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Receive and Transmit Beamforming in Dual-Hop Relay Network Using Fukunaga Koontz Transform Based SINR and SLNR Maximization

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Abstract: This paper investigates a linear beam forming technique aiming to maximize ergodic capacity for transparent relay MIMO network without direct link. Multiple antennas are deployed on each node of the network. A linear receive beam forming at relay is developed using signal-to- interference-plus-noise ratio (SINR) maximization. Also a signal to leakage plus noise ratio (SLNR) based precoding is employed at the relay downlink. A computationally efficient Fukunaga Koontz Transform is used as a tool to solve optimization problem. A sufficiently large number of numerical experiments are conducted to validate the enactment of proposed beam forming technique. The results obtained using MATLAB confirm that, the proposed relay beam forming and relay downlink precoding schemes offer substantial performance gain in terms of ergodic capacity over existing methods..

Keywords: Beam forming; MIMO; Relay; Ergodic capacity; Fukunaga Koontz Transform; Co-channel interference; Leakage.

1. INTRODUCTION

In wireless channel multipath fading effect, shadowing effect, path loss and signal interference are common transmission impairments, which can degrade the capacity, quality and reliability of the communication link. Relaying transmission technique has proved cost effective and a reliable for modern wireless systems which enhance base station coverage at the cell edges and improves wireless link quality between source and destination(Abe. *et. at.,* 2006). MIMO technology already has become an active topic of research and discussion in academia and industry. MIMO is considered as a good spectral efficient technique with very high communication capacity and reliability of wireless systems. The use of MIMO technique with relaying technique can thus be seen to increase capacity, quality, coverage and reliability of wireless link. Therefore, the arrangement of MIMO and relay techniques is able to achieve the benefits ofboth techniques, and has been extensively considered as a vital contender for current and future wireless networks (Chakrabarti. *et. at.,* 2006). (Cheng *et. at.,* 2004).

The transparent oramplifying and forward (AF) relaying technique is a promising one and famous for its employment and complexity, since fully decoding multiple data streams encompasses more computational efforts and cost as compared to the decode and forward relay(Zhioua. *et. at.,* 2013). The performance of such networks is enhanced with a suitable beam forming at channel state information (CSI). In (Bolcskei, *et. at.,* 2006) capacity scaling of relay assisted MIMO network is discussed and CSI considered at the relay terminal. Matched filter-regularized zero forcing schemeis proposedby (Zhang. *et. at.,*2010) which allows interference.

It has been revealed that MF beamforming at relay receiver brings substantial system performance because the noise is averaged over the multiple antennas butit provides better performance in noise limited scenarios. However in interference limited scenarios the MF cannot perform well(Zhang. *et. at.,*2010). Here, authors have validated that the MF cannot achieve the obvious performance gains even with the increased number of antennas. Therefore, it is often required to have techniques that efficiently work well in both scenarios.

Because, in practical wireless communication structures co-channel interference (CCI) and other interferences occur (Huang.*et al.,* 2013), they need to be incorporated in objective function of the beamforming. In MIMO relay assisted systems interference takes place over a common communication channel and has significant impact on the efficiency and reliability of the communication system, this requires to be managed and suitably mitigated. As in (Saand. *et al.,*2014) this paper also uses SLNR maximization (SLNRmax) based precoding at the relay downlink. However, unlike (Saand *et al.,* 2014)we use anew an efficient relay receive beamforming based on SINR maximization

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(SINRmax) criteria using Fukunaga Koontz Transform (FKT) instead of MF based relay receive beamforming. To overcome this problem, the SINR maximization based receive beamforming can be strong candidate for relay receive beamforming. The SINRmax based technique takes noise plus interference into the account and can bring better system performance. However, the beamforming computational load is usually high. In order to reduce that computational load, an efficient optimization tool Fukunaga Koontz Transform (FKT)(Saand *et. al.,* 2014).(Saeid. *et al.*,2012).can be used. The proposed relay linear processing scheme can give the better results in terms of ergodic capacity and can make it possible to control interference.

The rest of this paper is outlined as follows. In Section 2, single user MIMO relay system model is given. In section 3 the problem of relay processing is formulated. Section 4, discusses the numerical results of proposed scheme and compares the results with other conventional schemes. At the end conclusion is given in Section 5.

