Capacity Enhancement of Multiuser Wireless Communication System through Adaptive Non-Linear Pre coding

Dalveer Kaur, Neeraj Kumar

Department of Electronics & Communication Engineering, I.K Gujral Punjab Technical University, Jalandhar, India

Abstract: Multiuser multiple-input multiple-output (MIMO) nonlinear pre coding techniques face the issue of poor computational scalability of the size of the network. But by this nonlinear pre coding technique the interference is pre-cancelled automatically and also provides better capacity. So in order to reduce the computational burden in this paper, a definitive issue of MU-MIMO scalability is tackled through a non-linear adaptive optimum vector perturbation technique. Unlike the conventional (Vector Perturbation) VP methods, here a novel anterograde tracing is utilized which is usually recognized in the nervous system thus reducing complexity. The tracing of distance can be done through an iterative-optimization procedure. By this novel non-linear technique the capacity is improved to a greater extend which is explained practically. By means of this, the computational complexity is managed to be in the cubic order of the size of MUMIMO, and this mainly derives from the inverse of the channel matrix. The proposed signal processing system has been implemented in the working platform of MATLAB/SIMULINK. The simulation results of proposed communication system and comparison with existing systems shows the significance of the proposed work.

Keywords: adaptive optimum vector perturbation technique, anterograde tracing, multiple loop interference cancellation filters, equal probability (EP) algorithm.

1. Introduction

A wireless communications system incorporates a base station and a variety of terminal units comprising the storage unit and the communication unit which can be a mobile, radio transmission, microwave transmission, infrared and millimeter waves etc. The base station constitutes connections among sets of two or more of the mobile units so as to privilege private, full-duplex conversations that access within various set of terminal units [1]. The base station allots packet time slots for each active terminal unit to transmit, and dynamically diminishes the allocation per terminal unit only as the number of active terminal units increments [2]. The transmitter or the source transmits the message to the receiver or the destination through a secure channel that can be a satellite or a radio channel. The transmitter includes a microcontroller which transmits digital data to the receiver [3]. The data is encoded by the transmitter which is split into different streams and then the split encoded stream is transmitted to different transmit antennas. This output is received by the receiver where the decoder is obtained [4].

Some of the common challenges which tend to occur in the wireless communication network include the security vulnerabilities, some influence which can be made by the climatic conditions, interference from the other wireless devices etc. [5]. Apart from this the wireless network also includes problems such as the user mobility, noise limitations, spectrum limitations, energy limitations, multipath propagation which lead to the complications such as the fading and ISI (Inter Symbol Interference) [6]. The spectrum limitations occur since the spectrum available is limited and is also regulated by international agreements. In case of the user mobility the system should be aware of the cell which the user is using every time. The noise is added to the transmitted signal during the transmission through a communication channel or the radio channel which reduce the signal quality [7]. The interference signal usually is capable of modifying the transmitted signal recognized in the channel between the transmitter and the receiver. The interfering signal obtained is decoded by the receiver and it is cancelled from the original message [8].

It is seen that the 4G wireless network, the LTE and CRN plays a vital role. There has been a developing pattern toward applying game theory (GT) to different building fields keeping in mind the end goal to take care of improvement issues with various contending elements/benefactors/players. Looks into in the fourth era (4G) remote net-work field additionally misused this propelled theory to defeat long-term evolution (LTE) difficulties, for example, asset portion, which is a standout amongst the most vital research points. Truth be told, an effective de-indication of asset assignment plans is the way to higher execution. Be that as it may, the standard does not indicate the advancement way to deal with executes the radio asset administration and in this way it was left open for thinks about. 4G-LTE radio asset distribution issue and its improvement [9].Cognitive radio networks (CRNs) have risen as a worldview tending to the issue of restricted range accessibility also, the range underutilization in remote networks by entrepreneurially abusing bits of the unused range by authorized essential clients. Routing in CRNs is a testing issue because of the PU exercises and versatility that are past the control of CRNs. Then again, vitality mindful routing is exceptionally essential in vitality limitation CRNs. Keeping in mind the end goal to outline a strong routing plan for portable cognitive radio specially appointed networks (CRANs), the requirements on lingering vitality of every CR client, dependability, and the assurance of Pus should furthermore be taken into account. In addition, multipath routing has awesome potential for enhancing the conclusion to-end execution of specially appointed networks. [10].

In some cases, more than one transmitter and receiver stations are identified which results in the MU-MIMO (Multi User Multi Input Multi Output) where the base station execute scheduling scheme for scheduling the perfect terminal on the basis of the channel information which is fed to a variety of terminals [11]. By the usage of the MU-MIMO the inter-user interference complication can be eliminated but some practical complications are identified during implementation and the capacity and the reliability will be improved. Since there are large numbers of antennas, it is not possible to extend expensive and powerful hardware with small noise and distortion at the base station [12]. The techniques used to solve include the linear and non-linear pre coding. In existing paper the linear pre coding used is Zero-Forcing Coding (ZF) where an approximation to the distribution of the instantaneous per-terminal SNR of a ZF MU-MIMO system is presented to rectify the SNR (Signal to Noise Ratio) [13].

The linear Beam forming algorithm is also presented as a pre coding technique which is utilized for multi user Multi Input Single Output System (MU-MISO). A heuristic hybrid beam forming design was proposed that achieves a performance close to the performance of the fully digital beam forming baseline was designed also it establishes that if the number of RF chains is twice the total number of data streams, the hybrid beam forming structure can appreciate any fully digital beam former exactly, irrespective of the number of antenna elements [14]. The ZF and the Beam forming algorithms were also used hybrid and distributed implementations is facilitated by using Charnes-Cooper's transformation [15]. The nonlinear pre coding is identified better than the linear pre coding algorithm since the interference cancellation is done automatically and also it performs better. The nonlinear robust Tomlinson-Harashima pre coding outperforms by transforming the robust transceiver design problem into a difference of convex programming [16]. Capacity enhancements of multiuser wireless communication system through adaptive non-linear pre coding were addressed here. The outline of this paper is summarized as follows. Section 2 deals with related research problems. Section 3 discussed about the multiuser wireless communication system. Section 4 discussed about the simulation result and performance evaluation of this research and conclusion is stated in section 5.

2. Related Work

Some of the recent related works regarding multiuser wireless communication problems is discussed as follows

Jin *et al.*[17] presented about the massive multiple-input multiple-output (MIMO) antenna system that use of an enormous number of base station (BS) antennas to handle a small number of user terminals (UTs) for spectral efficiency. Due to the unavoidable reuse of pilot sequences from UTs the performance was identified limited by pilot contamination. The performance of massive MIMO zero-forcing (ZF) systems was analyzed using the time-shifted pilot scheme by which the achievable sum rates and the associated SINRs for both forward link and reverse link were derived which was tend to work with both the limited and unlimited antenna cases. Moreover, a user scheduling algorithm LCFS was introduced based on the difference between the MIMO zero-forcing system and the time shifted pilot scheme which that promote the rate and fairness performance for conjugate pre coder. Due to the use of the time shifting pilot scheme the interference process which occurs in the MIMO system can be reduced to minor state. This process is mainly employed to improve the throughput of system. In turn there arise a drawback in LCF which fails to optimize the seek time.

