

Multi-Target Expansion with QAM Alteration gamble on Beamforming for MIMO-OFDM Interference Channels

K.G.JothiShalini¹, R.Vedhapriyavadhana²P. G. Scholar, Department of ECE, Francis Xavier Engineering College, Affiliated to Anna University, Chennai,
Tamilnadu, India¹Associate Professor, Department of ECE, Francis Xavier Engineering College, Affiliated to Anna University, Chennai,
Tamilnadu, India²

ABSTRACT:In this paper, three beamforming models are designed by QAM modulation for multiuser multiple-input and multiple-output with orthogonal frequency division multiplexing interference channels. The suggested beamforming models are attained iteratively through sealed(closed)-procedure steps. First model consist of the known transmit beamformers (TX-BF), from which receive beamformers (RX-BF) are figured by projecting into null space of appropriate channels. Second model discuss the mutually optimizing the TX-RX beamformers from compelled SNR maximization. Third model is similarly for mutual optimization of TX-RX beamformers with both compelled SNR and SINR maximization. A Linear Constellation precoder is used in all the three models beneficial to excerpt the multipath diversity. The outcomes from the standardized channel model IEEE 802.11n, affords the faster beamforming, boosted error performance and the capability to excerpt multipath diversity.

KEYWORDS:Beamforming, Interference channels, optimization, signal-to-interference-plus-noise ratio, signal-to-noise ratio.

I. INTRODUCTION

In recent years, MIMO schemes assures a diversity benefit relative to the product of total number of antennas used for transmission and reception. In order to cope with frequency-selective channels, MIMO can be joined with OFDM [10], thereby converting the channel into number of subcarriers. The optimization based on null space constraint cannot be functional for more complex channels. Increasing the spatial correlation by maximizing the SINR before demodulation of OFDM [2] which practises multiple transmit-receive antennas for specific user and other users provided with single transmit-receive antennas. The multi-tap FIR filter for receiver is used to calculate the multipath diversity in OFDM systems [3]. This system is condense the channel to reduce the inter-carrier interference in order to satisfy the channel distortion. The optimization measures for beamforming designs to increase the sum rate is done by maximization of signal power in the network allocated by interference power and provides the high degrees of freedom [4]. It determines the result of channel imperfections by interference alignment based on sum rate. To avoid the multiuser interference, a null space constraint and pre-filter is offered for joint optimization of transmit and receive antennas [5]. The multielement transmitter and receiver is a current focus and it is altered from multiuser uplink and downlink beamforming which has considered in [5]-[8]. The scientific notation is proceeds as: column vectors and matrices are signified by boldface lower and upper case letters appropriately. Superscripts ^H and ^T offers the complex conjugate transpose and transpose, separately, and x^* shows the value of x , and does not represent the complex conjugate of x . The null space of matrix K is signified by $\mathcal{N}(K)$. $a_{\max}(K)$ is the standardised eigenvector of matrix K that shows the maximum eigenvalue of K . Expected value is symbolized by $E\{\cdot\}$.

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II. RELATED WORK

Comprehensive work at [7] beat the zero forcing based solution by providing SINR duality for both uplink and downlink. In MIMO-OFDM channels, Beamforming is engaged on each subcarriers [11]. But, this subcarrier-wise procedure involves high computational complexity hence a discrete Fourier transform (DFT) is necessary for all antenna element. The writers of [12] advanced and prolonged the outline of [13] to design with intersymbol interference and an ideal method by maximizing the signal-to-interference-plus-noise ratio at the feedback of DFT block is computed. By using the LCP matrix in Beamforming, the system performance is increased with Sphere Decoder.

