SLR in Uncoded-Noncooperative system [19] as shown in Figure 3. The abbreviations used in the simulation results are listed in Table 2

Table 1. Simulation parameters

Parameters	Definition
Modulation mode	QPSK
No. of input data	10000
BER compassion Point	10^{-4}
Downlink channel	Rayleigh
Inter-user channels	Rician
SNR of inter user channel	$5 - 25$
Number of users (U)	2
Number of antennas for BS (M)	2,4,6
Number of antennas for each use (N)	2,4,5,6
Rician channel factor (K_{Rician})	$10 - 25$
Beta (β)	$0.1 - 0.9$
Bose–Chaudhuri–Hocquenghem (BCH)	[15,5]

Table 2. Simulation abbreviations

Parameters	Definition
Beamforming of SIC in Uncoded cooperative scheme	BF(CS-SIC)
Beamforming of SIC in Coded cooperative scheme.	BF(CS-SIC-BCH)
No. of transmitted antennas	T
No. of received antennas	R
Non-cooperative beamforming	BF
SNR of inter-user channels dB	SNRdBin
Factor of the Rician channel	KdB

Comparison with other research

Figure 3 shows the bit error ratio (BER) performance for the downlink of the proposed scheme and Non-cooperative system in case Bs antenna assigned with M = 4 and each user assigned with N= 5, in Rician inter-user channel SNR= 20 with K_{Rician}= 25 and β = 0.1. Where Figure 3, demonstrate the performance of beamforming based on SLR of SIC Uncoded-cooperative scheme BF(CS-SIC) is better than Uncoded-Noncooperative system [19]. More specifically, to achieve a BER of about 10^{-4} the required SNR for the BF(CS-SIC) is about 3 dB less than the Uncoded-Noncooperative system [19]. On other hands, the performance of beamforming of based on SLR in SIC cooperative scheme BF(CS-SIC-BCH) is better than Uncoded-Noncooperative system [19]. More specifically, to achieve a BER of about 10^{-4} the required SNR for the proposed scheme BF(CS-SIC-BCH) is about 10 dB less than the Uncoded-Noncooperative system [19]. Also, the performance of beamforming of based on SLR in SIC cooperative scheme BF(CS-SIC-BCH) is better than Uncoded-cooperative scheme BF(CS-SIC) as shown in in Table 3.
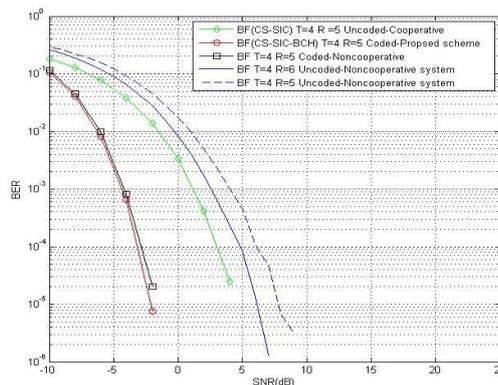

Figure 3. BER performances of the coded and Uncoded proposed scheme and Noncooperative system for M = 4 N= 5, in Rician inter user channel SNR= 20 with k = 25 and β = 0.1

Table 3. Describe of result in Figure 3

Parameters	BER compassion Point 10^{-4}
BF(CS-SIC) T=4 R=5	Required SNR 3
BF(CS-SIC-BCH) T=4 R=5	Required SNR -7
BF Coded-Noncooperative T=4 R=5	Required SNR -7.5
BF Uncoded-Noncooperative T=4 R=6 [19]	Required SNR 5
BF Uncoded-Noncooperative T=4 R=5 [19]	Required SNR 6.5

Figure 4, shows the comparison between Coded-Noncooperative system and the proposed scheme BF(CS-SIC-BCH) to select the optimum value of β. where a base station (BS) equipped with M=4 antennas communicates with N =4 in each user. We choose three different value β for the proposed scheme, to made comparison with Coded-Noncooperative system, first when β = 0.9, the performance of the Coded-Noncooperative system, which maximizes the useful power of users and neglects the multi-user interference, has better performance than the proposed scheme BF(CS-SIC-BCH). That is because the effect of multi-user interference is high, which becomes the main factor limiting 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 = 0.7 and 0.5 the effect of the interference on sharing signals is reduced. Therefore, the performance of the proposed scheme will be improved but still worse than the Coded-Noncooperative system. Whilst for the third scenario, when β = 0.1, noise is the main factor limiting the system performance. That is because the proposed scheme BF(CS-SIC-BCH) is making the interference signals turn into useful signals when it detected these signals by using SIC, and it could get the benefit from the multi-user interference via sharing these signals among users. Therefore, the performance of the proposed scheme BF(CS-SIC-BCH) will be improved as shown in in Table 4.