Huberman *et al.* [18] have presented a single or multi-user Multiple Input-Multiple-Output (MIMO) Full-Duplex (FD) pre coding transceiver structure relevant for single-carrier and Orthogonal Frequency Division Multiplexing (OFDM) systems. The cancellation of self-interference and for the combination of the forward beam forming with pre coding at the transmitter, its dimensionality was increased. A separate and a joint pre coding design was presented for sum-rate maximization where the joint designs make the benefit of Sequential Convex Programming (SCP).Other than the self-interference minimization the MIMO FDP structure that confess for different algorithms and optimization objectives. The separate FDP algorithm was identical to a self-interference canceller, where the cancellation is done by pre coding other than a self-interference while the joint FDP algorithms take procession of sequential convex programming. Although the separate and join designs offer an identical sum-rate performance; the amount of cancellation power was limited and further the joint FDP algorithm contribute performance improvements. Computational time and tradeoff are some factors are which needs improvement in FDP.

Christus masouros *et al.*[20] have considered a K link multiple-input multiple-output (MIMO) interference channel in which each link comprised of two full-duplex (FD) nodes exchanging information simultaneously in a bi-directional communication mode. The nodes in each pair suffered from self-interference occurred due to operating in FD mode, and inter-user interference from other links occurred due to accompanied transmission at each link. The transmitter and receiver filter design for Weighted Sum-Rate (WSR) maximization problem prone to sum-power constraint of the system at each node of the system. A low complexity alternating algorithm was recognized based on the relationship between WSR and Weighted Minimum-Mean-Squared-Error (WMMSE) problems for FD MIMO interference channels. The algorithm introduced was identified is not only applicable to FD cellular systems, in which a base station (BS) operating in FD mode serves multiple uplink (UL) and downlink (DL) users operating in half duplex(HD) mode, simultaneously along with FD MIMO interference channels. This provides acceptable spectral efficiency of optimized half duplex for SU-MIMO considerations anyhow there is a lagging in throughput of this system.

Masouros *et al.* [19] had introduced a data-aided transmit beam forming scheme for the multi-user multiple-input-single-output (MISO) downlink channel. In contrast with the conventional beam forming schemes aim the identified method used the knowledge of the data and the channel state information (CSI) at the transmitter to exploit interference other than suppression. Apart from that another pre coding scheme was designed for the MISO downlink that minimizes the transmit power for generic phase shift keying (PSK) modulated signals. The designed pre coder reduces the transmit power by the adaption of the QoS constraints to accommodate constructive interference when compared to conventional schemes. The designed scheme achieved the required QoS at lower transmit power by exploiting the power of the interference symbols and was extended to the signal to interference plus noise ratio (SINR) balancing problem. Additionally, equivalent virtual multicast formulations were derived for both optimizations. Finally, a beam forming technique was also introduced to deal with, that reduces the transmit power over conventional techniques and the required QoS was guaranteed. By using this technique the optimization of conventional transmit power occurs which in turn saves small scale MISO downlink channels with data-aided optimization. Reduced CSI must to be considered as drawback in turn reduces throughput.

Moretti *et al.* [21] had dealt with resource allocation scheme in the downlink of spatial multiplexing multiple-input–multiple-output (MIMO)-orthogonal frequency-division multiple-access (OFDMA) SDMA-MIMO-OFDMA systems. The problem of optimizing the transmitter and receiver processing matrices, the channel assignment, and the power allocation were concentrated with the objective of minimizing the total power consumption at the same time different quality-of-service (QoS) requirements are also satisfied. The introduced solution relied on the layered architecture in which MAI (Multiple Access Interference) was first removed by means of a THP technique operating at user level. A layered architecture was utilized where the users were first partitioned in different groups on the basis of their channel quality, and then channel assignment and transceiver design were addressed using a ZF-based approach. A Tomlinson–Harashima pre coder was utilized by which the multiuser interference among users belonging to different groups was removed at the base station (BS). This is mainly implemented to minimize the power consumption by satisfying the specific requirements of QOS given as the sum of the MSEs over the assigned subcarriers but further power consumption is needed and better transmit power.

Thus in above techniques discussed there are some drawbacks in terms of computational time, capacity and throughput. All the above criterias are considered and overcome in our framework.

3. Capacity Enhancement of MU-MIMO Wireless Communication System

The wireless communication system is meant for transmitting and receiving the voice or the data with the aid of electromagnetic waves. This information between the transmitter and the receiver is usually carried within a well-defined channel which imports a fixed frequency bandwidth and a capacity. The transmitter provides the message to the receiver through a secure communication channel. Also, the message sent by the transmitter is encoded by the encoder and then it is provided to the receiver. The receiver decodes the signal and eliminates the interference which is send along with the encoded message.

The wireless communication system includes the complications such as the security vulnerabilities, low capacity, high complexity, low speed. Also, for setting the infrastructure it requires high cost, it is also influenced by the climatic conditions, physical obstructions etc. Interference is another complication which is identified by the effect of nearby wireless devices. The nonlinear pre coding rectifies the above-mentioned problems along with the cancellation of the interference and enhances the capacity. In order to solve these problems the adaptive optimum vector perturbation technique along with multiple filters is presented.

Figure 1 shows the process flow of the proposed approach. The proposed methodology describes about the MU-MIMO which includes multiple transmitter, multiple receiver and communication channel. Initially transmitter transmits the signal to the receiver through the communication channel by pre coding process for which adaptive optimum vector perturbation technique is utilized. In this algorithm the Euclidean distance is replaced by utilizing anterograde tracing. After pre coding, scheduling is done by utilizing equal probability (EP) algorithm then the pre coded signal is fed as input to the communication channel, where communication channel adds noise along with interference.

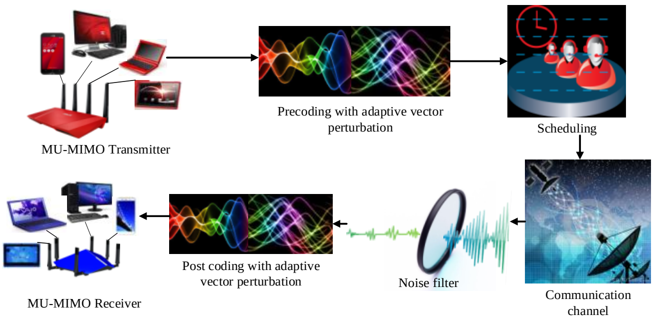

Figure 1: An MU-MIMO System with Adaptive Vector Pre coding

After that multiple loop interference cancellation filter is utilized to cancel the interference and also the capacity is enhanced also the Gaussian noise occurred is also reduced simultaneously. The pre coded message from the transmitter is post coded in the receiver and the corresponding message is obtained. The multiple receivers have some complications regarding the recognition of appropriate receiver and finally the corresponding recipient sends the message receipt after signal delivery.

