Transmit and Receive Antenna Pairing in MIMO Relay Networks

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***Abstract*—In this paper we consider the problem of antenna selection and pairing in a MIMO relay network when block diagonalization is used at the source with ZF combining at the destination. We start with relay selection where it is assumed that all receive and transmit antennas of a selected relay are used for transmission and argue that antenna selection is superior to relay selection. We propose two algorithms for joint receive and transmit antenna selection and pairing which we refer to as 'optimal pairing' and 'greedy pairing'. Simulation results show that optimal pairing scheme outperforms the existing antenna selection scheme and that greedy pairing gives nearly the same performance as optimal pairing.**

***Index Terms*—MIMO, relay networks, antenna selection.**

I. Introduction

COMMUNICATION systems using relays offer significant gains in spectral efficiency and increase the link reliability between the source and the destination [1]. MIMO relay networks using Amplify and Forward (AF) protocol for low processing complexity at the relays has been an area of interest recently. Earlier works [2], [3] assume the participation of all the relay nodes which is suboptimal when power across all the relays cannot grow unbounded as the number of relays increase.

Relay selection in MIMO relay systems with single antenna relays has been addressed in [4], [5] where low complexity algorithms were proposed for selecting a subset of relays for maximizing the sum rate. Given the obvious advantage of relays with multiple receive and transmit antennas, it is important to address the problem of relay selection in MIMO relay networks with multiple antennas at the relays. It may be noted that the problem of relay selection closely resembles the problem of user selection in MU-MIMO systems. It was established in [6] that Dirty paper coding (DPC) achieves the capacity region of MU-MIMO systems. Due to the high complexity of DPC, linear precoding schemes such as Block Diagonalization (BD) have been proposed in the literature [7].

Antenna selection in AF MIMO networks with ZF processing at the source and the destination has been considered in [8] using a semi-orthogonal strategy. A greedy algorithm for antenna selection based on the fundamental information theoretic capacity was proposed in [9]. The algorithms in [8] and [9] are iterative in nature and calculate the selection metric for all possible pairs of receive and transmit antenna at every relay, at each step. In this paper, we exploit the independence of the backward and forward channels to greedily pair receive and transmit antennas at the relays. We propose two algorithms for receive and transmit antenna pairing at relays for maximizing the sum rate and refer to them as optimal pairing and greedy pairing. We start by assuming only relay selection where all receive and transmit antennas of a selected relay are used for transmission and argue that it is a suboptimal strategy. Then we come up with a novel metric for greedily pairing the receive and transmit antenna at the relays. Simulation results establish the superiority of antenna selection over the relay selection. Further, greedy pairing is found to give nearly the same performance as optimal pairing.

Notation: We represent a matrix with capital boldface letter $\mathbf{A}$, a vector with a small boldface letter $\mathbf{a}$, $\dagger$ denotes the conjugate transpose and $\mathbf{I}$ is the identity matrix.

II. System Model

We consider a wireless MIMO relay network with N transmit and receive antennas at each of the K non-regenerative relays and M antennas at both the source and the destination, where $M \geq N$. Let $\mathbf{H}_k \in \mathcal{C}^{N\times M}$ denote the channel between the k^{th} relay and source, $\mathbf{G}_k \in \mathcal{C}^{M\times N}$ denote the channel between the k^{th} relay and the destination where all the channel entries are iid $\mathcal{CN}(0,1)$. The direct link between the source and the destination is assumed to be absent. In the presence of aggregate transmit power constraint of P_r at the relays, using all the relays for transmission will not be sum rate optimal [5] and thus there is a need to select a set of relays which maximize the sum rate. Let T denote the set of L selected relays for forwarding the source message to the destination. Throughout this section it is assumed that each selected relay uses all its receive and transmit antennas for transmission.