2. SYSTEM MODEL

In this system a three terminal MIMO network with one AF relay and one user is considered. The information signal sent is processed and forwarded to the destination by the relay node using half-duplex mode. Eachnodehas same quantity of antennas which are represented as M_s, M_r and M_d and shown in **(Fig.1).** The channel matrix $\boldsymbol{H}$from source-relay is $\boldsymbol{H} \in C^{M_r \times M_s}$ with $(l,i)^{th}$ entries. whereas$\boldsymbol{G} \in C^{\mathrm{M_d} \times \mathrm{M_r}}$ represents the channel with $(j,i)^{th}$entries between the relay and destination nodes. Let $E\{n_d n_d^H\} = \sigma_d^2 I_{M_r}$ and both channels have Rayleigh flat fading effect.

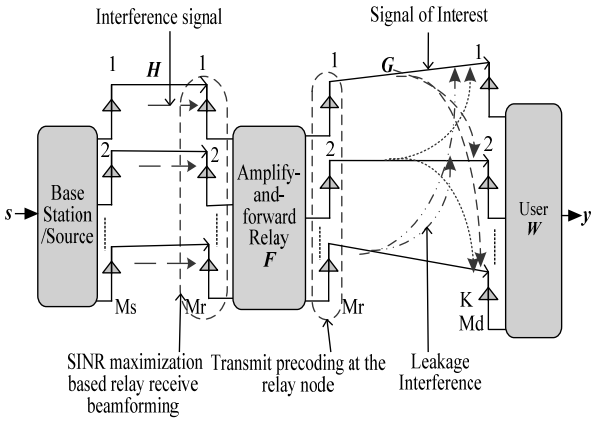


Fig.1. Single relay based MIMO network with Multiple antennas

Initially,the source sends signal $\boldsymbol{s}$to the relay with uniform power allocation strategy as $Z = \frac{P_S}{M_S}\boldsymbol{I}_{M_S}$, where,$P_s$is source transmit power and$\boldsymbol{I}_{M_S}$is identity matrix. The signal vector $\boldsymbol{y}_r$ received by relaythat is given as;

$$\boldsymbol{y}_r = \boldsymbol{Hs} + \boldsymbol{n}_r. \quad (1)$$

The relay forwards signal after signal processing on the received signal$\boldsymbol{y}_r$is expressed as;

$$\widehat{\boldsymbol{y}}_{\boldsymbol{r}} = \boldsymbol{FHs} + \boldsymbol{Fn}_r. \quad (2)$$

where$\boldsymbol{F}$ is relay receive beamforming matrix. The relay power has condition $E = \{\widehat{\boldsymbol{y}}_r{}^H \widehat{\boldsymbol{y}}_r\} \leq P_r$, where P_r is the total relay power conditionis given as;

$$\delta(\widehat{\boldsymbol{y}}_r) = tr\left\{\boldsymbol{F}\left[\frac{P_S}{N_S}\boldsymbol{HH}^H + \sigma_r^2 \boldsymbol{I}_{M_r}\right]\boldsymbol{F}^H\right\} \leq P_r. \quad (3)$$

From equation (3) the factor ρ can be formed as;

$$\boldsymbol{\rho} = \left(\frac{\boldsymbol{P_r}}{\boldsymbol{\delta(\widehat{y}_r)}}\right)^{\mathbf{1/2}}. \quad (4)$$

The signal $\boldsymbol{y}_d$reached at the destination is(Saand, Jeoti, & Saad, 2015);

$$\boldsymbol{y}_d = \sqrt{\frac{P_r}{tr\left\{\boldsymbol{F}\left[\frac{P_S}{M_S}\boldsymbol{HH}^H + \sigma_r^2 \boldsymbol{I}_{M_r}\right]\boldsymbol{F}^H\right\}}}\boldsymbol{HFG} + \boldsymbol{FGn}_r + \boldsymbol{n}_d. \quad (5)$$

3. PROPOSED SINRMAX BASEDBEAMFORMING AT RELAY NODE

Since the matched filter based relay receive beamformer considers only the noise mitigation at the relay receiver and thereby improves the output SNR, it ignores the interference among multiple antennas. To tackle this problem, a linear processing system uses signal to interference plus noise ratio maximization (SINRmax) criteria is proposed. The relay receive beamforming is designed using FKT at the same time, on the downlink of the relay a precoder is used which is designed using SLNR maximization criterion. This is done to mitigate CCI at relay receiver and leakage interference at the user end as shown in Fig.1.It provides apictorial concept of the CCI at the relay reception and interference due to leakage among multiple antennas at the destination.