3.1. Channel model for MU-MIMO wireless communication system

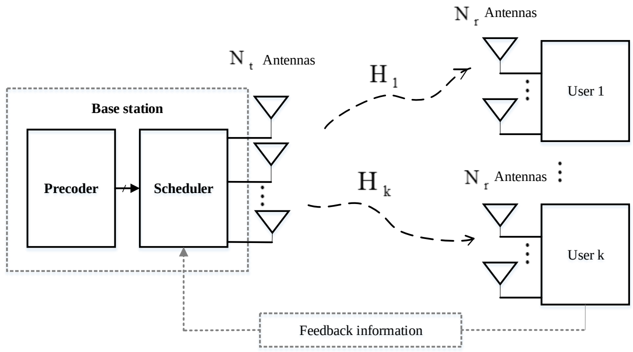

Figure2. Channel model for MU-MIMO wireless communication system

Figure 2 shows the Channel model for MU-MIMO wireless communication system. Initially the transmitter transmit the input signal T and the received signal at receiver is given as,

$$R = HT \tag{1}$$

Consider a MIMO multiuser transmission system, the coupling between the transmitter and receiver can be modelled using

$$R = HT + k \tag{2}$$

Where H is the $n_R \times n_T$ (number of receive antenna by transmit antenna) channel matrix, containing the complex attenuation between each transmit and receive antenna, T is an $n_T \times n_S$ matrix containing the n_S samples of the transmit array vector, R is an $n_R \times n_S$ matrix containing the n_S

samples of the complex receive-array output and k is an $n_R \times n_S$ matrix containing zero-mean complex Gaussian noise and is added in the communication channel. It is often useful to investigate the structure of the channel matrix and the mean-square attenuation independently. This can be achieved by studying the root-mean-square normalized channel matrix

$$\overline{H} \equiv \frac{1}{m} H \tag{3}$$

$$m^2 \equiv \frac{\|H\|_F^2}{n_T n_R} \tag{4}$$

Where m^2 is the mean-square transmitter-to-receiver attenuation, $\overline{H}$ is the normalized channel matrix, and $\|\Lambda\|_F$ indicates the Frobenius norm. The input signal from the transmitter is fed to the pre coding section.

3.2 Adaptive optimum vector perturbation technique for pre coding

Pre coding is a technique which misuses transmit diversity by weighting information stream, i.e. the transmitter transmits the coded information to the receiver in order to the pre-learning of the channel. The receiver is a simple detector which does not have any knowledge about channel side information.

In multi-user MIMO, a multi-antenna transmitter communicates at the same time with multiple receivers (each having one or multiple antennas) known as space-division multiple access (SDMA). Pre-coding algorithms for SDMA systems can be sub-separated into linear and nonlinear pre coding types. Linear pre coding approaches as a rule achieve sensible performance with much lower complexity, however the interference cannot be canceled automatically and practically capacity achieving algorithms are nonlinear. It is designed in light of the concept of dirty paper coding (DPC), which demonstrates that any known interference at the transmitter can be subtracted without the punishment of radio resources if the ideal pre-coding scheme can be connected on the transmit signal.

This can be seen as a multi-objective optimization issue where each objective corresponds to maximization of the capacity of one of the clients. For simplify this problem we are using adaptive optimum vector perturbation. Usually the perturbation technique uses the Euclidean distance to measure the distance between the transmitter and receiver where the complexity increases. Here we replace the Euclidean distance by utilizing Anterograde tracing by which the complexity is reduced to a greater extend by iterative processing and also the capacity enhancement is also made alternatively and is explained mathematically. It traces the distance between the transmitter and the receiver. This anterograde tracing was usually recognized in the nervous system which is used to trace the axonal projections from the source i.e. the cell body to the point of termination i.e. synapse perfectly and also allow mapping of connections between neurons. The iterative tracing is done with the help of the objective function and hence reduces the complexity and the performance is improved by including multiple iterations also reducing the coverage problems.

Generally in the Euclidean distance estimation the minimum mean square error is utilized where some information loss occurs but in the anterograde tracing sigmoid function is utilized that derives a maximum entropy level i.e. by information theory all the information given through the communication channel is given clearly to the receiver. Non-linear sigmoid function applied to the signal by anterograde tracing before transmitting in order to express the derivative in terms of mathematical function such as

$$f'(T_i) = f(T_i)(1 - f(T_i)) \tag{5}$$

where $f(T_i)$ is a sigmoid function.

$$f(T_i) = \frac{T_i}{(1+T_i)^2} \tag{6}$$

Consider transmit vector constructed from the user data vector $v = [v_1, v_2, ...v_N]^{\omega} \in D^{N\times 1}$ and perturbation vector $u = [u_1, u_2, ...u_N]^{\omega} \in D^{N\times 1}$ such that,

$$T = v + \omega u \tag{7}$$

Where, ω is a positive scalar u is a complex Gaussian integer vector that is, $u_i \in \{b + ja | b, a \in Y\}$, $i = 1,.......N$. Transmit vector T is pre coded by the pre coder matrix $Z \in D^{P\times N}$ to produce pre coded symbol vector $c = [c_{1,} c_2, ...c_P]^{\omega} \in D^{P\times 1}$ that is $c = ZT$. Consequently, each user for example the $i-th$ user receives the signal $R_i \in D$ over the channel $Ch_i \in D^{P\times 1}$ contaminated by the additive white Gaussian noise $k_i \in D$ and $k_i \sim Cn(0, K_o)$. $Cn(0,\sigma)$, denotes a zero-mean circularly symmetric complex Gaussian (CSCG) random variable with variance σ. We consider a spatially uncorrelated Rayleigh fading environment that is the elements of Ch_i is independent and identically distributed $Cn(0,1)$. As a result the received signal of $i-th$ user R_i can be written as,

$$R_i = Ch_i^H c + k_i, \; i = 1,.........N \tag{8}$$

The user scales R_i by the normalization factor $\alpha(>0)$ that has been chosen to satisfy the base station power constraint. Therefore the scaled received signal $\hat{T}_i = \alpha R_i$, $i = 1,......N$ can be given by,

$$\hat{T} = \alpha H c + \alpha k \tag{9}$$

Where $H = [Ch_1, Ch_2, ...Ch_n]^H$, $k = [k_1, k_2 ....k_n]^{\omega}$ and $\hat{T} = [\hat{T}_1, \hat{T}_2, ...\hat{T}_N]^{\omega}$. The impact of channel quantization errors on the performance of VP pre coding, each user is assumed to obtain Ch_i perfectly, check its channel direct information $(\text{i.e.}, Ch_i / |Ch_i|)$ against a pre-agreed codebook, and feed the index of the best match back to the base station.

ω, is chosen to provide symmetric decoding regions around constellation points and the choice $\omega = 2(|C|_{\max} + \Delta/2)$ where, $(|C|_{\max})$ is the absolute value of the value of the largest magnitude constellation symbol and Δ is the spacing between constellation points, serves this purpose. With this choice for ω, each user is able to apply modulo function $f_\omega(.)$ on $\hat{T}_i$ independently (i.e., without cooperation) and remove u_i without knowing its value. Here, $f_\omega(b) \underline{\underline{\Delta}} b - [(b+\omega/2)/\omega]\omega$ where $[.]$ denotes the largest integer less than or equal to its argument. Note that $f_\omega(.)$ is independently performed on both real and imaginary components of $\hat{T}_i$.