III. SYSTEM MODEL

We consider the MIMO-OFDM channel with M users and Q subcarriers. All the M users share the identical spectrum instantaneously with multiple transmit and receive antennas. The standardized channel model IEEE 802.11n has two models as follows 1) a channel with tapped delay line 2) a channel with single-tap flat fading with spatial correlation matrix. The first channel is used for MIMO-OFDM channel and organising multipath diversity with LCP precoder. The second channel provides the comparison of bit error rate performance and feedback rate with already existing methods. From Fig. 1, the TX beamformer for j th user at q th subcarrier is register as $x_j(q) \in \mathbb{C}^{P_t \times 1}$, and similarly the RX beamformer for j th user at q th subcarrier is provided as $y_j(q) \in \mathbb{C}^{P_r \times 1}$ for $j \in \{1, 2, \dots, M\}$ then $q \in \{0, 1, 2, \dots, Q - 1\}$, s_i is the input symbol stream of j .

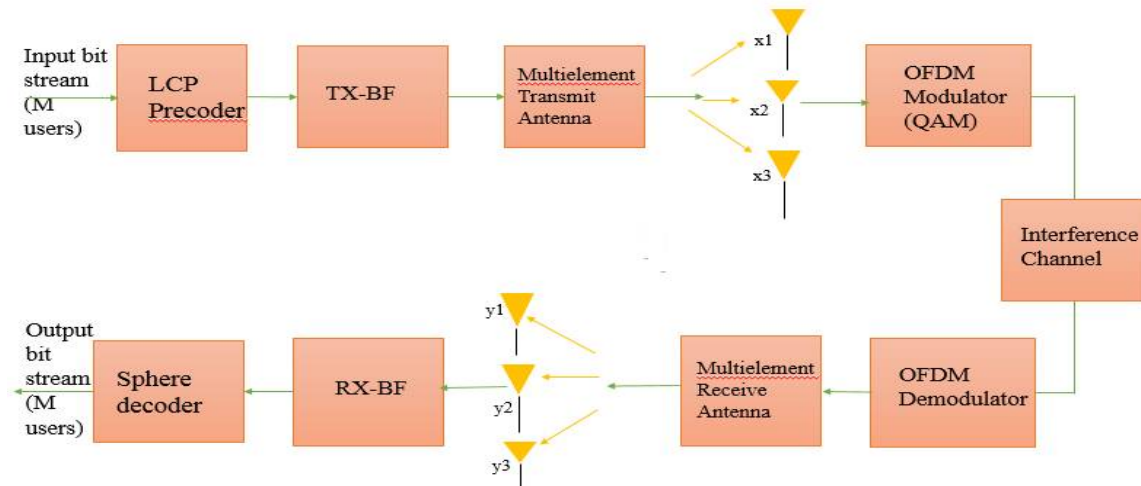


Fig 1. General structure of Multiuser MIMO-OFDM Beamforming model

Fig. 1 shows the simple structure of multiuser MIMO-OFDM beamforming model which consists LCP precoder at the transmitter side and sphere decoder at the receiver side. Here, the multiple antennas are processed via OFDM channel model with QAM modulation. The system comprises of M users consuming P_t transmit antennas and P_r receive antennas and each users contribute Q subchannels. The symbol stream is given by $\tilde{a}_j \triangleq \Theta[a_j(0), \dots, a_j(Q - 1)]^T$ then the output of transmit beamformer is given as $x_j(q)\tilde{a}_j(q)$. The channel length and the channel is represented as Z and G respectively. After deduction of cyclic prefix and next to FFT, the received signal vector for j th user is given as:

$$s_j(q) = \mathbf{G}_{j,j}(q)x_j(q)a_j(q) + \sum_{j' \neq j}^M \mathbf{G}_{j,j'}(q)x_{j'}(q)a_{j'}(q) + n_j(q) \quad (1)$$

From (1), the subcarrier of the channel q is given as, $\mathbf{G}_{w,j}(q) \in \mathbb{C}^{P_t \times P_r}$ and the entry of (v, μ) is derived as, $[\mathbf{G}_{w,j}(q)]_{v\mu} \triangleq \mathbf{G}_{v\mu}^{w,j}(q)$, where,