The SINR maximization strategy provides a compromise between eliminating interference and minimizing the noise factor (Sibille, Oestges, & Zanella, 2010).The criterion of SINR maximization is an important criterion for interference cancellation in multiuser MIMO preceding. We adopt this criterion by using FKT as relay receive beamforming to reduce the interference effect. The signal to interference plus noise ratio (SINR) can be written in terms of beamforming vectors as follows;

$$SINR^l = \frac{\left\|\boldsymbol{h}^l \boldsymbol{p}^l\right\|_F^2}{\sigma_r^{2l} + \sum_{\substack{l=1 \\ k \neq l}}^{M_r} \left\|\boldsymbol{h}_i^l \boldsymbol{p}_i^l\right\|_F^2}. \quad (6)$$

Alternatively this can be written as:

$$SINR^{l} = \frac{\boldsymbol{p}^{l^H}(\boldsymbol{h}^{l^H}\boldsymbol{h}^{l})\boldsymbol{p}^{l}}{\boldsymbol{p}^{l^H}(\boldsymbol{H}^{l^H}\boldsymbol{H}^{l}+\sigma_r^{l^2}I_{M_S})\boldsymbol{p}^{l}}. \quad (7)$$

Now per antenna SINR maximization beam forming problem leading to vector $\breve{\boldsymbol{p}}^{l}$ is designed as:

$$\breve{\boldsymbol{P}}^{\boldsymbol{l}} = \arg\max_{P^l \in C^{M_r\times 1}} \frac{p^{l^H}(h^{l^H}h^{l})p^{l}}{p^{l^H}(H^{l^H}H^{l}+\sigma_r^{l^2}I_{M_S})p^{l}}. \quad (8)$$

3.1. Fukunaga-Koontz Transform in relay beamforming

In 1970 (Fukunaga & Koontz, 1970), Fukunaga and Koontz proposed an statistical approach for feature selection of high dimensional data.. Let $\boldsymbol{\psi}_1$ and $\boldsymbol{\psi}_2$ be two data matrices;

$$\boldsymbol{A}_1 = \boldsymbol{\psi}_1 \boldsymbol{\psi}_1{}^T \text{ and} \quad (9)$$
$$\boldsymbol{A}_2 = \boldsymbol{\psi}_2 \boldsymbol{\psi}_2{}^T. \quad (10)$$

The covariance matrices $\boldsymbol{A}_1$ and $\boldsymbol{A}_2$ must be computed. As shown in (9) and (10), respectively. In next stage is to sum $\boldsymbol{A}_1$ and $\boldsymbol{A}_2$as in (11) and (12) and to decompose this sum matrix as (13) (Fukunaga andKoontz, 1970).

$$\boldsymbol{A} = \boldsymbol{A}_1 + \boldsymbol{A}_2. \quad (11)$$
$$\text{or} \boldsymbol{A} = \boldsymbol{\psi}_1 \boldsymbol{\psi}_1{}^T + \boldsymbol{\psi}_2 \boldsymbol{\psi}_1{}^T. \quad (12)$$

The (17) is decomposed by using s.v.d as;

$$\boldsymbol{A} = [\boldsymbol{U}\boldsymbol{\Sigma}\boldsymbol{V}^{\boldsymbol{T}}]. \quad (13)$$

Then operator $\boldsymbol{P}$is built by using $\boldsymbol{U}$ and $\boldsymbol{\Sigma}$ matrices, where $\boldsymbol{U}$ is the unitary matrix with eigenvectors of $\boldsymbol{A}_1 + \boldsymbol{A}_2$, $\boldsymbol{\Sigma}$is the diagonal matrix whose entries are positive and non-zero singular values being equal to the eigen values, that is $\boldsymbol{\Sigma} = diag\{\lambda_1, \dots, \lambda_r\}, \lambda_1 \geq \cdots \geq \lambda_r > 0$.