Let the signal transmitted by the source be $\mathbf{s} = \sum_{k=1}^{L} \mathbf{W}_k\mathbf{s}_k$ where $\mathbf{W}_k$'s are the precoding matrices designed using BD. The choice of BD is motivated by the system model in [5] with the difference that instead of one, the relays have multiple antennas. Using BD obviates the need of any kind of coordination between the relays and also suppresses multi relay interference which makes the system more tractable. The signal received at the k^{th} selected relay in the first time slot is

$$\mathbf{y}_{T(k)} = \mathbf{H}_{T(k)}\mathbf{W}_k\mathbf{s}_k + \mathbf{n}_{T(k)} \tag{1}$$

where $\mathbf{n}_{T(k)} \sim \mathcal{CN}(0, \sigma^2\mathbf{I}_N)$. Equal power distribution is assumed at the source i.e. $\mathbb{E}\{\mathbf{s}_k\mathbf{s}_k^\dagger\} = p_s\mathbf{I}$ where $p_s = P_s/\sum \mathrm{Tr}\{\mathbf{W}_k\mathbf{W}_k^\dagger\}$ and P_s is the total transmit power at the source. Relays linearly process the received signal using the weighting matrix $\mathbf{F}_k$ and transmit $\mathbf{t}_k = \mathbf{F}_k\mathbf{y}_{T(k)}$ to the destination in the second time slot. Due to the aggregate power constraint at the relays $\sum_{k=1}^{L}\mathbb{E}\{\mathrm{Tr}\{\mathbf{t}_k\mathbf{t}_k^\dagger\}\} \leq P_r$. The signal

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received at the destination is processed using Zero Forcing (ZF) combining matrices $\mathbf{V}_k$ which satisfy $\mathbf{V}_k^\dagger \mathbf{G}_{T(i)} = 0, \forall i \neq k$. The post processing signal at the destination is given by

$$\mathbf{z}_k = \mathbf{V}_k^\dagger \mathbf{G}_{T(k)} \mathbf{F}_k \mathbf{H}_{T(k)} \mathbf{W}_k \mathbf{s}_k + \mathbf{V}_k^\dagger \mathbf{G}_{T(k)} \mathbf{F}_k \mathbf{n}_{T(k)} + \mathbf{V}_k^\dagger \mathbf{n}_2 \quad (2)$$

where $\mathbf{n}_2 \sim \mathcal{CN}(0, \sigma^2 \mathbf{I}_M)$. The selected system is now equivalent to L parallel single relay MIMO channels with the effective backward channel as $\bar{\mathbf{H}}_k = \mathbf{H}_{T(k)} \mathbf{W}_k$ and the effective forward channel $\bar{\mathbf{G}}_k = \mathbf{V}_k^\dagger \mathbf{G}_{T(k)}$. Therefore the sum rate optimal $\mathbf{F}_k$ would follow the same structure as the optimal weighting matrix for a single relay MIMO channel [10]. As the optimal weighting matrix for a single relay MIMO channel decomposes the system into multiple SISO streams, each of the L MIMO relay channels are further broken down into parallel SISO streams. Since the total number of data streams under BD is limited to M, one must select the best possible M paths to reach from source to destination. However since all the antennas of a selected relay are being used we are constrained to select a set of N streams together instead of selecting the N streams independently giving rise to sub optimality. This motivates us to jointly choose receive and transmit antennas on the relays for communicating the message from source to destination.

III. Antenna Selection

Let $\mathbf{H}_k = [\mathbf{h}_{1,k}^\dagger \cdots \mathbf{h}_{N,k}^\dagger]^\dagger$ and $\mathbf{G}_k = [\mathbf{g}_{1,k} \cdots \mathbf{g}_{N,k}]$ where $\mathbf{h}_{i,k}$ denotes the channel between the i^{th} receive antenna of k^{th} relay and the source and similarly $\mathbf{g}_{i,k}$ denotes the channel between the i^{th} transmit antenna of k^{th} relay and the destination. We denote the set of selected antennas and their corresponding relay by $S = \{\{a_1, b_1, \pi(1)\} \ldots \{a_L, b_L, \pi(L)\}\}$ where a_i & b_i are the indices of the selected receive antenna and transmit antenna respectively and $\pi(i)$ is the corresponding relay. Using (2) the post processing signal reduces to

$$z_k = \mathbf{v}_k^\dagger \mathbf{g}_{b_k,\pi(k)} f_k \mathbf{h}_{a_k,\pi(k)} \mathbf{w}_k s_k + \mathbf{v}_k^\dagger \mathbf{g}_{b_k,\pi(k)} f_k n_k + \mathbf{v}_k^\dagger \mathbf{n}_2$$