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$$G_{\nu\mu}^{w,j}(q) := \sum_{j=0}^Z g_{\nu\mu}^{w,j}(z) e^{-j2\pi i r/Q} \quad (2)$$

For both the channel model of IEEE 802.11n, the main aim is the beamforming design. By applying the RX-BF in all users for each subcarriers, it is given by,

$$y_j^{\mathcal{H}} a_j = y_j^{\mathcal{H}} \mathbf{G}_{j,j} x_j a_j + \sum_{j' \neq j}^M y_j^{\mathcal{H}} \mathbf{G}_{j,j'} x_{j'} a_{j'} + y_j^{\mathcal{H}} \quad (3)$$

Thus the optimization problem for the channel model is assumed by,

$$\begin{aligned} \max_{y_j x_j} \text{SNR}_j &= S_j / N_j \\ \text{s.t. } D_i &= 0 \quad i \neq j \end{aligned} \quad (4)$$

Where, $S_j = y_j^{\mathcal{H}} \mathbf{G}_{j,j} x_j x_j^{\mathcal{H}} \mathbf{G}_{j,j}^{\mathcal{H}} y_j$, $D_i = y_j^{\mathcal{H}} \mathbf{G}_{i,j} x_i$ and $N_j = \sigma_{n_j}^2 y_j^{\mathcal{H}} y_j$ ($\sigma_{s_j}^2 = 1$) and it provides secure procedure steps. Therefore the simplification of compelled SNR maximization is easier for (4).

IV. PROPOSED MODELS FOR BEAMFORMING

A) CALCULATION OF RX-BF FROM IDEAL TX-BF ARE KNOWN

Here, the transmit beamformers are known from the null space of proper channels, from which the receive beamformers are found. The odd number of antennas are given by $M \in \{2(m+1) : m \in \mathbb{P}\}$ and it is derived as,

$$x_j = \mathcal{N}(\mathbf{G}_{P+1-j,j}) \quad (5)$$

And the even ($M \in \{2m+1 : m \in \mathbb{P}\}$) number of antennas is derived as,

$$x_j = \begin{cases} \mathcal{N}(\mathbf{G}_{P+1-j,j}) & \text{if } P+1-j < j \\ \mathcal{N}(\mathbf{G}_{P,j}) & \text{if } P+1-j = j \\ \mathcal{N}(\mathbf{G}_{P-j,j}) & \text{if } P+1-j > j \end{cases} \quad (6)$$

They are obtained by satisfying the orthogonal condition stated as,

$$\mathcal{N}(\mathbf{B}) \triangleq \{\mathbf{v} | \mathbf{B}\mathbf{v} = \mathbf{0}, \|\mathbf{v}\| = 1\} \quad (9)$$

The optimization problem μ is specified as,

$$\begin{aligned} \rho: \max_{y_1 \in \mathbb{C}^{P \times Q \setminus 0}} y_1^{\mathcal{H}} \mathbf{G}_{1,1} \frac{x_1 x_1^{\mathcal{H}} \mathbf{G}_{1,1}^{\mathcal{H}} y_1}{y_1^{\mathcal{H}} y_1} \\ \text{s.t. } \begin{cases} y_1^{\mathcal{H}} \mathbf{G}_{1,2} x_2 = 0 \\ y_1^{\mathcal{H}} \mathbf{G}_{1,3} x_3 = 0 \\ \vdots \\ y_1^{\mathcal{H}} \mathbf{G}_{1,P-1} x_{P-1} = 0 \end{cases} \end{aligned} \quad (10)$$

The optimization problem not only having global maximum but also it consists of local maximum denoted as v^{lm} . Thus the local maxima for μ is stated as,

$$\begin{cases} \mathbf{N} v^{lm} = 0 \\ \mathbf{n}_j^{\mathcal{H}} v^{lm} = 0 \end{cases} \quad (11)$$

The interest in the above equation is $v^{lm} \neq 0$ but it could be zero. The sum of unidentified parameters and number of equations in (9) for $v^{lm} \neq 0$ defines the least number of antennas for the optimization problem μ .