Let $\boldsymbol{P}$is Fukunaga-Koontz Transform and is expressed as;

$$\boldsymbol{P} = \boldsymbol{U}\boldsymbol{\Sigma}^{-1/2}. \quad (14)$$

By using $\boldsymbol{P}$ operator the$\boldsymbol{A}_1$ and $\boldsymbol{A}_2$ matrices are transformed into subspace with low dimension. After transformation two new matrices $\widetilde{\boldsymbol{A}}_1$ and $\widetilde{\boldsymbol{A}}_2$ are obtained as;

$$\widetilde{\boldsymbol{A}}_1 = \boldsymbol{P}^{\boldsymbol{T}}\boldsymbol{A}\boldsymbol{P}. \quad (15)$$
$$\widetilde{\boldsymbol{A}}_2 = \boldsymbol{P}^{\boldsymbol{T}}\boldsymbol{A}\boldsymbol{P}. \quad (16)$$

The sum of (15) and (16) be equal to the identity matrix as;

$$\widetilde{\boldsymbol{A}}_1 + \widetilde{\boldsymbol{A}}_2 = \boldsymbol{I}. \quad (17)$$

By rewriting (17) we have

$$\widetilde{\boldsymbol{A}}_1 = \boldsymbol{I} - \widetilde{\boldsymbol{A}}_2. \quad (18)$$

If the eigenvector of $\widetilde{\mathrm{A}}_1$is v with eigenvalue λ_1 that is $\widetilde{\mathrm{A}}_1\mathrm{v} = \lambda_1\mathrm{v}$(Zhang. *et. al.*, 2006).

$$(\boldsymbol{I} - \widetilde{\boldsymbol{A}}_2)\boldsymbol{v} = \boldsymbol{\lambda}_1\boldsymbol{v}. \quad (19)$$
$$\widetilde{\mathbf{A}}_2\mathbf{v} = (\mathbf{1} - \boldsymbol{\lambda}_1)\mathbf{v}. \quad (20)$$

The problem of optimization of (8) mapped to FKT as;

$$\widetilde{\boldsymbol{A}}_1 = \boldsymbol{h}^{j^H}\boldsymbol{h}^{j}. \quad (21)$$
$$\widetilde{\boldsymbol{A}}_2 = \boldsymbol{H}^{\boldsymbol{H}}\boldsymbol{H} + \boldsymbol{\sigma}_d^2\boldsymbol{I}_{N_d}. \quad (22)$$

Then the sum of these matrices is;

$$\boldsymbol{A} = \widetilde{\boldsymbol{A}}_1 + \widetilde{\boldsymbol{A}}_2. \quad (23)$$

By using the facts of (21) and (22) for each relay receive antenna, the FKT factor $\boldsymbol{P} = \boldsymbol{U}\boldsymbol{\Sigma}^{-1/2}$can be calculated, that generates the shared eigenspace matrices $\widetilde{\boldsymbol{A}}_1and\widetilde{\boldsymbol{A}}_2$ these are complement of each other(Saeid *et al.*, 2012).

3.2. SLNRbased Relay Transmit Beamforming

A beam forming technique maximizing signalto leakage plus noise ratio (SLNR) was introduced in (Sadek, Tarighat, & Sayed, 2007; Saeid *et al.*, 2012). The SLNR is defined as;

$$\boldsymbol{SLNR}^{\boldsymbol{j}} = \frac{\|\mathbf{g}^{j}\boldsymbol{f}^{j}\|_F^2}{\sum_{\substack{j=1\\k\neq j}}^{\boldsymbol{M_d}}\|\mathbf{g}^{j}\boldsymbol{f}^{k}\|_F^2 + \boldsymbol{\sigma}_d^{j^2}}. \quad (24)$$