Here $f_k = \sqrt{p_{r,k}/(p_s |\mathbf{h}_{a_k,\pi(k)} \mathbf{w}_k|^2 + \sigma^2)}$ is the power normalizing coefficient and $p_{r,k}$ is the relay power allocated for the k^{th} selected antenna pair. The SINR corresponding to the k^{th} data stream z_k is given by

$$\text{SINR}_k = \frac{\rho_s \rho_{r,k} \tau_k \eta_k}{\rho_s \tau_k + \rho_{r,k} \eta_k + 1} \quad (3)$$

Here $\tau_k = |\mathbf{h}_{a_k,\pi(k)} \mathbf{w}_k|^2$ is the backward gain coefficient, $\eta_k = |\mathbf{v}_k^\dagger \mathbf{g}_{b_k,\pi(k)}|^2$ is the forward gain coefficient, $\rho_s = p_s/\sigma^2$ and $\rho_{r,k} = p_{r,k}/\sigma^2$. The sum rate of the selected set of antennas S is

$$R(S) = \max_{\rho_{r,k}} 0.5 \sum_k \log \frac{(1 + \rho_s \tau_k)(1 + \rho_{r,k} \eta_k)}{1 + \rho_s \tau_k + \rho_{r,k} \eta_k} \quad (4)$$

$$s.t \quad \sum_k \rho_{r,k} \leq \frac{P_r}{\sigma^2} \quad (5)$$

where the factor of 0.5 takes into account that the communication takes place over two time slots. The above problem is convex in $\rho_{r,k}$ and can be solved analytically using KKT conditions [10]. However for simplicity we are going to assume equal power distribution at the relays in the rest of the paper. Now as each of the K relays have N^2 possible pair of antennas, number of sets of antenna pairs of size less than M are of the order $\sum_{i=1}^{M} \binom{KN^2}{i}$, so an exhaustive search for the best set of antenna pairs will be computationally very expensive. Since each relay is equipped with N receive and transmit antennas, selecting receive and transmit antennas can be looked upon as a relay selection case when the relays have one antenna, with an additional step of pairing the antennas at the relays. Low complexity greedy algorithms for the single antenna relay selection problem were proposed in [5] where an iterative approach was used to compute the gain coefficients τ_k and η_k efficiently. We use a similar greedy strategy to select antenna pairs where the principle idea is to add a pair of receive, transmit antenna to the already selected set of antennas at every iteration and select the pair which produces the maximum sum rate. Although initially we assumed $M \geq N$, it may be noted that antenna selection scheme can be used even when this condition does not hold.

IV. Algorithm

Let the set of selected transmit and receive antennas at the end of $(n-1)^{th}$ step of the algorithm be $S = \{\{a_1, b_1, \pi(1)\} \ldots \{a_{n-1}, b_{n-1}, \pi(n-1)\}\}$. Define the composite channel direction matrices of all the selected antenna pairs as $\tilde{\mathbf{H}}_S = [\tilde{\mathbf{h}}_{a_1,\pi(1)}^\dagger \ldots \tilde{\mathbf{h}}_{a_{n-1},\pi(n-1)}^\dagger]^\dagger$ and $\tilde{\mathbf{G}}_S = [\tilde{\mathbf{g}}_{b_1,\pi(1)} \ldots \tilde{\mathbf{g}}_{b_{n-1},\pi(n-1)}]$ where $\tilde{\mathbf{h}} = \mathbf{h}/\|\mathbf{h}\|$ and $\tilde{\mathbf{g}} = \mathbf{g}/\|\mathbf{g}\|$ are the unit norm backward and forward channel direction vectors respectively. Using the QR decomposition of $\tilde{\mathbf{H}}_S$ and $\tilde{\mathbf{G}}_S$ we can write

$$\tilde{\mathbf{H}}_S = \mathbf{C}_S \mathbf{Q}_S$$
$$\tilde{\mathbf{G}}_S = \mathbf{U}_S \mathbf{D}_S$$

