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COOPERATIVE BEAMFORMING DESIGN TO ACHIEVE HIGH INFORMATION RATES FOR MIMO RELAY CHANNELS

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ABSTRACT: Now a days, multiple input multiple output (MIMO) relaying has gained much consideration, due to its improved data rate, coverage extension and also improved signal to noise ratio (SNR). In this paper, a transmit beam forming design for MIMO decode-and-forward (DF), half-duplex two-hop relay channels with a direct source–destination link to achieve high information rates is been considered. Network model consist of source, relay and destination. Design includes four different cases in terms of the number of antennas deployed at source, relay and destination node which contains 2:2:1 scenario, N_s:1:1 scenario, N_s: N_r:1 scenario, N_s: N_r: N_d scenario. Here, beam forming design is based on exact capacity formulation and low-complexity explicit expressions are used. Effect of parameter such as number of antennas on the performance of MIMO relay channels is also examined. Optimal beam forming design for MIMO DF relaying scheme achieves high performance gain and higher information rates than MIMO AF and MIMO CF relaying scheme.

Keywords: Beam forming and optimization, decode and forward (DF), MIMO, relay, SNR(Signal to Noise ratio).

1. INTRODUCTION

The wireless communication environment is very constrained. Recently, full-duplex relaying systems have been intensively investigated due to a wide coverage area and high spectral efficiency. The full duplex operation by supporting concurrent transmission and reception in a single time/frequency channel is expected to be implemented in future generation networks.Relaying is an important and effective technology in achieving coverage extension, energy saving and spectral efficiency improvement for wireless systems and therefore has received a considerable amount of research interest. Several relaying schemes have been incorporated in standard proposals, such as 3GPP release 10 for next generation wireless systems. Generally there are two popular relay Strategies:

1) amplify-and-forward (AF), where the relay decodes the received signals and then forwards them to the destination and

2) decode-and-forward (DF), where the relay decodes the received signals and then forwards the re-encoded information to the destination.

Compared to AF strategy, the DF strategy difficulty relay nodes with greater signal processing capabilities, but it outperforms the AF strategy especially when the source relay channel is statistically better than the source-destination and relay-destination channels. In this paper, we consider half-duplex DF relaying systems, where the relay is only allowed to transmit and receive using orthogonal time or frequency.

1.1. CO-OPERATIVE COMMUNICATIONS

The classic representation of a communication network is a graph with asset of nodes and edges. The nodes usually represent devices such as a router, a wireless access point, or a mobile telephone. The edges usually represent communication links or channels, for example, an optical fibre, a cable, or a wireless link. This work deals mainly with Rayleigh at fading wireless channels. Both devices and the channels may have constraints on their operation, For example, a router might have limited processing power, a wireless phone has limited battery resources, the maximum transmission distance of an optical fibre is limited by several types of dispersion, and a wireless link can have rapid time vibrations arising from mobility and multipath propagation of signals.

The purpose of a communication network is to enable the exchange of messages between its nodes. Due to the broadcast nature of wireless links, signal transmissions between two nodes may be received at the neighbour nodes. It has been understood in the information theory for over three decades that overhear the transmission, as these intermediate nodes may themselves generate transmissions based on processing of the overhead signals. Let us consider the system, where one system node (source) is sending a message to another system node (destination).due to the broadcast nature of the wireless link, this message is overhead by a third node of the network (relay).During the First phase of transmission, the source broadcasts the unitary message symbols to both relay and destination using the power Es. The second phase consisting of relay which transmitting a transformed version of its received signal to destination while source is silent. Note that the two phases indicate two independent transmissions. This may be achieved by using orthogonal coding; e.g. using different time slots or different frequency careers.

1.2 COOPERATIVE STRATEGIES

The strategies are as follows:

1. Amplify-and-forward (AF)
2. Classic multi-hop
3. Compress-and-forward (CF)
4. Decode-and-forward (DF)
5. Multipath decode-and-forward (MDF)

The above strategies can be used for both wire line and wireless networks and they require progressively more coordination. For example, consider a RC, AF and classic multi-hop do not necessarily require changes at the source or destination nodes, e.g., for multi-hop the relay can behave as if it is the destination or the source.CF does not necessarily require changes at the source but it does require some extra knowledge about the link capabilities. DF requires changes at both the source and destination, and MDF requires additional changes at higher layers of the protocol stack. DF or MDF with network coding require even more changes at higher layers.