Expression (24) can be rewritten as;

$$\boldsymbol{SLNR}^{\boldsymbol{j}} = \frac{\boldsymbol{f}^{j^H}(\mathbf{g}^{j^H}\mathbf{g}^{j})\boldsymbol{f}^{j}}{\boldsymbol{f}^{j^H}(\boldsymbol{G}^{j^H}\boldsymbol{G}^{j} + \boldsymbol{\sigma}_d^{j^2}\boldsymbol{I}_{M_r})\boldsymbol{f}^{j}}. \quad (25)$$

Here, the row vector is $\mathbf{g}^{j}$of the j^{th} antenna at the destination that is $j = 1, \dots, M_d$. The $\sigma_d^{j^2}$ is the NV at destination$\sigma_d^{j^2} = \sigma_1^2, \dots, \sigma_d^2$ and $\boldsymbol{F}^{j} = \boldsymbol{f}^{1}, \dots, \boldsymbol{f}^{M_d}$ is relay downlink precoder (Saand *et al.*, 2014). At the downlink, relay transmitter can pre-process relay receive beam former output signal according to the channel condition of relay to the destination channel(Saand *et al.*, 2014)as illustrated in **Fig.1**.

The precoder is formulated under power P_r constraints as follow:

$$\widehat{\boldsymbol{F}}^{\boldsymbol{j}} = \arg\max_{F^j \in C^{M_r\times 1}} \boldsymbol{SLNR}^{\boldsymbol{j}}(\boldsymbol{F}^{\boldsymbol{j}})$$

subject to

$$\boldsymbol{tr}\left\{\boldsymbol{F}\left[\frac{\boldsymbol{P_s}}{\boldsymbol{M_s}}\boldsymbol{H}\boldsymbol{H}^{\boldsymbol{H}} + \boldsymbol{\sigma}_r^2\boldsymbol{I}_{M_r}\right]\boldsymbol{F}^{\boldsymbol{H}}\right\} \leq \boldsymbol{P}_r. \quad (26)$$

Therefore PA-SLNRmax precoder is built as;

$$\boldsymbol{F}^{\boldsymbol{SLNR}} = \arg\max_{F^j \in C^{M_r\times 1}} \frac{\boldsymbol{f}^{j^H}(\mathbf{g}^{j^H}\mathbf{g}^{j})\boldsymbol{f}^{j}}{\boldsymbol{f}^{j^H}(\boldsymbol{G}^{j^H}\boldsymbol{G}^{j} + \boldsymbol{\sigma}_d^{j^2}\boldsymbol{I}_{M_r})\boldsymbol{f}^{j}}.$$
$$\text{s.t}\delta(\widehat{\boldsymbol{y}}_{\boldsymbol{r}}) \leq P_r. \quad (27)$$

After multiplying relay receive beamforming matrix(8) with (27) we get

$$\boldsymbol{F} = \arg\max_{F^l \in C^{M_r\times 1}} \frac{f^{j^H}(g^{j^H}g^{j})f^{j}}{f^{j^H}(G^{j^H}G^{j} + \sigma_d^{j^2}I_{M_r})f^{j}}\breve{\boldsymbol{P}}^{\boldsymbol{l}}. \quad (28)$$

Finally the signal received at the user end is given as;

$$\boldsymbol{y_d} = \sum_{\substack{j=1\\k\neq j}}^{M_d}\boldsymbol{\rho}\,\boldsymbol{GFHs} + \sum_{\substack{j=1\\k\neq j}}^{M_d}\boldsymbol{G}\,\boldsymbol{Fs_{id}} + \boldsymbol{GFn_r} + \boldsymbol{n_d}. \quad (29)$$

3.3. QRD based Signal Detection

The MIMO detection technique used in this systemis given by(Y. Zhang *et al.*, 2010). QRD of the equivalent channel $\boldsymbol{G}_{sd}$ of the equation (29) is given as;

$$\boldsymbol{G_{sd}} = \boldsymbol{QRD}. \quad (30)$$

The QRD operation gives two output matrices namely $\boldsymbol{Q}$ and$\boldsymbol{R}$, which are the$m \times n$unitary and a

triangular matrix respectively represented as (Zhang *et al.,* 2010);

$$\boldsymbol{R} = \begin{bmatrix} \boldsymbol{r_{11}} & \boldsymbol{r_{12}} & \boldsymbol{r_{13}} \\ \boldsymbol{0} & \boldsymbol{r_{22}} & \boldsymbol{r_{23}} \\ \boldsymbol{0} & \boldsymbol{0} & \boldsymbol{r_{33}} \end{bmatrix}. \quad (31)$$