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B) MUTUAL RX-BF AND TX-BF FOR COMPELLED SNR MAXIMIZATION

In this section, the RX-BF and TX-bf are calculated by mutual optimization of compelled SNR maximization by with Expanded Oscillating Maximization Algorithm for Multi-target optimization. In EOM, the optimization problem is considered as,

$$\min_{v \in \Omega_j} E(v) = E_1(v_1, \dots, v_M) + \dots + v_M(v_1, \dots, v_M) \tag{12}$$

Where $\Omega_1 \times \Omega_2 \times \dots \times \Omega_E$ is a realistic set. By EOM the solution for difficult optimization problem is set by solving M problems as follows:

$$\min_{v_j \in \Omega_j} E_j(v_1, \dots, v_{j-1}, v_j, v_{j+1}, \dots, v_M) \tag{13}$$

The ideal solution of (11) with nonlinear function is stated with following property:

$$\forall v_j \in \Omega_j, E_j(v_1, \dots, v_{j-1}, v_j, v_{j+1}, \dots, v_M) \geq E_j(v_1, \dots, v_{j-1}, v_j, v_{j+1}, \dots, v_M) |_{v_j = z_j(v_1, \dots, v_{j-1}, v_{j+1}, \dots, v_M)} \tag{14}$$

Finally, the Nash Equilibrium for M games by using EOM algorithm is given by,

$$v_j^{(p+1)} = z_j(v_1^{(p+1)}, \dots, v_{j-1}^{(p+1)}, v_{j+1}^{(p)}, \dots, v_M^{(p)}) \tag{15}$$

For mutual TX-RX beamformers, the problem for first user (SNR) is given as,

$$\mathcal{F} : \max_{x_1 \in \mathbb{C}^{P_t}, y_1 \in \mathbb{C}^{P_r}} y_1^H \mathbf{G}_{1,1} x_1 x_1^H \mathbf{G}_{1,1}^H y_1 \tag{16}$$

The value of channel C and G is given as,

$$\mathbf{C}_m \triangleq [(\mathbf{G}_{m,m} x_w^{(m+1)})^H, \dots, (\mathbf{G}_{m,a} x_a^{(m+1)})^H] w, a \in \mathcal{N} \setminus \{m\} \tag{17}$$

$$\mathbf{G}_1 \triangleq \mathbf{G}_{m,m}^H [\mathcal{N}(C_m)]_1 [\mathcal{N}(C_m)]_1^H \mathbf{G}_{m,m} \tag{18}$$

$$\mathbf{G}_2 \triangleq \mathbf{G}_{1,1}^H [\mathcal{N}(C_1)]_2 [\mathcal{N}(C_1)]_2^H \mathbf{G}_{1,1} \tag{19}$$

The TX and RX beamformer is given as

$$x_m^{(m+1)} = h_{\max}(\mathbf{G}_1 + \mathbf{G}_2) \tag{20}$$

$$y_m = \sqrt{\frac{\sigma_1}{\sigma_1 + \sigma_2}} [\mathcal{N}(C_n)]_1 + \sqrt{\frac{\sigma_2}{\sigma_1 + \sigma_2}} e^{-\iota\varphi} [\mathcal{N}(C_n)]_2 \tag{21}$$

TABLE I

Compelled SNR maximization by EOM algorithm	
1:	Select $P > 1$; $\mathbf{x}_m^{(0)}$, For $k = 0 : P-1$ do (FOR TX-BF)
2:	Compute the channel values \mathbf{C}_m , \mathbf{G}_1 and \mathbf{G}_2 and Find the transmit BF \mathbf{x}_m for (p+1) iteration
3:	Stop until criterion met
4:	For $k = 0 : P-1$ do (FOR RX-BF)
5:	Compute the channel values \mathbf{C}_m , \mathbf{G}_1 and \mathbf{G}_2 and Find the receive BF \mathbf{y}_m for (p+1) iteration
6:	$\sigma_1 = x_m^{(p)H} \mathbf{G}_1 x_m^{(p)}$, $\sigma_2 = x_m^{(p)H} \mathbf{G}_2 x_m^{(p)}$
7:	End till criteria met

The above Table I shows the EOM algorithm for (p+1) iterations to find the TX and RX beamformers with M users. All the channel values are also computed between $0 \leq k \leq P-1$.