2. SYSTEM MODEL

Consider a network model consisting of a source S, a relay R and a destination D, as shown in the figure. It is assumed that the direct link between S and D exists in the system and the relay R helps the information transmission from S to D. Multiple antennas are been deployed to both S and R, and only one antenna is equipped at D.

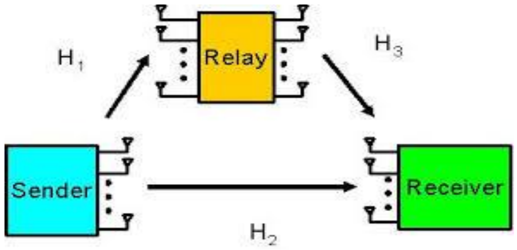


Fig.2.1.System model of MIMO relay channel

Half duplex mode is adopted so that R cannot transmit and receive signals at the same time. Therefore, each round of information transmission from S to D can be divided into two phases. In the first source phase, S broadcasts its information to both R and D, while in the second relay phase R decodes the received information and then forwards the decoded information to D. Thus, D can achieve the desired information by decoding the combined signals received over the above mentioned two phases.

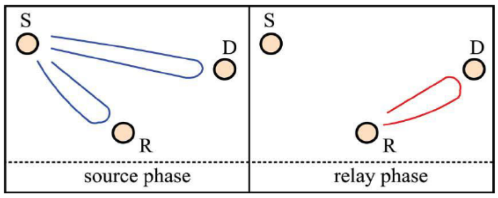


Fig.2.2.Two-phase DF relay transmission.

All channel state information (CSI) for each round of transmission is known at the transmitters, by using techniques such as channel training, feedback and channel reciprocity exploiting etc. Consequently, S and R can configure their beam forming vectors accordingly to achieve the best transmission performance. Without loss of generality, the transmitted information from S and R can be represented by symbols Xs and Xr respectively. Such that, Ns and Nr antennas are deployed at S and R, respectively.

2.1. BEAM FORMING DESIGN USING MRT TECHNIQUE

Beam forming means when combining the received signals from multiple antennas, it is possible to create strong differentiation in gains for signals that arrive from different angles. The beam forming technique has traditionally been applied in the transmit/receive antenna pattern. With proper knowledge of the channel and accordingly setting the combining coefficients, a beam forming receiver can increase the antenna gain along the direction of the intended transmitter while at the same time suppressing the interferences from other directions.

Consider a network model consisting of a source S, a relay R and a destination D, as shown in the below fig. It is assumed that the direct link between S and D exists in the system and the relay R helps the information transmission from S to D. Multiple antennas are deployed both S and R, and only one antenna is equipped at D. Half duplex mode is adopted so that R cannot transmit and receive signals at the same time.

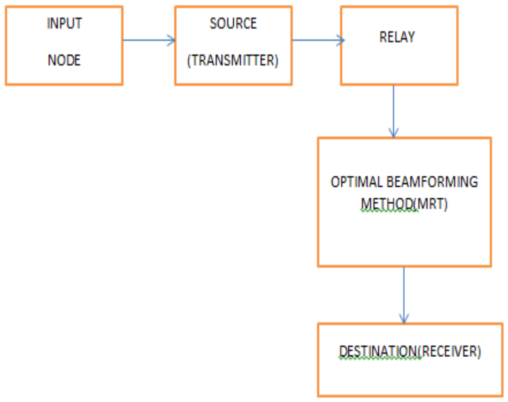


Fig.2.3.Block diagram of Beam forming design by using MRT Technique

Therefore, each surrounding of information transmission from S to D can be divided into two phases, In the source phase, S broadcasts its information to both R and D, while in the relay phase; R decodes the received information and then forwards the decoded information to D. Thus, D can obtain the desired information by decoding the combining signals received over the mentioned two phases.