The detection at the receiver is given as in(Y. Zhang *et al.,* 2010);

$$\boldsymbol{W} = (\boldsymbol{Q}_{sd})^{H}. \quad (32)$$

The effective SINR in terms of powerfor j^{th} antenna is given by (Adam, Li, Haruna, & Mohammed, 2014) ;

$$\boldsymbol{SINR} = \frac{\left(\frac{P_s}{M_d}\right) r_{jj}^2}{\left\|(\rho(Q_{sd})^H GF)_j\right\|^2 \sigma_r^2 I + \sigma_d^2}. \quad (33)$$

The capacity ergodic is given as;

$$\boldsymbol{C_{erg}} = \boldsymbol{E}_{\{H,G\}} \left\{ \frac{1}{2} \sum_{\substack{j=1 \\ k \neq j}}^{M_d} \log_2 (1 + \boldsymbol{SINR}) \right\}. \quad (34)$$

Table.1. Simulation Parameters

Parameters	Value
Relay type	Amplify-and-forward
Network configuration	single relay based dual-hop single user MIMO system
No. of antennas	$M_s = M_r = M_d = 3$ $M_s = M_r = M_d = 4$ $M_s = M_r = M_d = 6$ and $M_s = M_r = M_d = 8$
Noise variance at relay and destination	$\sigma_r^2 = \sigma_d^2$
Channels	Rayleigh
SNR_{sr}	$SNR_{sr} = P_s/\sigma_r^2$
SNR_{rd}	$SNR_{rd} = P_r/\sigma_d^2$
Noise	AWGN zero mean and variance
CSI	Assumed perfect at relay node

4. SIMULATION METHODOLOGY

In all simulations, spatially uncorrelated MIMO channels in both hops are generated as complex Gaussian $CN(0,1)$ and equal noise variance $\sigma_r^2 = \sigma_d^2$ is assumed for relay and destination nodes(Y. Zhang *et al.,* 2010). To evaluate the proposed scheme, we compare the capacities at various number of the number of antennas. In simulations, we assume four sets of system configurations as the first system has 3 antennas at each node, while second has 4, third has 6 and fourth has 8 antennas respectively. The results are presented by using MATLAB. The list of parameters used in simulation is given in (**Table.1).**

The system performance of the suggested method is assessed and measured in bits per second per Hertz terms as given in (Abdul *et al.,v* 2016). and upper bond capacity as in (Bolcskei *et al.,* 2006)which is compared with four beam forming methods, first one is proposed in (Saand *et al.,* 2014), second MF-RZF in. third is MF-ZF in (Zhang *et al.,* 2010) and fourth one is ZF-ZF in. The simulation effects are run over 10000 independent channel realizations.

5. RESULTS AND DISCUSSION

The simulations results evaluating the magnitude of the proposed relay beam forming scheme are presented in this section. The simulations are run according to the simulation parameters given above. The **(Fig. 2)** shows the performance comparisons between the proposed scheme and other four methods (Saand *et al.,* 2014) MF-RZF MF-ZF and ZF-ZF (Shi. *et al.,* 2007). This shows the ergodic capacity gains in bits/sec/Hz with respect to the SNR in dB. We set $M_s = M_r = M_d = 3$ antennas at each node.

The figure shows that, at every SNR value, the proposed precoding scheme out performs the scheme in (Saand *et al.,* 2014) which consider MF beamforming at relay receive and the leakage at user end. The MF-RZF outperforms the MF-ZF because of the regularization factor included in the design. It is noted that the MF-ZF outperforms ZF-ZF technique only at low SNR because MF gives better performance at low SNR , While zero forcing (ZF) is simple precoding technique and beam forming weights are designed to cancel interference but it contributes poor performance at low SNR area but recovers at high SNR. To report the disadvantages of ZF method in (Zhang *et al.,* 2010), regularized zero forcing (RZF) was proposed.