3.3 Equal probability (EP) algorithm for scheduling

Assume that the BS schedules in each slot on each beam where a single user is randomly chosen among the positive feedback for that beam reported.. According to the conservative rate assignment, the average sum-rate is formulated as,

$$R_{SUM} = \sum_{j=1}^{J} R_j = \sum_{j=1}^{J}\sum_{l=1}^{L} P^S(j,l)\log_2(1+\beta_j) \quad (10)$$

Depends on the probability of scheduling the user j on beam l, here rewritten as

$$P^S(j,l) = \left(\sum_{d=1}^{J} P_l(d \mid j)\frac{1}{d}\right) p(\gamma_{j,l} \geq \beta_j) \quad (11)$$

Where $P_l(d \mid j)$, is the probability that d users (out of J) exceed their thresholds on beam l conditioned to the event that the user j exceeds its threshold on the same beam l, and $p(\gamma_{j,l} \geq \beta_j)$ is the probability that the SINR of user j on beam l exceeds the threshold β_j. The beam forming randomization of opportunistic strategy implies that the SINR probability density function experienced by each user depends only on the channel power p_j and on the receiver characteristics (namely the number of antennas No_l and the receiver's combining scheme), but it is independent of the beam index l, so that $p(\gamma_{j,l} \geq \beta_j) = p(\gamma_{j,l} \geq \beta_j)$. Hence, all the beams have the same (average) performance and thus the beam index *m* will be omitted. The sum-rate (11) reduces to:

$$R_{SUM} = \sum_{j=1}^{J} L\left(\sum_{j=1}^{J} P(d \mid j)\frac{1}{d}\right) p(\gamma_j \geq \beta_j)\log_2(1+\beta_j) \quad (12)$$

The drawback to sum-rate (12) maximization is the need to set up a centralized optimization problem to evaluate all the optimal thresholds β_j in addition to the lack of a manageable expression for $P(d \mid j)$. The nearly-optimal distributed threshold estimation algorithm described below guarantees the evaluation of a set of thresholds β_j for the asymptotical maximization of the sum-rate based on local estimates carried out by each MS independently.

The EP threshold setting algorithm forces all the J users to set their SINR threshold on any of the beams according to the system-defined feedback loading probability

$$\overline{F} = p(\gamma_j \geq \beta_j) \quad (13)$$

Once every MS is aware of the system-defined feedback probability value $\overline{F}$, it can locally evaluate its SINR threshold by solving (13) for β_j. From a practical point of view, it is convenient to redefine (13) according to the scheduling outage probability (i.e., the probability that no user exceeds its threshold on a given beam and thus the beam is not used):

$$P_{out} = (1-\overline{F})^J \quad (14)$$

Sum-rate (12) and thresholds $\{\beta_j\}$ can thus be rewritten in terms of outage probability P_{out} once it is known the number of users J. Channels independence implies that the scheduling probability is the same for all the users so that

$$P^S(j) = P^S = \frac{1-P_{out}}{J} \quad (15)$$

Therefore, when constraint (13) holds the resources are shared in a fair way among all the J MSs with respect to the scheduling probabilities. The achievable sum-rate (12) under EP scheduling constraint (13) reduces to

$$R_{SUM} = L\frac{1-P_{out}}{J}\sum_{j=1}^{J}\log_2(1+\beta_j(P_{out})) \quad (16)$$

Where we highlighted the dependence of β_j from P_{out}. The sum-rate maximization problem is thus reduced to optimizing the system-defined outage probability value P_{out} in (16). As it will be shown in the next paragraph, the nearly optimal value of P_{out} (or equivalently $\overline{F}$ according to (14)) can be locally evaluated by the BS and all the MSs without any need for dedicated signalling.

After scheduling the pre coded signal is fed to the communication channel. Then the interference will acquires. The interference is anything which modifies, or disrupts a signal as it travels along a channel between a source and a receiver. The interference matrix is E, $E = [E_1, E_2, ...E_P]^\omega$ Then the output from the communication channel is

$$I = (\alpha Hc + \alpha k)E \quad (17)$$

3.4 Multiple loop interference cancellation filter

We define $T = [T_1, T_2, ...T_P]^\omega \in D^{P\times 1}$ and $R = [R_1, R_2, ...R_P]^\omega \in D^{P\times 1}$, and these are the vector of the data signal at the BS and the vector of the received signal at the MSs, respectively. After pre coding the signal changes in the form of $\hat{T}_i = \alpha R_i$. The inter-antenna/multi-stream interference is mitigated using pre coding matrix $Z \in D^{P\times N}$ at the BS. The loop interference Matrix E is cancelled using cancelling matrix C. Note that the dimension of matrices Y and C are $M \times M$ and $N \times N$, respectively.

$$C = [E_{1,} E_2, ...E_P]^{\omega} \quad (18)$$

The BS transmits data signal T to the MS. The channel receives the signal and then cancels the loop interference $E = [E_{1,} E_2, ...E_P]^{\omega}$ by using C. The signal after the loop interference cancellation, can be written as

$$f = \frac{(\alpha Hc + \alpha k)E}{C} \quad (19)$$

That complication includes the interference cancellation that also comprises loop interference caused by coupling, ILS (Integer Least Square), coverage problems. After loop interference cancellation, the signal is processed using weighting matrix W and then transmitted to the MSs. The received signal at the MSs can be written as

$$f = \alpha Hc + \alpha k \quad (20)$$

Where k is the vector of noise at the MSs. Then the noise is removed by using k_0

$$f = \alpha Hc + \alpha k - k_0 \quad (21)$$

The received signal at the MSs can be rewritten as

$$f = \alpha Hc \quad (22)$$

3.5 Adaptive optimum vector perturbation technique for Post coding

The pre coded message from the transmitter is post coded in the receiver and the corresponding signal is obtained. By the usage of the adaptive non-linear vector perturbation technique the corresponding capacity improvement is made in the receiver side. The multiple receivers have some complications regarding the recognition of appropriate receiver. Finally the corresponding recipient sends the message receipt after signal delivery. It is a reverse process of pre coding. Here the matrix Z and α normalization factor can be removed. Thus the receiver gets the original signal as output.
The received signal at the receiver can be rewritten as

$$R = \alpha Hc \quad (23)$$

Where $c = ZT$ then the received signal is

$$R = \alpha HZT \quad (24)$$

In the post coding we remove the normalization factor and pre coded matrix.

$$R = \frac{\alpha HZT}{Z\alpha} \quad (25)$$

Then we get the original signal as output

$$R = HT \quad (26)$$

3.6 Multiuser MIMO Capacity

The multiuser system capacity enhancement made in the receiver side is then a simple extension of channel capacity for single-input single-output channels with memory can be expressed mathematically as

$$\overline{C}a = \frac{1}{L}\sum_{P=1}^{v} \log_2 \det\left(\frac{[T_1, T_2, ...T_N]^{\omega} + I}{[k_1, k_2 ....k_n]^{\omega}} \right) \quad (27)$$

where v is a single user. L is Data transmitted in blocks of symbols of length. $\det(.)$, represents the determinant of the input matrix $|\bullet|$ takes the modulus of every entry of the input matrix.
MIMO and the upper bound are based on diagonalization and uncoupled channels result, capacity is readily calculated (27). To allow performance comparisons in addition to bit-error rate (BER), we introduce an approximate capacity measure. Such a measure is based on the use of the Gaussian assumption which implies that the interference becomes Gaussian distributed when there are several users. Suppose that we have a linear model similar $R = HT + k$.
where k is the undesired signal vector which can be correlated noise. Assuming that k is Gaussian with covariance matrix $[k_1, k_2 ....k_n]^{\omega}$ and is uncorrelated with T. From (27), we know that the capacity is of the form

$$Ca = \log_2 \frac{\det([T_1, T_2, ...T_N]^{\omega})}{\det([k_1, k_2 ....k_n]^{\omega})} \quad (28)$$

After some manipulation, (28) can be simplified as

$$Ca = \log_2 \frac{\det(\mathrm{H}[T_1, T_2, ...T_N]^{\omega} + \Phi)}{\det \Phi} \quad (29)$$

The multiuser MIMO channel capacity is just a simple extension of (29). Using the system model defined in Section 3.1, the total capacity per transmission of the P[th] user link, Ca_P, can be found by

$$Ca_P = \log_2 \frac{\det(\mathrm{H_P} T_P + \Phi_P)}{\det \Phi_P} \quad (30)$$

where

$$\Phi_\mathrm{P} = \sum_{\substack{\bar{P}=1 \\ \bar{P} \neq P}}^{v} \mathrm{H_P} T_P + k_P I \quad (31)$$

As a result, the overall system spectral efficiency of a multiuser MIMO system is given by

$$\overline{C}a = \frac{1}{L}\sum_{P=1}^{v} Ca_P \text{bits/transmission} \quad (32)$$

The above capacity expression is generally not exact, but is a good approximation when the number of users or the number of transmits antennas is large by central limit theorem. Because this approximate capacity expression inherits the relations between the co-channel signals, capacity based on (32) is still used for primary performance comparison even for the case when the number of users and the number of transmit antennas are small.