3. OPTIMAL COOPERATIVE BEAMFORMING DESIGN

3.1. OPTIMAL BEAMFORMING ALGORITHM

In most of the cases the beam forming was fixed in the sense that the weights multiplied the signals at each element were fixed (they do not depend on the received data).Now allow those weights to change or adapt, depending on the received data to achieve a certain goal. Try to adapt these weights to suppress interference. The interference occurs due to the fact that the antenna might serve multiple users. The signal received is a sum over the signals from multiple users. The signal received

is a sum over the signals from multiple users, one of which will designate the"desired" signal. The received data is computation of signal, interference and AWGN.

The main objective of beam forming or interference cancellation is to isolate the signal of the desired user from the interference and noise. In this project, this algorithm Is used between joint source-relay node and destination node .It is used to calculate the exact capacity range of the transmission from source-relay node to destination node without loss of signals. Singular value decomposition is used to find the absolute value. From the positive and non-positive integers, the singular value decomposition is used to get the positive integers. In this project the singular value decomposition is used to find the magnitude and sum of the received signal.

3.2. OPTIMAL COOPERATIVE BEAMFORMING USING ZERO-FORCING PRECODER:

Multi-stream beam forming /spatial processing that occur at the transmitter. Beam forming (single-stream) to same signal is emitted from each of the transmit antennas with appropriate phase and gain weighting such that the signal over is maximised at the receiver input. If the receiver having multiple antennas the transmitted beam forming cannot, at the same time maximize the signal power at the receiver input so the pre-coding with multiple streams is used.

The benefits of beam forming,

1. Increase the received signal
2. Reduce the multipath fading effect.

In this the zero-forcing precoder method is used instead of singular value decomposition method. Zero-forcing precoding is a method of partial signal processing by which the multiple antenna transmitters can null multiuser interference signals. It is enhanced processing to consider the impact on a background noise and unknown user interference. It is one of the method of beam forming for narrowband signals, where we can have a simple way of compensating delays of receiving signals from a specific source at different elements of the antenna array .If the transmitter knows the downlink channel state information (CSI) perfectly, ZF precoding can achieve almost the system capacity when the number of users is large.

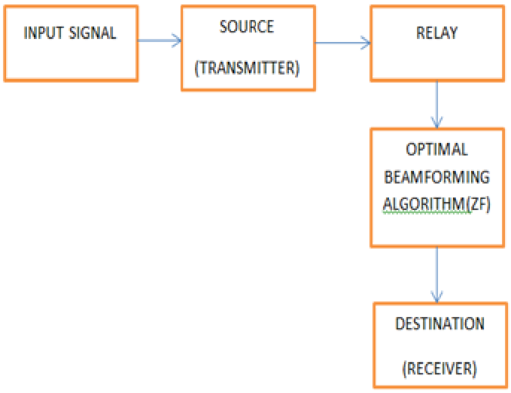


Fig.3.1. Block diagram of optimal beam forming design using zero-forcing precoder

Here, the joint source-relay beam forming design for the three-node MIMO DF relay network with source-destination direct link is been considered. Assume that both the source and relay nodes are equipped with multiple antennas while the destination node is only deployed with single antennas. Such that, a transmission scenario is readily been appropriate for the downlink transmission of a relay of enhanced cellular system, wherever the base-station and the relay can accommodate multiple antennas but the mobile user equipment can only afford to a single antenna due to its size or other constraints. Note that downlink transmission to resource-limited mobile terminals limits the overall performance of cellular systems. As such, this design aims to fully explore the spatial diversity advantage of MIMO-DF relay channels, while relies on complex numerical solutions, it strikes to derive the explicit expressions for the optimal beam forming design for this concerned model.

3.3. Optimal Beam forming Design for 2:2:1 Scenario

The reasons are, firstly, the deployment of two antennas is more realistic than deploying two more antennas in many practical cases. Especially on some Size-limited devices such as notebook PC. Secondly, the MIMO scenario also applies to the situation that only two antennas are selected to transmit signals at the source and relay nodes and 2 X 2 MIMO channel has attracted much attention. Although, in the later versions, more antennas are suggested to be employed, deploying two antennas is commonly considered as the most practical antenna choice strategy due to the larger quantity of time-frequency resource consumption of channel estimation and feedback they produce.