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Thus the TX-RX BF are determined by mutual optimization from compelled SNR maximization obtained from EOM algorithm.

c) MUTUAL RX-BF AND TX-BF FOR COMPELLED SNR AND SINR MAXIMIZATION

This section uses the fixed point method for multi-target optimization by Expanded Oscillating Maximization (EOM) algorithm. Here due to both SNR and SINR maximization, there are two optimization problem as follows:

$$F_1 : \max_{x_1 \in \mathbb{C}^{P_t}} x_1^H \mathbf{G}_{1,1}^H y_1 y_1^H \mathbf{G}_{1,1} x_1 \tag{22}$$

$$F_2 : \max_{y_1 \in \mathbb{C}^{P_r}} \frac{y_1^H \mathbf{G}_{1,1} x_1 x_1^H \mathbf{G}_{1,1}^H y_1}{y_1^H \left(\sum_{i \neq 1}^M \mathbf{G}_{i,j} x_i x_i^H \mathbf{G}_{i,j}^H + \frac{\sigma_n^2}{\sigma_s^2} \mathbf{R} \right) y_1} \tag{23}$$

TABLE II

Compelled SNR and SINR maximization by EOM algorithm

- | | |
|----|---|
| 1: | Select $P > 1$; $\mathbf{y}_m^{(0)}$ |
| 2: | For $k = 0 : P-1$ do |
| 3: | Compute the values of \mathbf{T}_m , \mathbf{x}_1 , \mathbf{x}_2 , and \mathbf{x}_3 |
| 4: | If $\text{margin} < 2$, find ϑ else find \mathbf{T}_m |
| 5: | Find TX-RX BF for M users at (p+1) iteration |
| 6: | End |

The above Table I shows the EOM algorithm for (p+1) iterations for mutual beamformers for Compelled SNR and SINR optimization to find the TX and RX beamformers with M users. All the channel values are also computed between $0 \leq k \leq P-1$ and when the input arguments is strictly less than 2, then the value ϑ should be obtained otherwise the values for global minimizer for optimization problem can be calculated.

The value of transmit beamformer for M=3 is given as,

$$x_1 \triangleq [\mathcal{N}(\mathbf{T})]_1^H \mathbf{G}_{1,1}^H y_1 y_1^H \mathbf{G}_{1,1} [\mathcal{N}(\mathbf{T})]_1 \tag{24}$$

$$x_2 \triangleq [\mathcal{N}(\mathbf{T})]_2^H \mathbf{G}_{1,1}^H y_1 y_1^H \mathbf{G}_{1,1} [\mathcal{N}(\mathbf{T})]_2 \tag{25}$$

$$x_3 \triangleq |[\mathcal{N}(\mathbf{T})]_1^H \mathbf{G}_{1,1}^H y_1 y_1^H \mathbf{G}_{1,1} [\mathcal{N}(\mathbf{T})]_2| \tag{26}$$

Where, $\mathbf{T} \triangleq [(\mathbf{G}_{2,1}^H y_2)^H, \dots, (\mathbf{G}_{M,1}^H y_M)^H]$ and $\vartheta \triangleq \angle [\mathcal{N}(\mathbf{T}_j^{(p)})]_1^H \mathbf{G}_{j,j}^H y_j^{(p)} \mathbf{T}_j^{(p)} \mathbf{T}_{j,j} [\mathcal{N}(\mathbf{T}_j^{(p)})]_2$.