where $\mathbf{Q}_S = [\mathbf{q}_1^\dagger \ldots \mathbf{q}_{n-1}^\dagger]^\dagger$ and $\mathbf{U}_S = [\mathbf{u}_1 \ldots \mathbf{u}_{n-1}]$ are the orthonormal basis vectors of the selected backward channels and forward channels. Further $\mathbf{C}_S$ and $\mathbf{D}_S$ denote the lower and upper triangular matrices obtained after QR decomposition of aggregate channel direction matrices. Define $\mathbf{A}_S = \mathbf{C}_S^{-1} = [\boldsymbol{\alpha}_1 \ldots \boldsymbol{\alpha}_{n-1}]$ and $\mathbf{B}_S = \mathbf{D}_S^{-1} = [\boldsymbol{\beta}_1^\dagger \ldots \boldsymbol{\beta}_{n-1}^\dagger]^\dagger$. Using [5]

$$\tau_m = \frac{\|\mathbf{h}_{a_m,\pi(m)}\|^2}{\|\boldsymbol{\alpha}_m\|^2} \quad (6)$$

$$\eta_m = \frac{\|\mathbf{g}_{b_m,\pi(m)}\|^2}{\|\boldsymbol{\beta}_m\|^2} \quad (7)$$

The above relation is made use of for the efficient computation of the gain coefficients τ_m and η_m. Let $\Omega_k^{(t)}$ and $\Omega_k^{(r)}$ denote the set of transmit and receive antennas available for selection at the k^{th} relay respectively. Now construct the candidate set $S_{i,j}^{(k)} = S \cup \{i, j, k\}$ where $i \in \Omega_k^{(r)}$ and $j \in \Omega_k^{(t)}$. Let

$$\boldsymbol{\omega}_{i,k} = \tilde{\mathbf{h}}_{i,k} \mathbf{Q}_S^\dagger$$
$$\boldsymbol{\nu}_{j,k} = \mathbf{U}_S^\dagger \tilde{\mathbf{g}}_{j,k}$$

where the elements of $\boldsymbol{\omega}$ are the components of the candidate backward channel along the basis vectors of the subspace of selected backward streams and similarly elements of $\boldsymbol{\nu}$ are the components of the candidate forward channel along the basis vectors of the subspace of selected forward streams. Then

$$\boldsymbol{\phi}_{i,k} = \tilde{\mathbf{h}}_{i,k} - \boldsymbol{\omega}_{i,k}\mathbf{Q}_S$$
$$\boldsymbol{\psi}_{j,k} = \tilde{\mathbf{g}}_{j,k} - \mathbf{U}_S\boldsymbol{\nu}_{j,k}$$

where $\boldsymbol{\phi}_{i,k}$ and $\boldsymbol{\psi}_{j,k}$ are the component of the candidate backward and forward channel which does not lie in the subspace spanned by S. Let $\mathbf{C}_{i,k}$ and $\mathbf{D}_{j,k}$ denote the lower and upper triangular matrices obtained after QR decomposition of the composite backward and forward channels of the candidate set. Their corresponding inverse matrices are given by [5]

$$\mathbf{A}_{i,k} = \mathbf{C}_{i,k}^{-1} = \begin{bmatrix} \mathbf{A}_S & \mathbf{0} \\ -\boldsymbol{\omega}_{i,k}\mathbf{A}_S/\|\boldsymbol{\phi}_{i,k}\| & 1/\|\boldsymbol{\phi}_{i,k}\| \end{bmatrix} \quad (8)$$
$$\mathbf{B}_{j,k} = \mathbf{D}_{j,k}^{-1} = \begin{bmatrix} \mathbf{B}_S & -\boldsymbol{\nu}_{j,k}\mathbf{B}_S/\|\boldsymbol{\psi}_{j,k}\| \\ \mathbf{0} & 1/\|\boldsymbol{\psi}_{j,k}\| \end{bmatrix} \quad (9)$$

The basis vectors of the backward and forward channel space of $S_{i,j}^{(k)}$ are $\mathbf{Q}_{i,k} = [\mathbf{Q}_S^\dagger \mathbf{q}_{i,k}^\dagger]^\dagger$ and $\mathbf{U}_{j,k} = [\mathbf{U}_S\mathbf{u}_{j,k}]$ where $\mathbf{q}_{i,k} = \boldsymbol{\phi}_{i,k}/\|\boldsymbol{\phi}_{i,k}\|$ and $\mathbf{u}_{j,k} = \boldsymbol{\psi}_{j,k}/\|\boldsymbol{\psi}_{j,k}\|$. Then the effective backward and forward gain coefficients for the candidate set $S_{i,j}^{(k)}$ can be evaluated using the columns of $\mathbf{A}_{i,k}$ and rows of $\mathbf{B}_{j,k}$ in (6) and (7) respectively.