Especially for the channels with fast variation and large Doppler frequency spread which makes channel estimation more complex and resource consumptive. Hence, in this subsection, we will give out the close-form result for the overall optimal beam forming design for the scenario. With the closed-form solution at hand, the beam forming design is significantly simplified. In the scenario, Lemma 1 is still valid, which presents the optimal phase design, and in this case the optimization problem is reduced to

$$\gamma_{D,s} = (|h^T{}_{D,}v_1 \,||\, W_1| + |h^T{}_{D,}v_2 \,||W_2| \ldots +| h^T{}_{D,S}v_{Ns}|| W_{Ns}|^2 Ps \quad (1)$$

Where v unitary matrix of full rank

$$\max_{\alpha_1\alpha_2} \min\, (\boldsymbol{\lambda}_1{}^2\boldsymbol{\alpha}_1 + \boldsymbol{\lambda}_2{}^2\boldsymbol{\alpha}_2, (\beta_1\alpha_1+\beta_1\alpha_2)^2 + \gamma_{D,R}) \quad \ldots\ldots (2)$$

$$\textbf{s.t.}\,\alpha_1 + \alpha_2 = \mathbf{1}$$

$$\alpha_1\alpha_2 \geq \mathbf{0}$$

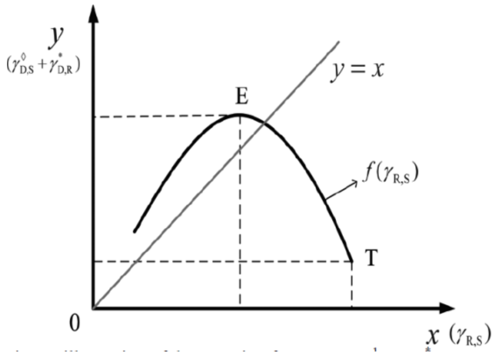
$$\begin{cases} \alpha_1 = \dfrac{K-\lambda_2^2 P_s}{\lambda_1^2-\lambda_2^2} \\ \alpha_2 = \dfrac{\lambda_2^2 P_s - K}{\lambda_1^2-\lambda_2^2} \end{cases} \quad (3)$$

Which leads to maximum values?

$$\gamma^0_{D,S} + \gamma^*_{D,R} = \frac{1}{\lambda_1^2-\lambda_2^2}$$

$$x\left[\beta_1\sqrt{k-\lambda_1^2 P_S} + \beta_2\sqrt{\lambda_1^2 P_S - k}\right]^2 + \gamma^*_{D,R} \quad (4)$$

According to the flow diagram the optimal beam forming method is carried out



The points $\mathbf{x}_E$, $\mathbf{x}_T$, $\mathbf{y}_E$ and $\mathbf{y}_T$ can be calculated from the following equations:

$$\mathbf{x}_T = \lambda^2{}_1 P_S$$

$$y_T = \beta^2{}_1 P_S + \| h_{D,R}\|^2 P_S \quad (5)$$

$$\mathbf{X}_E = \left(\frac{\sum\lambda_i^2\beta_1^2}{\boldsymbol{\beta}_1^2+\cdots+\boldsymbol{\beta}_{N_S}^2}\right)\boldsymbol{P_s}$$

$$\mathbf{Y}_E = \Sigma\, \beta^2{}_i\, Ps\|\, h_{D,R}\|^2 P_r \quad (6)$$

Then if the condition satisfies the flow will come to 2:2:1 scenario. Then for 2:2:1 scenario the alpha value can be calculated according to the following equations

$$\begin{cases} \alpha_1 + \alpha_2 = 1 \\ \lambda_1^2\alpha_1 + \lambda_2^2\alpha_2 = (\beta_1\sqrt{\alpha_1} + \beta_2\sqrt{\alpha_2})^2 + \gamma^*_{D,R} \end{cases} \quad (7)$$