Thus the receive beamformer for all M users is derived as,

$$x_j^{(p+1)} = h_{\max} \left(\left(\sum_{j \neq i}^M \mathbf{G}_{j,i} x_i^{(m)} x_i^{(m)H} \mathbf{G}_{j,i}^H + \frac{\sigma_n^2}{\sigma_s^2} \mathbf{R} \right)^{-1} \mathbf{G}_{j,j} x_j^{(m)} x_j^{(m)H} \mathbf{G}_{j,j}^H \right) \tag{27}$$

All the beamformer design proposed are secure (closed) procedure steps.

V. LCP ENCODING IN TX

Multipath Diversity can be extracted from all the beamforming models by using linear constellation precoder encoding in the transmitter side and thus sphere decoder is used in receiver side in MIMO-OFDM beamforming model.

By deploying Γ , the design procedure for multipath diversity is,

$$y_1^H(q) s_1(q) = y_1^H(q) \mathbf{G}_{1,1}(q) x_1(q) \tilde{a}_1(q) + y_1^H(q) n_1(q) \tag{28}$$

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The $y_i^H(q)s_1(q)$ are arranged for all subchannels and this is decoded by sphere decoder. Instead of subcarrier-wise beamforming LCP matrix is used denoted as $\Gamma = R_{Q \times Q}$. This excerpt the multipath diversity. First, the unitary rotation

matrix $\Lambda \in \mathbb{C}^{E \times E}$ should be obtained. It has the following structure for finding the ideal LCP: $\Lambda = \frac{1}{\phi} \begin{bmatrix} 1 & \theta_1 & \dots & \theta_1^{E-1} \\ 1 & \theta_2 & \dots & \theta_2^{E-1} \\ \vdots & \vdots & \ddots & \vdots \\ 1 & \theta_l & \dots & \theta_l^{E-1} \end{bmatrix}$

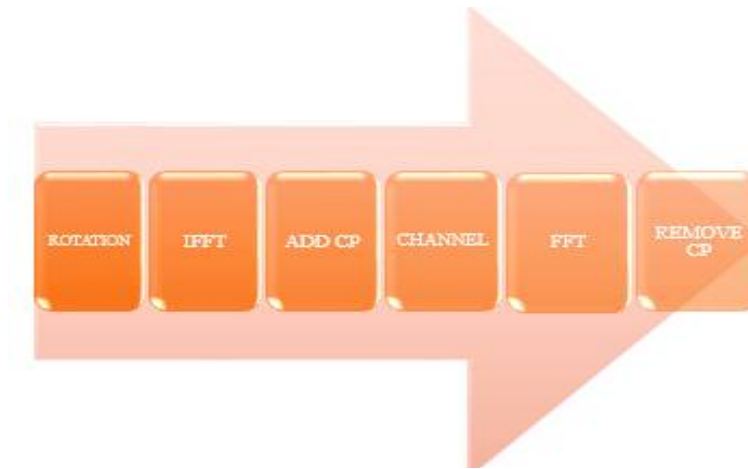


Fig 2: The simple LCP encoding in OFDM channel

Fig. 2 gives the way of LCP encoding in OFDM channel. To find the LCP matrix, the value of rotation matrix should be calculated by adding and removing cyclic prefix via Fast Fourier Transform. This LCP encoding for finding the rotation matrix is similar to the process of OFDM channel. Secondly, assume $Q = BE$ where $E \in \{2^m, m \in \mathbb{P}\}$ and $\mathcal{T} \triangleq \{0, 1, \dots, Q-1\}$. This is given by sub-channel grouping and it is simplified by partitioning \mathcal{T} into B non-connecting subsets as, $\mathcal{T}_b \triangleq \{q_{b,1}, \dots, q_{b,M}\}$. This is useful for finding sub-channels selector matrix $\Psi_b \triangleq R_Q(\mathcal{T}_b, \cdot)$. From this sub-channel matrix the ideal sub-channel grouping can be obtained as $\mathcal{T}_{mo} = \{b-1, B+b-1, \dots, (E-1)B+b-1\}$.