Algorithm 1 Optimal pairing

1) Initialization:
   - Find $a_k = \arg\max_{1\le j\le N} \|\mathbf{h}_{j,k}\|^2$ and $b_k = \arg\max_{1\le j\le N} \|\mathbf{g}_{j,k}\|^2$, $\forall$ relay k.
   - Compute $r_k = \frac{\rho_s\rho_r\|\mathbf{h}_{a_k,k}\|^2\|\mathbf{g}_{b_k,k}\|^2}{\rho_s\|\mathbf{h}_{a_k,k}\|^2+\rho_r\|\mathbf{g}_{b_k,k}\|^2+1}$ where $\rho_s = \frac{P_s}{\sigma^2}$ and $\rho_r = \frac{P_r}{\sigma^2}$.
   Denote $\pi(1) = \arg\max_k r_k$ and set $S = \{a_{\pi(1)}, b_{\pi(1)}, \pi(1)\}$, $\mathbf{A}_S = \mathbf{B}_S = 1$, $\mathbf{Q}_S = \tilde{\mathbf{h}}_{a_{\pi(1)},\pi(1)}$, $\mathbf{U}_S = \tilde{\mathbf{g}}_{b_{\pi(1)},\pi(1)}$, $\Omega_{\pi(1)}^{(t)} = \Omega_{\pi(1)}^{(t)} - \{b_{\pi(1)}\}$, $\Omega_{\pi(1)}^{(r)} = \Omega_{\pi(1)}^{(r)} - \{a_{\pi(1)}\}$, $R(S) = 0.5\log(1 + r_{\pi(1)})$ and $n = 1$
2) While $(n < M)$: $\forall$ relay k such that $\Omega_k^{(r)} \neq \emptyset$
   - Compute $\boldsymbol{\omega}_{i,k}, \boldsymbol{\phi}_{i,k}, \mathbf{A}_{i,k}$, $\forall$ $i \in \Omega_k^{(r)}$ and $\boldsymbol{\nu}_{j,k}, \boldsymbol{\psi}_{j,k}, \mathbf{B}_{j,k}$, $\forall j \in \Omega_k^{(t)}$ to find $R(S_{i,j}^{(k)})$
   - $\{a_{\pi(n)}, b_{\pi(n)}, \pi(n)\} = \arg\max_{k,i,j} R(S_{i,j}^{(k)})$, and denote the rate achieved by $S_{a_{\pi(n)},b_{\pi(n)}}^{(\pi(n))}$ as R_{temp}
   - If $R_{temp} < R(S)$ then stop, else $R(S) = R_{temp}$, $S = S \cup \{a_{\pi(n)}, b_{\pi(n)}, \pi(n)\}$, $\Omega_{\pi(n)}^{(t)} = \Omega_{\pi(n)}^{(t)} - \{b_{\pi(n}\}$, $\Omega_{\pi(n)}^{(r)} = \Omega_{\pi(n)}^{(r)} - \{a_{\pi(n)}\}$, $n = n + 1$.
   Update $\mathbf{Q}_S, \mathbf{U}_S, \mathbf{A}_S, \mathbf{B}_S$.

In the proposed algorithm initially the pair with the highest capacity is selected and in the subsequent iterations the antenna pair which generates maximum rate with the already selected antennas is added to S. The algorithm finds the best candidate pair of receive and transmit antenna at each relay by searching exhaustively through all $O(N^2)$ pairs and then selects the pair which is optimal across all the relays. This algorithm is referred to as optimal pairing algorithm. The algorithm stops when the number of antenna pairs selected becomes M or when the sum rate begins to decrease. The above algorithm can be executed at the destination where an approach similar to the one suggested in [5] can be used to obtain the CSI.