Figure 5, presents the performance of proposed scheme BF(CS-SIC-BCH) 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, and 25 dB. The result shows the performance of the system is enhanced when the inter- channel SNR increase.
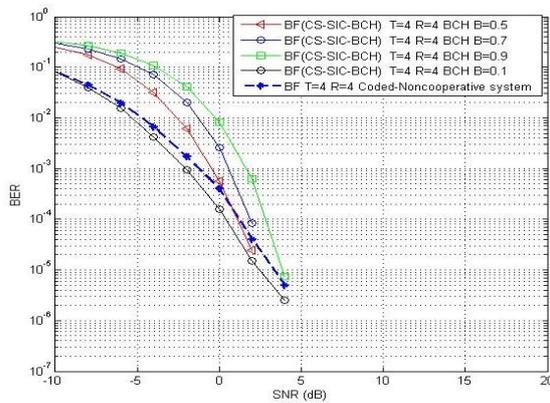

Figure 4. BER performances of the proposed scheme and Coded-Noncooperative system for M = 4 and N = 4 in Rician inter user channel with k=25 and SNR = 20
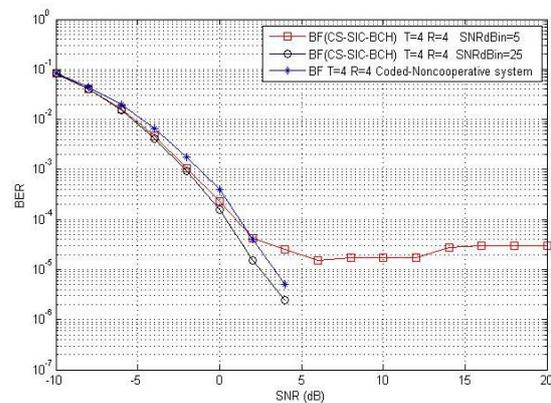
Figure 5. BER performances of the proposed and anchor scheme for M = 4 N= 4, in Rician inter user channel with k = 25 and β = 0.1

Table 4. Describe of result in Figure 4

Parameters	BER compassion Point 10^{-4}
BF(CS-SIC-BCH) T=4 R=4 B=0.1	Required SNR 1
BF(CS-SIC-BCH) T=4 R=4 B=0.5	Required SNR 2
BF(CS-SIC-BCH) T=4 R=4 B=0.7	Required SNR 2.3
BF(CS-SIC-BCH) T=4 R=4 B=0.9	Required SNR 3
BF Coded-Noncooperative T=4 R=4	Required SNR 2

Figure 6, 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 BF(CS-SIC-BCH) is better than the performance of the Coded-Noncooperative system. More specifically, in case k = 25 to achieve a BER of about 10^{-5} the required SNR   for the proposed scheme BF(CS-SIC-BCH) is about 1 dB less than Coded-Noncooperative system. It also shows the proposed scheme BF (CS-SIC-BCH) performance is worse than the Coded-Noncooperative system 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 as shown in in Table 5.
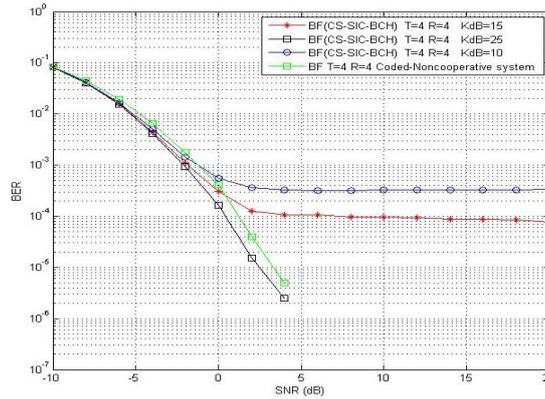
Figure 6. BER performances of the proposed and Coded-Noncooperative system for M = 4 N= 4, in LOS
environment of inter user channel SNR=20, β = 0.1

Table 5. Describe of result in Figure 6

Parameters	BER compassion Point 10^{-4}
BF(CS-SIC-BCH) T=4 R=4 KdB=25	Required SNR 1
BF(CS-SIC-BCH) T=4 R=4 KdB=15	Required SNR 4
BF(CS-SIC-BCH) T=4 R=4 KdB=10	Required SNR 2 at 10^{-3}
BF Coded-Noncooperative T=4 R=4	Required SNR 2

Figure 7, shows comparison between BER performance BF(CS-SIC-BCH) and the Coded-Noncooperative system employed multi-antenna in both Bs and users, where BS antennas M = 2,4 and 6 while users antennas U = 2,4 and 6, the result shows the system has a significant improvement for M = 6, N=6 in both Coded-Noncooperative system and proposed scheme BF(CS-SIC-BCH), while the proposed scheme BF(CS-SIC-BCH) still got enhancement comparing with Coded-Noncooperative system as shown in in Table 6.
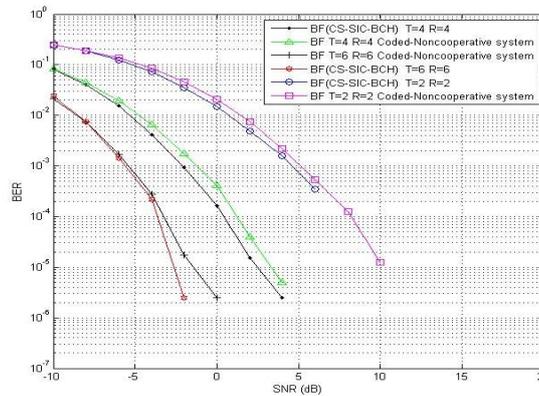