Finally, the Linearprecoder matrix is derived as,

$$\Gamma = \sum_{h=1}^H \Psi_b^R \Lambda \Psi_b \tag{29}$$

VI. SIMULATION RESULTS

In this section, simulation results are described for analyzing the proposed beamforming models. In evaluation each user uses the QAM modulation to improve the error performance.

TABLE III

SIMULATION PARAMETERS USED IN THIS PAPER		
Character	Name	Dimensions
Q	Number of subcarriers	16
M	Number of users	3,4
Z+1	OFDM Channel length	9
z_{cp}	Cyclic Prefix	10
P	Iterations of EOM	16

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As per the simulation parameters mentioned in Table III, the MIMO-OFDM beamforming model provides the faster beamforming and improved performance. Table III provides the value of subcarriers, number of users, Channel length and cyclic prefix for Multiuser MIMO-OFDM interference channels. In designing the OFDM channel the size of FFT and number of subcarriers should be equal, so that the complexity of the system is reduced and the BER performance is improved.

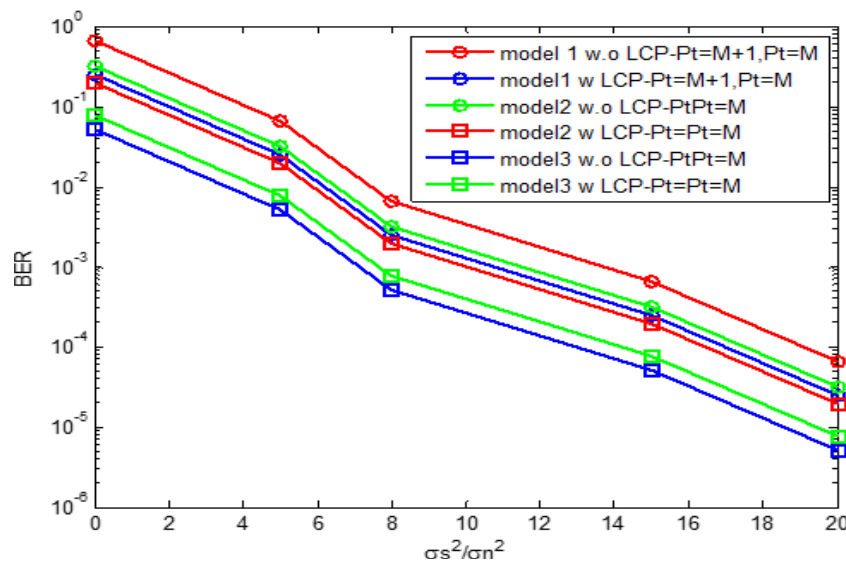


Fig. 3 The BER performance of model 1,2,3 with (w) or without (w.o) using LCP precoder and sphere decoder for M=3 users.

Simulation results in Fig. 3 reveals that, this MIMO channel designed for WLAN with 9 paths, by LCP matrix advances the system performance. Lastly, it is evoked that the intricacy of SD decoding at the receiver upsurges with the constellation size but not with the sum of antennas. Fig. 3 shows the bit error rate performance of M=1,2,3 users with or without the LCP precoder and sphere decoder for all beamforming designs.