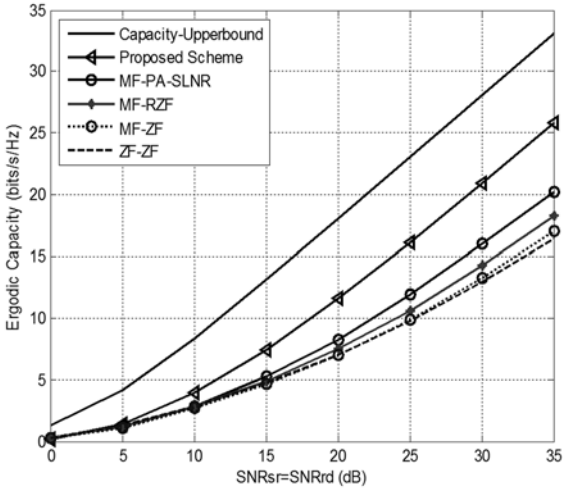


Fig.2. Capacity vs SNR of the proposed scheme and existing schemesunder $M_s = M_r = M_d = 3$system configuration

(Fig.3, Fig.4 and Fig.5) show the effectiveness of the proposed technique at increased number of antennas 4, 6 and 8 antennas at each node respectively. The increased number of multiple antennas contributes to the diversity gain and capacity is also increased. The performance gain of the proposed scheme validates the efficiency of the proposed technique against the interference as compared to other techniques.

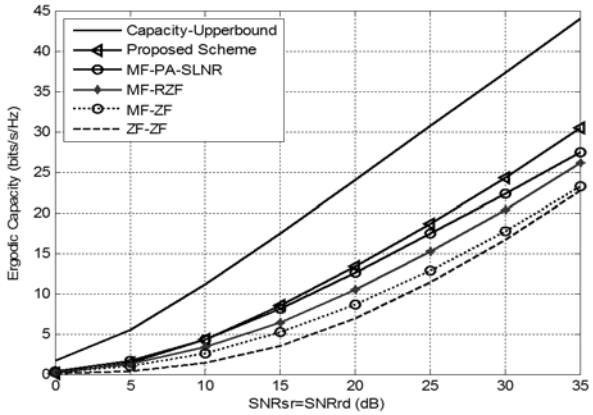


Fig. 3. Capacity vs SNR of the proposed scheme and existing schemes under system configuration of $\mathbf{M_s = M_r = M_d = 4}$

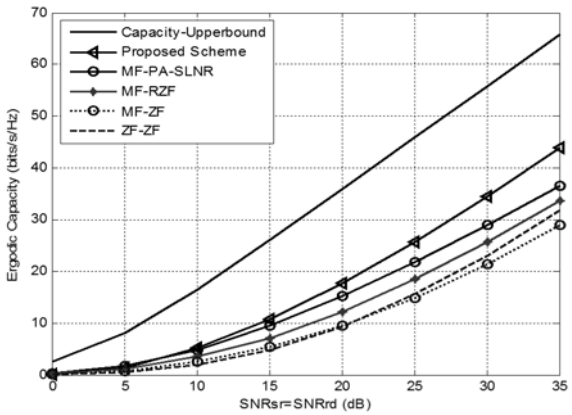


Fig .4. Capacity vs SNR of the proposed scheme and existing schemes under system configuration of$\mathbf{M_s = M_r = M_d = 6}$

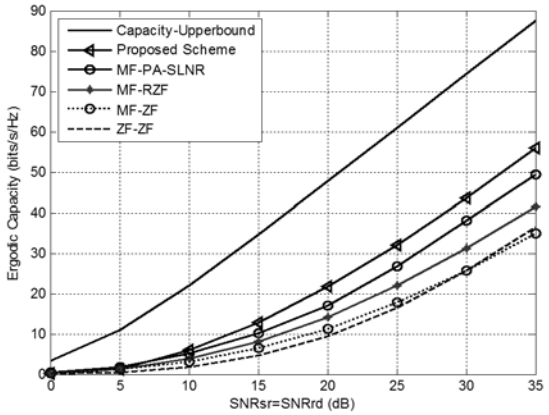


Fig .5. Capacity vs SNR of the proposed scheme and existing schemes under system configuration of $\mathbf{M_s = M_r = M_d = 8}$