Table 1. Nomenclature

VARIABLES	EXPLANATION
R	receive-array output
H	channel matrix
T	transmit array vector
k	Gaussian noise

n_R	number of receive antenna
n_T	number of transmit antenna
n_S	number of samples
m	mean-square transmitter-to-receiver attenuation
u	perturbation vector
v	user data vector
ω	positive scalar
D	channel side information quantization
Z	Pre coder matrix
Y	Complex function
a	imaginary components
b	Real components
c	Pre coded symbol vector
$Cn(0,\sigma)$	zero-mean circularly symmetric complex Gaussian
α	normalization factor
$\hat{T}$	scaled received signal
$f_\omega(.)$	modulo function
$(\lvert C\rvert_{\max})$	absolute value of the value of the largest magnitude constellation symbol
Δ	spacing between constellation points
R_{SUM}	average sum rate
j	user
l	Beam index
$P^S(j,l)$	Probability of scheduling the user j on beam l.
$P_l(d \mid j)$	probability that d users (out of J) exceed their thresholds on beam l conditioned to the event that the user j exceeds its threshold on the same beam l
$p(\gamma_{j,l} \geq \beta_j)$	probability that the SINR of user j on beam l exceeds the threshold β_j
p_j	channel power
No_l	number of antennas
$\overline{F}$	feedback probability value
P_{out}	outage probability
E	Interference matrix
C	cancelling matrix
W	Weighted matrix
L	symbols of length
Ca	channel capacity

4. Simulation results and discussion

This section presents the simulation results in the proposed research work. Our proposed work has been implemented in the MATLAB/SIMULINK platform. The proposed methodology describes about the MU-MIMO which includes multiple transmitter, receiver and communication channel. The transmitter transmits the signal to pre coding process. For pre coding adaptive optimum vector perturbation technique will be utilized. In this algorithm we replace the Euclidean distance by utilizing anterograde tracing. After pre coding, scheduling will be done by utilizing equal probability (EP) algorithm. Then the pre coded signal fed as input to the communication channel, where the communication channel adds noise along with the interference. After that the multiple loop interference cancellation filter is utilized to cancel the interference and also the capacity will be enhanced also the Gaussian noise occurred will also be reduced simultaneously. The pre coded message from the transmitter will be post coded in the receiver and the corresponding message will be obtained. The multiple receivers have some complications regarding the recognition of appropriate receiver. Finally the corresponding recipient sends the message receipt after signal delivery. The simulation outputs obtained from the proposed design is presented in the upcoming sections.

4.1 Simulink model of the proposed system

The Simulink model design of the proposed communication system is shown in figure 3 (on the last page). The proposed methodology describes about the MU-MIMO which includes multiple transmitter, receiver. The multi transmitter connected to the multi receiver through a communication channel. Here the transmitter side pre coding and the receiver side post coding will be done.

4.2 Proposed System Results

In our proposed work the transmitter transmit the signal to receiver through communication channel. The input signal fed as the input for pre coding process. The input signal from the transmitter is shown in the figure 4. In this work we considered 6 input signals.

The input signal is pre coded using adaptive optimum vector perturbation technique. In that we are using anterograde tracing for trace the distance between the transmitter and receiver. In this process we multiply the matrix with original input signal. After pre coding, scheduling will be done by utilizing equal probability (EP) algorithm. The pre coded signal is shown in the figure 5.

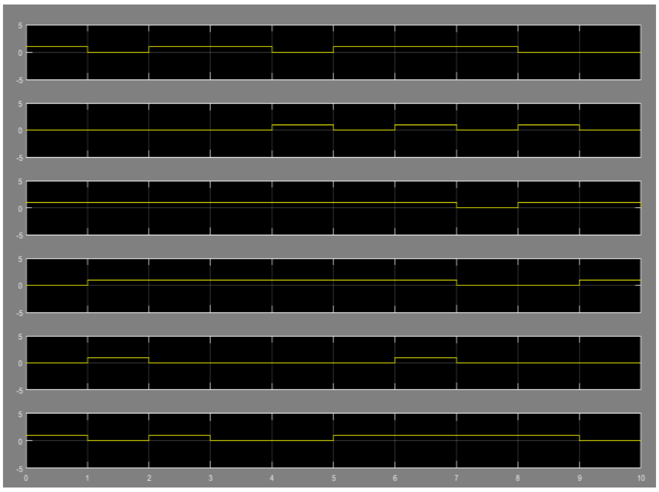

Figure 4. The input signal from the transmitter

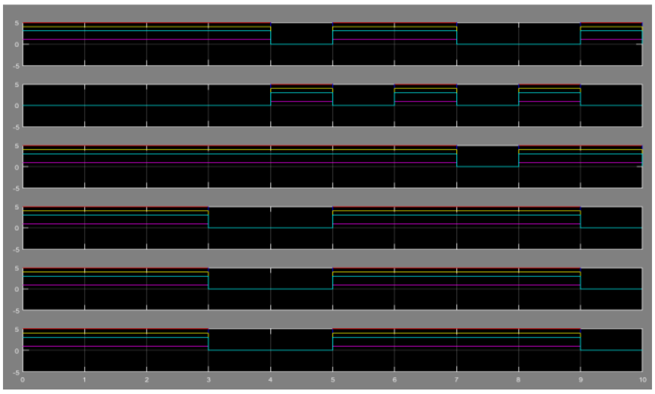

Figure 5. The pre coded signal

After pre coding the pre coded signal is scheduled using equal probability (EP) algorithm. Then it is fed as the input to the communication channel. In this communication channel the interference and Gaussian noise will be added with the pre coding signal. After this signal fed as the input for filtering. The output from the communication channel is shown in figure 6.

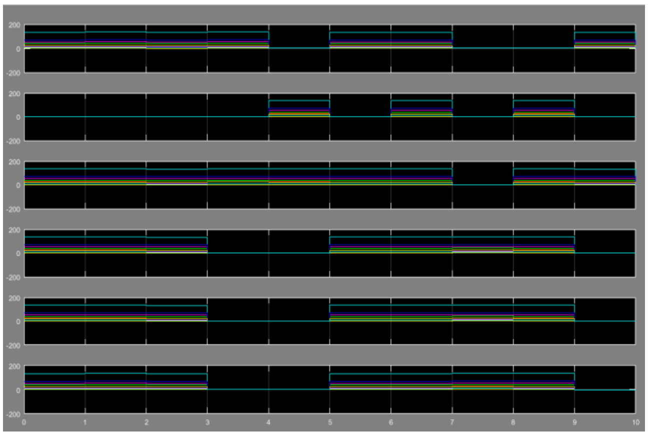

Figure 6. Output from the communication channel

The output from the communication channel is filtered by using multiple loop interference cancellation. Utilizing this filter the interference will cancelled also the capacity will be enhanced also the Gaussian noise occurred will also be reduced simultaneously. The filtered output is shown in the figure 7.