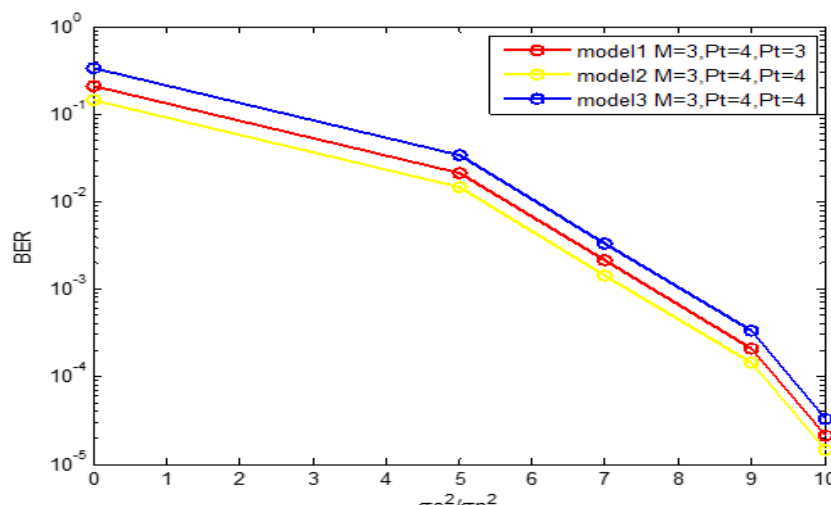


Fig. 4 The BER performance of proposed beamforming model 1,2,3 for M=3 users.

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Fig. 4, shows the proposed beamforming designs of MIMO-OFDM beamforming model of IEEE 802.11n which has the higher performance compared to the existing methods. From that, the bit error performance is less than 10^{-3} (especially for second model) and provides the SNR of 10 dB meant for $\rho \geq 0.9$ at all the three models. In IEEE 802.11n channel model has three models as: 1)The combined multi-target TX-RX BF design (model 3) has the improved performance. 2)The mutual single TX-RX BF design (model2). 3)The individual design (model 1). Here LCPmatrix is used to improve the error performance of MIMO-OFDM channel for M users.

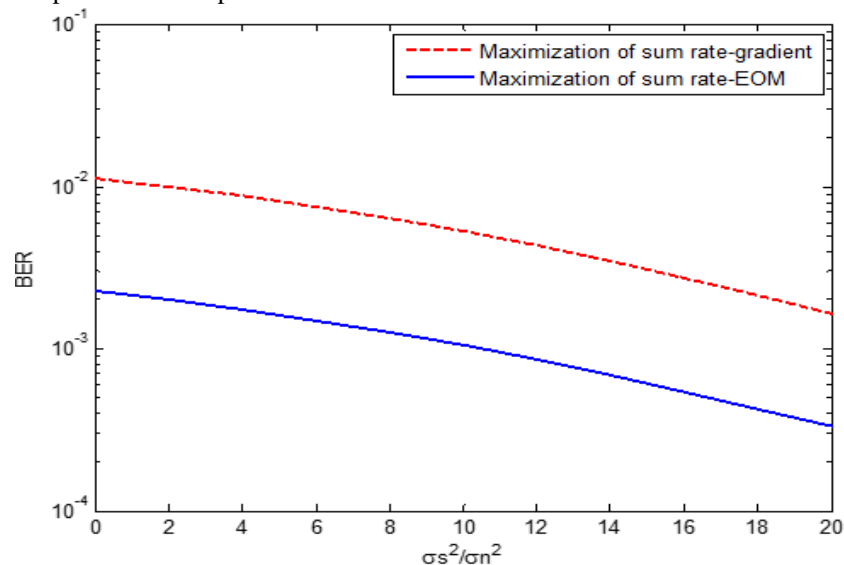


Fig. 5 Comparison of BER performance of gradient method of sum rate and EOM for M=3 users.

Fig. 5, shows the comparison of sumrate optimization of rate-gradient descent method and sumrate optimization of EOM algorithm in proposed method. Here, the performance loss is 0.8 dB. Thus reduces the complexity of the system. The requisite Computational times (not displayed) designate that our proposed method is five times quicker for M=3 (Fig. 5).

VII. CONCLUSION

This paper has discussed the three beamforming models for multiuser MIMO-OFDM interference channel. By using the LCP matrix the error performance is improved and it is useful for excerpting the multipath diversity. This transmit and receive beamformer produces secure-(closed) procedure steps. The EOM algorithm reduces the intricacy of the channel and requires reduced feedback with low computational time. Future work aim at replacing the LCP precoder by Viterbi encoding and sphere decoder by Viterbi decoding with QPSK modulation in order to increase the performance of the channels.

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