Low Complexity Pairing

Consider the candidate set $S_{i,j}^{(k)}$ in the n^{th} iteration. The backward gain coefficients τ_m of this set are not dependent on the choice of the transmit antenna j and similarly the forward gain coefficients η_m are independent of i. This leads to the motivation for greedily selecting receive and transmit antenna at each relay instead of exhaustively searching through all the possible antenna pairs at every iteration.

Algorithm 2 Greedy pairing

1) Initialize as given in algortihm 1
2) While $(n < M)$: $\forall$ relay k such that $\Omega_k^{(r)} \neq \emptyset$
   - Find $a_k = \arg\max_{i\in\Omega_k^{(r)}} \|\mathbf{h}_{i,k}\|^2\|\boldsymbol{\phi}_{i,k}\|^2$,
   $b_k = \arg\max_{j\in\Omega_k^{(t)}} \|\mathbf{g}_{j,k}\|^2\|\boldsymbol{\psi}_{j,k}\|^2$.
   Compute $\mathbf{A}_{a_k,k}, \mathbf{B}_{b_k,k}$ and set $R_k = R(S_{a_k,b_k}^{(k)})$
   - $\pi(n) = \arg\max_k R_k$. If $R_{\pi(n)} < R(S)$ then stop else set $R(S) = R_{\pi(n)}$, $S = S \cup \{a_{\pi(n)}, b_{\pi(n)}, \pi(n)\}$, $\Omega_{\pi(n)}^{(t)} = \Omega_{\pi(n)}^{(t)} - \{b_{\pi(n}\}$, $\Omega_{\pi(n)}^{(r)} = \Omega_{\pi(n)}^{(r)} - \{a_{\pi(n)}\}$, $n = n + 1$ and update $\mathbf{Q}_S, \mathbf{U}_S, \mathbf{A}_S, \mathbf{B}_S$.

Using (6) and (9) the effective backward channel gain coefficients if the receive antenna i of k^{th} relay is selected in the n^{th} iteration can be written as

$$\tau_{i,k}^{(m)} = \frac{\|\mathbf{h}_{a_{\pi(m)},\pi(m)}\|^2}{\|\boldsymbol{\alpha}_m\|^2 + |\boldsymbol{\omega}_{i,k}\boldsymbol{\alpha}_m|^2/\|\boldsymbol{\phi}_{i,k}\|^2}, m \le n - 1$$
$$\tau_{i,k}^{(n)} = \|\mathbf{h}_{i,k}\|^2\|\boldsymbol{\phi}_{i,k}\|^2$$

where $\boldsymbol{\alpha}_m$ denotes the m^{th} column of $\mathbf{A}_S$. Hence higher the value of $\|\boldsymbol{\phi}_{i,k}\|$ higher will be the backward gain coefficients. Since $\boldsymbol{\phi}_{i,k}$ is the component of the candidate backward channel that does not lie in the space of $\tilde{\mathbf{H}}_S$, $\|\boldsymbol{\phi}_{i,k}\|$ is a measure of how orthogonal the candidate backward channel is to the space of selected backward channels. More orthogonality between the channels would relax the null space constraint on the precoding vectors and would result in higher gain coefficients. Similarly higher the value of $\|\boldsymbol{\psi}_{j,k}\|$ higher will be the value of forward gain coefficients. Instead of searching through all the N^2 pairs exhaustively we propose to select and pair the candidate transmit and receive antenna for each relay based on the value of $\tau_{i,k}^{(n)}$ and $\eta_{j,k}^{(n)}$ respectively. This takes into account the channel quality measured in terms of norm of the channel, along with effective orthogonality measure $\|\boldsymbol{\phi}_{i,k}\|$ and $\|\boldsymbol{\psi}_{j,k}\|$