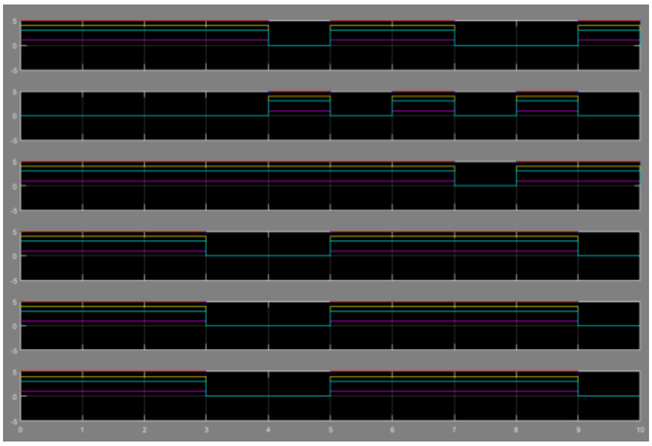

Figure 7. The filtered output

The pre coded message from the transmitter will be post coded in the receiver and the corresponding message will be obtained. It is the reverse process of pre coding. The multiple receivers have some complications regarding the recognition of appropriate receiver. Finally the corresponding recipient sends the message receipt after signal delivery. The simulation outputs obtained from the proposed design is presented in the upcoming sections. The output signal from the receiver is shown in the figure 8.

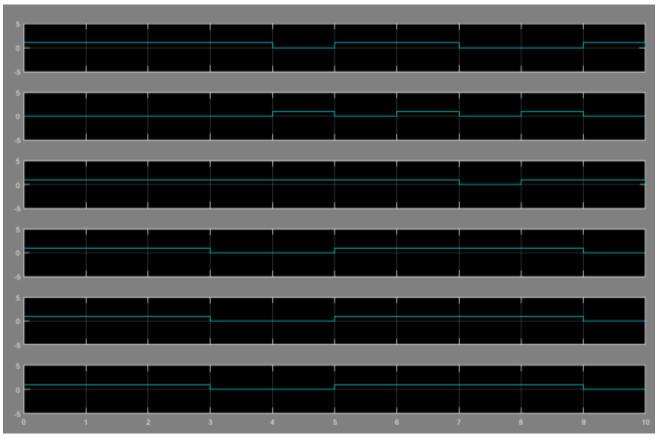

Figure 8. The output signal

4.3 Performance and evaluation

In this work Performance such as throughput, BER, delay, SINR, complexity, capacity and SNR are calculated. Then it is compared with the existing methods.

4.3.1 Throughput

Throughput is the rate of successful message delivery over a communication channel. Throughput is usually measured in bits per second (bit/s or bps) as in (33).

$$\text{Throughput} = \frac{\text{Number of bits}}{\text{Time}} \quad (33)$$

4.3.2 Bit error rate (BER)

In transmission, the number of bit errors is the number of received bits of a data stream over a communication channel that have been altered due to noise, interference, distortion as in (34).

$$\text{BER} = \frac{\text{Number of error}}{\text{Number of bits sent}} \quad (34)$$

4.3.3 Delay

It is a transmission delay. It is the amount of time required to push all the packet's bits into the wire as in (35).

$$\text{Delay}=\frac{\text{Number of bits}}{\text{Rate of transmission}} \quad (35)$$

4.3.4 SNR (Signal Noise Ratio)

It is a signal to noise ratio between the input and output signals.

$$\text{SNR}=\frac{\text{Signal in receiver}}{\text{Noise}}$$

4.3.5 SINR (Signal to Interference Noise Ratio)

The signal to noise interference ratio is described as the ratio of the power of incoming signal (P) from the transmitter divided by the sum of the interference signal (I) and the noise (N) as in (36).

$$SINR=\frac{P}{I+N} \quad (36)$$

4.3.6 Capacity

Along with all other parameters the capacity of the MU-MIMO system is also considered in order to verify the effectiveness of the system. For practical applications the capacity is calculated by using by the formula as in (30, 31 and 32). As in (30) the capacity of each and every signal is calculated individually and thus capacity for every users are recorded. Then as in (32) the total capacity value is calculated by taking the summation of the values obtained.

4.3.7 Complexity

The complexity of the proposed method is reduced to a greater extend since the proposed anterograde tracing methods in most cases identify the receiver without any iterations and thus implementing a better output. The complexity is measured with the aid of delay. The BER, Throughput, delay, SINR, Capacity and SNR of our proposed work is shown in the table 1 and figure 8.

Table 2. BER, Throughput, SINR, Capacity, SNR and Delay

Signal	Throughput	BER	Delay	SINR	Capacity	SNR
1	5.9037	0	1.0163	0.0409	99.5025	1
2	6.8877	0	1.0163	0.05597	99.1312	1
3	7.8716	0.0909	1.0163	0.055972	99.7506	1.1000
4	9.9494	0.2727	1.0163	0.03490	99.6343	1.3750
5	10.8235	0.3636	1.0163	0.02977	98.3761	1.5714
6	10.8235	0.4545	1.0163	0.051724	99.5737	1.8333

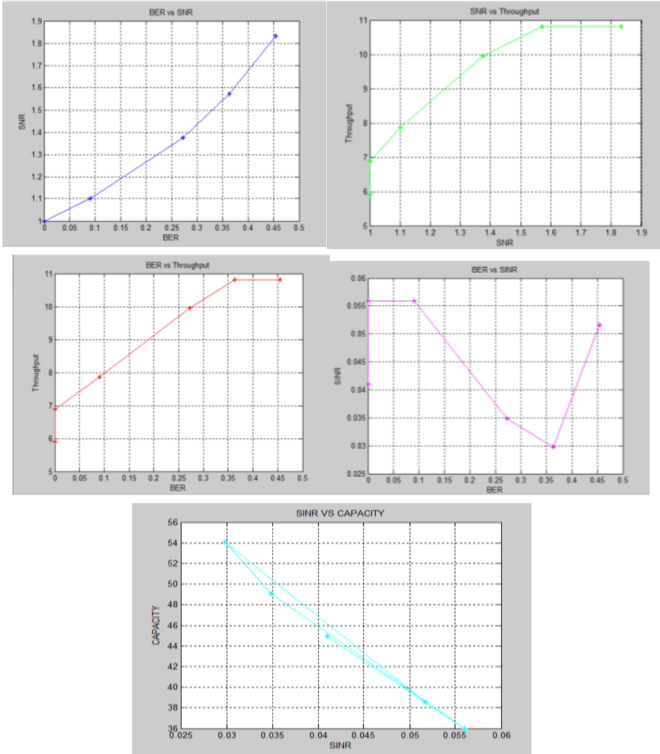

Figure 9. Proposed parameters for SNR, BER, Throughput, SINR and Capacity

4.4 Comparison Results

Our proposed signal processing system is compared with the existing system. This proposed approach throughput, BER, SINR, complexity, throughput, capacity and SNR is compared with the existing VP (Vector perturbation) approaches. The given parameters are compared with the existing pre coding approaches such as the Robust Minimum Mean Square Error Pre coding (RRMMSEP), Robust Multi Branch Tomlinson–Harashima Pre coding (RMTHP), Lattice-Reduction Aided successive Optimization Tomlinson-Harashima Pre coding (LRASOTHP), Block Diagonalization with Limited Feedback (BDP), Minimum Mean Square Error Pre coding (MMSEP), Minimum Mean Square Error (MMSE), Distributed Block Diagonalization with Selective Zero Forcing (DBP-ZP), Multi-Branch Tomlinson-Harashima Pre coding (MBTHP), Coordinated Multi-Point (CoMP), Multi-Cell Block Diagonalization Pre coding (MC-BDP). The comparison graphs for all the parameters are shown in the corresponding figure given as the [10], [11], [12], [13], [14] and [15].