If we discusses the enactment obtained with MF-RZF (Zhang *et al.,* 2010) , in each simulation set up the performance of MF-RZF is inferior to the proposed technique and the technique in (Saand *et al.,* 2014) and in (Abdul *et al.,* 2016) , in MF-RZF a regularization parameter is used at cost of some interference because the value of the parameter is always greater than zero. The regularized parameter is optimized well in the literature. In (Saand *et al.,* 2014), the performance of (Zhang *et al.,* 2010) is compared at different values of the regularized parameter. At the lower value this technique approaches to the zero forcing technique. The ergodic capacity performance curves in **(Fig. 6)** shows an approximately linear increase in capacity gain of proposed technique and others. The performance of zero forcing is lower than the MF based technique at lower SNR but improves at the high SNR

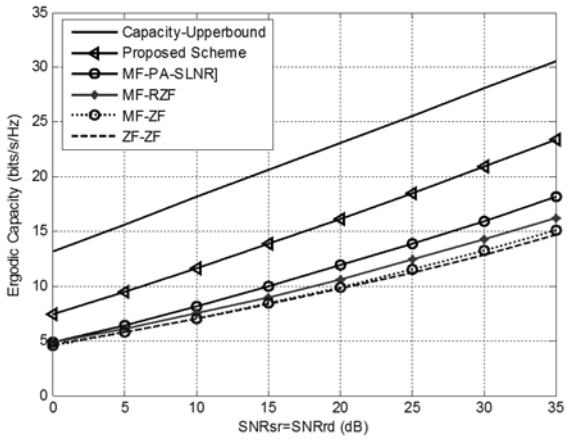


Fig. 6. The linear behavior of the newly designed scheme

Table.2. The performance comparison among different techniques

Beamforming Techniques	**Capacity in bits per second per Hertz**			
	Total antennas equipped at each terminal			
	3	4	6	8
The proposed technique	20.9	24.24	34.49	43.46
MF-PA-SLNR	15.79	22.28	28.87	38.28
MF-RZF	14.65	20.41	25.79	31.2
MF-ZF	13.38	17.73	23.25	25.8
ZF-ZF	12.54	16.64	21.39	25.5

In (**Table. 2)** the performance of proposed and compared beamforming techniques is presented. The performance is compared at different number of antennas at each node. The values of the capacity gain are taken at 30 dB SNR level as indicated in the Fig.3 and so on. It can be seen that, there is an increase in capacity with moreantennas. As we increase antennas from 3 to 4 and 8 correspondingly, the capacity gained by the proposed scheme with 3 antennas is 5.11 b/s/Hz and 22.56 b/s/Hz is attended with 8 antennas as compared to the 3 antennas at each node.

The simulation results reveals that, with the increase in number of antennas from 3 to 4, the measured sum capacity using the proposed scheme is increased as compared to conjugate beam forming at the

relay receive side. Likewise with 8 antennas alsothere is anincrease in capacity, approximately linearly. The results reveal that the proposed scheme is more efficient than other compared techniques. Among various beamforming techniques, the zero forcing beamforming technique mitigates the interference but it neglects the noise enhancement. The matched filter beamforming strategy minimizes noise and maximizes the signal-to-noise ratio (SNR). However this approach has disadvantage of not completely eliminating the interference. In the RZF technique non-zero value of the regularization parameter contribute some amount of interference. The proposed technique takes both the interference and noise reduction into account.Furthermore the use of FKT in the proposed beamforming solves the optimization problem in a computationally efficient manner.

6. CONCLUSION

A linear beamforming scheme is proposed for AF MIMO relay based MIMO network. The proposed relay receive beamforming scheme based on SINR maximization criteria using FKT outperformed the techniques presented in the literature.Disparate the traditional approaches which do not contemplate the interference and noise cancellation in their design, the proposed technique mitigates the both effects effectively. The performance results of proposed scheme demonstrate that, by considering interference mitigation criteria improves the ergodic capacity at significant level. Therefore proposed technique of SINRmax beam forming plus SLNRmax relay precoding outperforms the other conventional techniques.

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