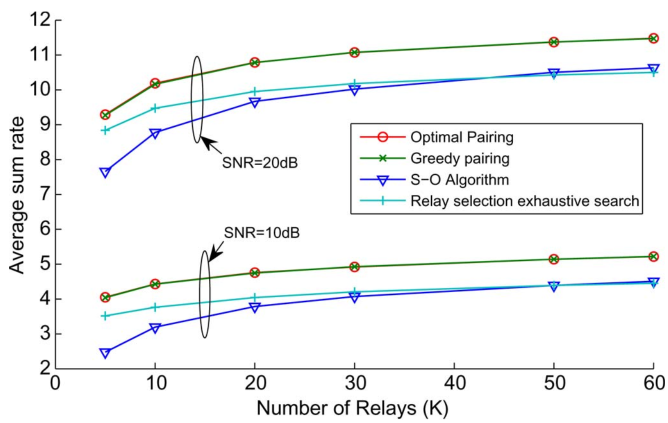

Fig. 1. Average capacity vs number of relays for $M = 4$, $N = 2$.

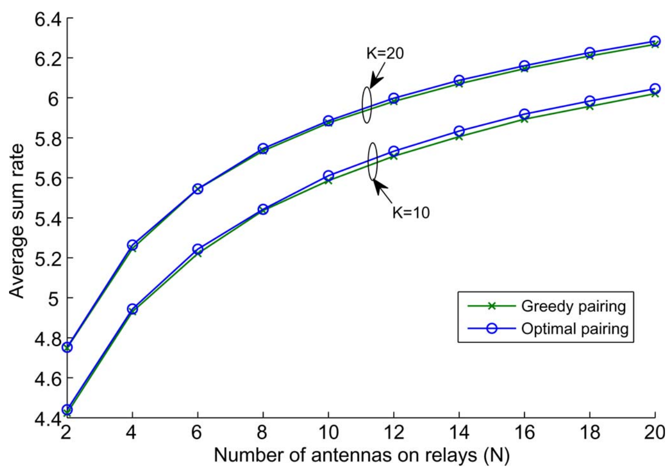

Fig. 2. Average capacity vs number of antennas on a relay for $M = 4$, $SNR = 10$ dB.

of the candidate backward and forward channel. We refer to this algorithm as greedy pairing.

The complexity of the optimal pairing algorithm turns out to be $O(KM^3N + KM^2N^2)$ while the complexity of the greedy pairing algorithm is $O(KM^3N)$. Let us compare this with the Mean Square Error (MSE) based antenna selection algorithms in [11] and [12]. The discrete optimization algorithm in [11] has $O(K^3M^3)$ complexity while the greedy algorithm in [12] computes MSE for all possible antenna pairs on every relay at each iteration. Thus, compared to both these algorithms the greedy pairing algorithm has a lower complexity.

V. Simulation Results

In this section we compare the performance of relay and antenna selection schemes. We fix the noise variance $\sigma^2 = 1$, assume $P_s = P_r = P$ and plot the average sum rate versus number of relays in Fig. 1 where S-O (Semi orthogonal) denotes the antenna selection scheme proposed in [8]. As expected, antenna selection scheme is clearly superior to the relay selection method and greedy pairing gives almost the same performance as optimal pairing. Also, our scheme outperforms the S-O algorithm [8]. To compare the performance of greedy pairing with optimal pairing, we plot the average sum rate versus number of antennas on a relay (N) in Fig. 2 for $M = 4$ and $P = 10$ dB. It can be observed that greedy pairing performs close to optimal pairing even for large values of N. This is because in greedy pairing we select the antenna pair on the basis of gain coefficients of the candidate channels whose higher value generally translates to higher value of the gain coefficients of the remaining gain coefficients. Note that greedy pairing will not be the same as optimal pairing because it pairs the antennas only on the basis of n^{th} gain coefficient and does not consider the other $n - 1$ gain coefficients which also get affected depending on the choice of the receive and transmit antenna.

VI. Conclusion

We began by considering relay selection and noted that the optimal weighting matrices at the relays diagonalize the multi-relay MIMO channel into parallel SISO channels, thus motivating joint selection of receive and transmit antennas at the relays. It turns out that antenna selection indeed gives better performance than relay selection. We proposed an optimal pairing algorithm for joint receive and transmit antenna selection. Further we propose a low complexity pairing scheme where we greedily pair the antennas based on a metric which captures both the channel quality and the orthogonality with the already selected set. Simulation results show that optimal pairing performs better than the existing antenna selection scheme and further greedy pairing gives nearly the same performance as optimal pairing, even for large N.

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