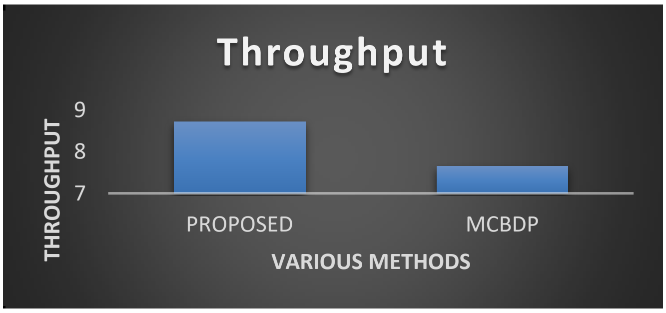

Figure 10. Comparison for Throughput

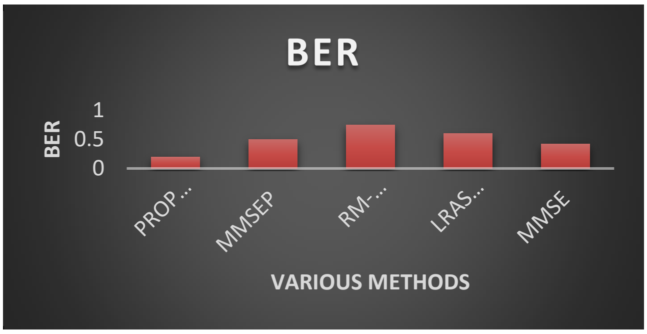

Figure 11. Comparison for BER

In this work the SNR is high when compared with the existing methods. The comparison graph for SNR is shown in the figure 12.

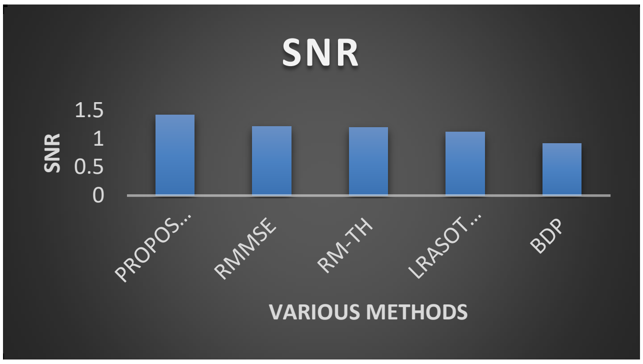

Figure 12. Comparison for SNR

In this proposed method the capacity is high when compared with the existing methods. The comparison graph for capacity is shown in the figure 13 providing a better capacity value. In this proposed method the SINR is high when compared with the existing methods. The comparison graph for SINR is shown in the figure 13 providing a better output.

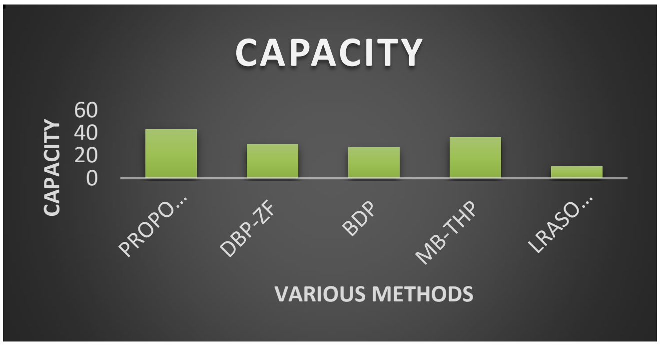

Figure 13. Comparison for Capacity

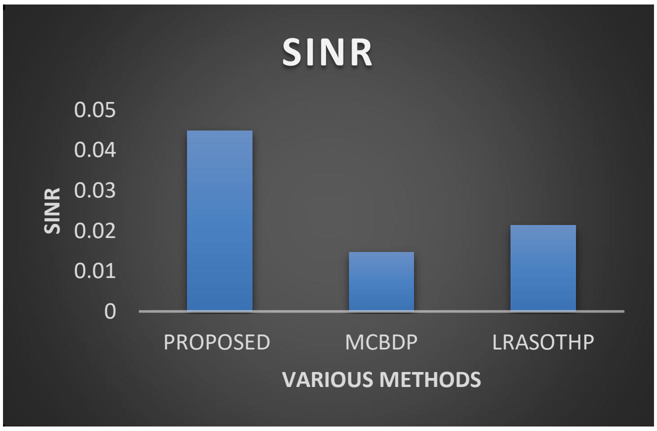

Figure14. Comparison for SINR

5. Conclusion

In this paper Multiuser multiple-input multiple-output (MUMIMO) nonlinear pre coding with adaptive optimum vector perturbation technique is presented. It traces the distance by using anterograde tracing. This anterograde tracing was usually recognized in the nervous system.This trace the distance through an iterative-optimization procedure. Each iteration performs vector perturbation over two optimally selected subspaces. By this means, the computational complexity is managed to be in the cubic order of the size of MUMIMO, and this mainly comes from the inverse of the channel matrix. Our proposed signal processing system has been implemented in the working platform of MATLAB/SIMULINK. This proposed approach obtained high throughput 10.8235, with less BER 0.0909, delay 1.0163, SINR 0.0448, capacity 99.6504, SNR 1.00 and also less complexity when compared with the existing VP approaches.

References

[1] Dahlman, Erik, Gunnar Mildh, Stefan Parkvall, Janne Peisa, Joachim Sachs, Yngve Selén, and Johan Sköld, “5G wireless access: requirements and realization,” IEEE Communications Magazine, Vol. 52, No. 12, pp.42-47, 2014.

[2] Larsson, G. Erik Ove Edfors, Fredrik Tufvesson, and L. Thomas Marzetta. “Massive MIMO for next generation wireless systems,” IEEE Communications Magazine, Vol. 52, No. 2, pp.186-195, 2014.

[3] Ren, Fang, Juhao Li, Tao Hu, Ruizhi Tang, Jinyi Yu, Qi Mo, Yongqi He, Zhangyuan Chen, and Zhengbin Li, “Cascaded mode-division-multiplexing and time-division-multiplexing passive optical network based on low mode-crosstalk FMF and mode MUX/DEMUX,” IEEE Photonics Journal, Vol. 7, No. 5, pp.1-9, 2015.

[4] Zou, Yulong, Jia Zhu, Xianbin Wang, and C.M. Victor Leung, “Improving physical-layer security in wireless communications using diversity techniques,” IEEE Network, Vol. 29, No. 1, pp.42-48, 2015.

[5] Yang, Nan, Lifeng Wang, Giovanni Geraci, Maged Elkashlan, Jinhong Yuan, and Marco Di Renzo, “Safeguarding 5G wireless communication networks using physical layer security,” IEEE Communications Magazine, Vol. 53, No. 4, pp.20-27, 2015.

[6] Bi, Suzhi, Chin Keong Ho, and Rui Zhang, “Wireless powered communication: opportunities and challenges,” IEEE Communications Magazine, Vol. 53, No. 4, pp.117-125, 2015.