Figure 7. BER performances of the proposed and Coded-Noncooperative system for M =2, 4 and 6,
N = 2, 4 and 6, in Rician inter user channel with k = 25 with SNR=20, β = 0.1

Table 6. Describe of result in Figure 7

Parameters	BER compassion Point 10^{-4}
BF(CS-SIC-BCH) T=2 R=2	Required SNR 3
BF Coded-Noncooperative T=2 R=2	Required SNR 3.5
BF(CS-SIC-BCH) T=4 R=4	Required SNR 1
BF Coded-Noncooperative T=4 R=4	Required SNR 2
BF(CS-SIC-BCH) T=6 R=6	Required SNR 2.5
BF Coded-Noncooperative T=6 R=6	Required SNR 2

9.   CONCLUSION

In this paper, the beamforming base on maximizing the signal to leakage Ratio are employed in download cooperative scheme. Successive interference cancellation detector is used in each cooperative user to separate the leakage signal from the desired signal and exploit the leakage power as a useful power in the second time slot after user cooperation. More explicitly, an updating in maximizing SLR power constraint problem is proposed which is aiming to fully benefit from leaking power to each user. The Rayleigh fading downlink channel in the first-time while Rician fading inter-user channel in the second time slot. Bose–Chaudhuri–Hocquenghem (BCH) codes employed in Beamforming of (SIC) cooperative scheme BF(CS-SIC-BCH) in order to enhance the BER performance. The results show the performance of the proposed scheme outperforms the Coded-Noncooperative system.

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BIOGRAPHIES OF AUTHORS

Mohammed Fadhil received the B.Sc. degree in electrical engineering from AL-Mustansiria University, College of Engineering, Iraq 2001 and the M.Sc. degree from University Tenaga National (UNITEN), Malaysia in 2013. He is currently Ph.D. candidate at Universiti Kebangsaan Malaysia (UKM), His research **interests** include wireless communication, with a focus on cooperative communication and beamforming.

Nor Fadzilah Abdullah received her B.Sc. degree in Electrical and Electronics from Universiti Teknologi Malaysia in 2001, M.Sc. degree (Hons.) in Communications Engineering from University of Manchester, U.K. in 2003, and Ph.D. degree in Electrical and Electronic Engineering from University of Bristol, U.K., in 2012. She is currently a Senior Lecturer in Universiti Kebangsaan Malaysia, Selangor, Malaysia. Her research interests include 5G, millimeter wave, LTE-A, vehicular networks, massive MIMO, space time coding, fountain codes, channel propagation modelling and estimation. Shehas been an IEEE member since March 2008.

Mahamod Ismail received the B.Sc. degree in electrical and electronics from the University of Strathclyde, U.K., in 1985, the M.Sc. degree in communications engineering and digital electronics from the Institute of Science and Technology, University of Manchester, Manchester, U.K., in 1987, and the Ph.D. degree from the University of Bradford, U.K., in 1996. He joined the Departmentof Electrical, Electronics and Systems Engineering, Faculty of Engineering and Built Environments, Universiti Kebangsaan Malaysia, in 1985, where he is currently a Professor in communications engineering. He was with the first Malaysia Microsatellite TiungSat Team Engineers in Surrey Satellite Technology Ltd., U.K., for nine months beginning in 1997. His research interests include mobile, wireless networking, and radio resource management for the next generation wireless communication.

Rosdiadee Nordin received the B.Eng. degree from the Universiti Kebangsaan Malaysia in 2001 and the Ph.D. degree from the University of Bristol, U.K., in 2011. He is currently a Senior Lecturer with the Department of Electrical, Electronics and System Engineering, Universiti Kebangsaan Malaysia, teaching different subjects related to wireless networks and mobile and satellite communications. His research **interests** include resource allocation, green radio, multiple-input multiple-output, orthogonal frequency-division multiple access, carrier aggregation, cognitive radio, and indoor wireless localization.

Cebrail Ciflikli was born in K. Maras, Turkey, in 1961. He received the Ph.D. degree in electronics engineering from Erciyes University in 1990. In 2004, he joined Erciyes University Kayseri Vocational College as Professor where he is now Principal. Dr. Ciftlikli's current research interests include spreadspectrum communications, wireless ATM/LAN, signal processing, DSCDMA system engineering, RF power amplifier linearization for wireless communication systems.

Musaab Sami Al-Obaidi was born in Bagdad, Iraq, in 1981. 2000-2004 B.Sc. in department of Electrical engineering-Al-Mustanseria University/Iraq. 2010-2013 M.Sc. in Electrical Engineering / Universiti Tenaga Nasional/Malaysia. Since 2014 he is PhD student in Erciyes University.