[7] Razaviyayn, Meisam, Maziar Sanjabi, and Zhi-Quan Luo, “A stochastic successive minimization method for nonsmooth nonconvex optimization with applications to transceiver design in wireless communication networks,” Mathematical Programming, Vol. 157, No. 2, pp.515-545, 2016.

[8] Ng, Derrick Wing Kwan, S. Ernest Lo, and Robert Schober, “Multiobjective resource allocation for secure communication in cognitive radio networks with wireless information and power transfer,” IEEE Transactions on Vehicular Technology, Vol. 65, No. 5, pp.3166-3184, 2016.

[9] S. Oulaourf, A. Haidine, A. Aqqal, and H. Ouahmane, “Review on Radio Resource Allocation Optimization in

LTE/LTE-Advanced using Game Theory," International Journal of Communication Networks and Information Security (IJCNIS), Vol.9, No.1, pp.117-153, 2017.

[10] S.M. Kamruzzaman, X. Fernando, and M. Jaseemuddin, "Energy aware multipath routing protocol for cognitive radio ad hoc networks," International Journal of Communication Networks and Information Security, Vol.8, No.3, pp.187, 2016.

[11] Björnson, Emil, Luca Sanguinetti, Jakob Hoydis, and Mérouane Debbah, "Optimal design of energy-efficient multi-user MIMO systems: Is massive MIMO the answer," IEEE Transactions on Wireless Communications, Vol. 14, No. 6, pp.3059-3075, 2015.

[12] Choi, Junil, Jianhua Mo, and W. Robert Heath, "Near maximum-likelihood detector and channel estimator for uplink multiuser massive MIMO systems with one-bit ADCs," IEEE Transactions on Communications, Vol.64, No. 5, pp.2005-2018, 2016.

[13] Tataria, Harsh, J. Peter Smith, J. Larry Greenstein, and A. Pawel Dmochowski, "Zero-Forcing Precoding Performance in Multiuser MIMO Systems with Heterogeneous Ricean Fading," IEEE Wireless Communications Letters, Vol. 6, No. 1, pp.74-77, 2017.

[14] Sohrabi, Foad, and Wei Yu, "Hybrid digital and analog beam forming design for large-scale antenna arrays," IEEE Journal of Selected Topics in Signal Processing, Vol.10, No. 3, pp.501-513, 2016.

[15] Vu, Quang-Doanh, Le-Nam Tran, Ronan Farrell, and Een-Kee Hong, "Energy-efficient zero-forcing precoding design for small-cell networks," IEEE Transactions on Communications, Vol.64, No. 2, pp.790-804, 2016.

[16] Q. Li, Q. Zhang, and J. Qin, "Robust Tomlinson–Harashima Precoding With Gaussian Uncertainties for SWIPT in MIMO Broadcast Channels," IEEE Transactions on Signal Processing, Vol. 65, No.6, pp.1399-1411, 2017.

[17] Jin, Shi, Xiaoyu Wang, Zheng Li, Kai-Kit Wong, Yongming Huang, and Xiaoyong Tang, "On massive MIMO zero-forcing transceiver using time-shifted pilots," IEEE Transactions on Vehicular Technology, Vol. 65, No. 1, pp.59-74, 2016.

[18] Huberman, Sean, and Tho Le-Ngoc, "MIMO full-duplex precoding: A joint beam forming and self-interference cancellation structure," IEEE Transactions on Wireless Communications, Vol. 14, No. 4, pp.2205-2217, 2015.

[19] Cirik, Ali Cagatay, Rui Wang, Yingbo Hua, and Matti Latva-aho, "Weighted sum-rate maximization for full-duplex MIMO interference channels," IEEE Transactions on Communications, Vol. 63, No. 3, pp.801-815, 2015.

[20] Masouros, Christos, and Gan Zheng, "Exploiting known interference as green signal power for downlink beamforming optimization," IEEE Transactions on Signal Processing, Vol. 63, no. 14, pp.3628-3640, 2015.

[21] Moretti, Marco, Luca Sanguinetti, and Xiaodong Wang, "Resource allocation for power minimization in the downlink of THP-based spatial multiplexing MIMO-OFDMA systems," IEEE Transactions on Vehicular Technology, Vol. 64, No. 1, pp.405-411, 2015.

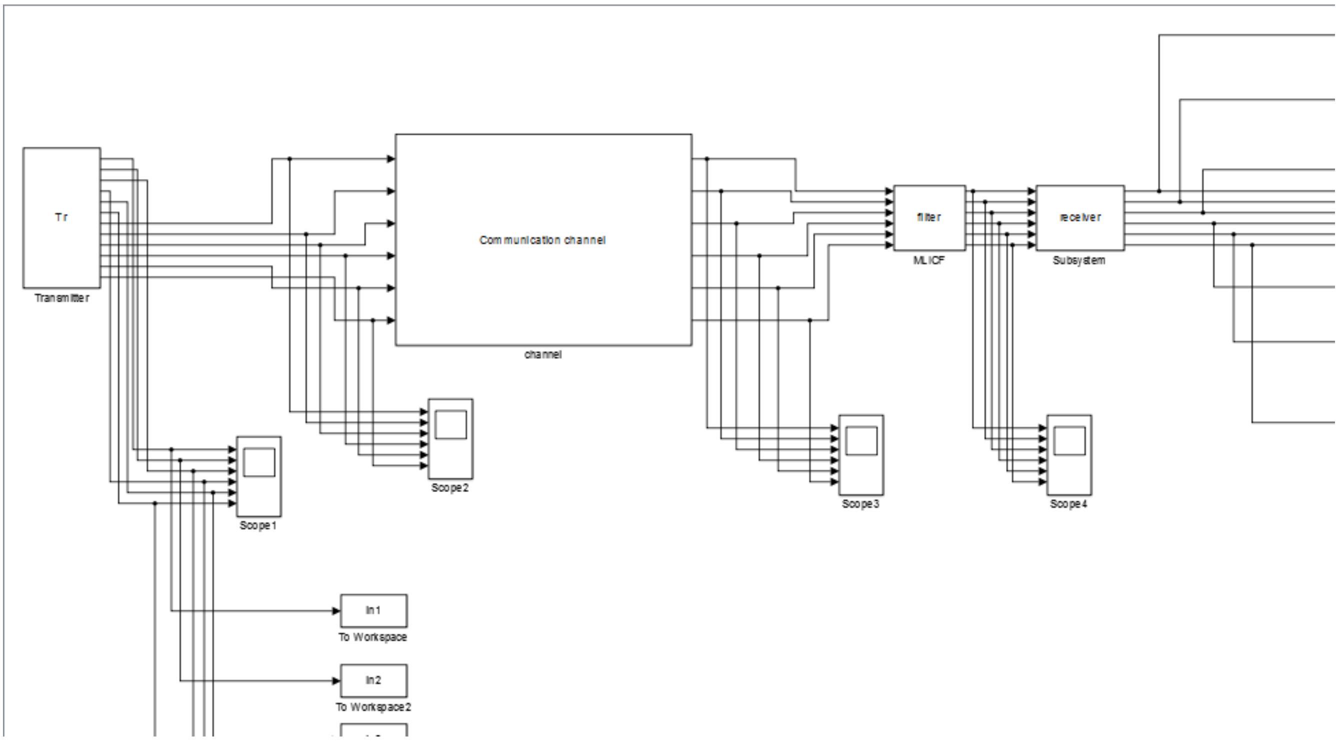

Figure 3: Simulink model of the proposed system