$$\alpha_1 = \frac{1 - 2AB \pm \sqrt{1 - 4ABPS - 4B2}}{2 + 2P_S^2}$$

$$\alpha 1 = 1 - \alpha 1,\ \alpha 1,\ \alpha 2 \geq 0,$$

where

$$\begin{cases} A = \dfrac{\lambda_1^2 - \lambda_2^2 - \beta_1^2 + \beta_2^2}{2\,\beta_1\,\beta_2} \\ B = \dfrac{\lambda_1^2 P_S - \beta_2^2 P_S - \gamma^*_{D.R}}{2\,\beta_1\,\beta_2} \end{cases} \quad (8)$$

If the solutions are all non-negative, only the one which maximizes $\boldsymbol{\lambda}_1{}^2\boldsymbol{\alpha}_1 + \boldsymbol{\lambda}_2{}^2\boldsymbol{\alpha}_2$ should be selected as the final optimal solution.

Once find out the alpha value by using lemma 1 the beam forming matrix w* can be calculated.

IV.RESULTS AND DISCUSSION

MATLAB is a high-performance language for technical computing. It integrates computation, visualization and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. The channel realizations has been used for simulations in matlab.

5.1.OPTIMAL BEAMFORMING DESIGN FOR 2:2:1 SCENARIO

The optimal beam forming design for 2:2:1 scenario achieves the maximum achievable information rates.

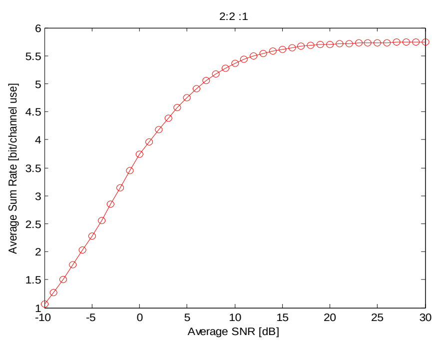


Fig.5.1.Optimal beam forming design for 2:2:1 scenario

5.2.OPTIMAL BEAMFORMING DESIGN FOR 2:2:4 SCENARIO

The optimal beam forming design for 2:2:4 scenario achieves the maximum achievable information rates.

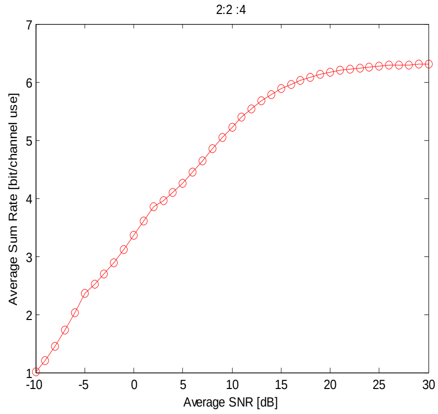


Fig.5.2.Optimal beamforming design for 2:2:4 scenario

5.3.OPTIMAL BEAMFORMING DESIGN FOR 2:4:1 SCENARIO

The optimal beam forming design for 2:4:1 scenario achieves the maximum achievable information rates.

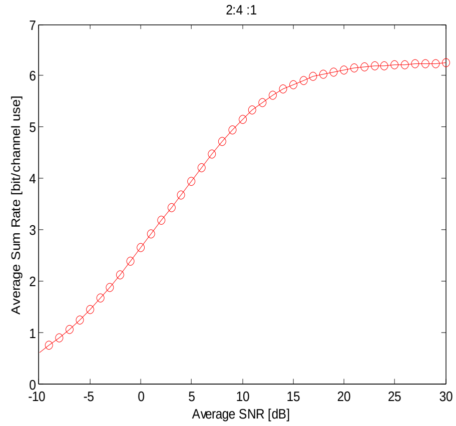


Fig.5.3.Optimal beam forming design for 2:4:1 scenario

5.4.OPTIMAL BEAMFORMING DESIGN FOR 2:4:4 SCENARIO

The optimal beam forming design for 2:4:4 scenario achieves the maximum achievable information rates .

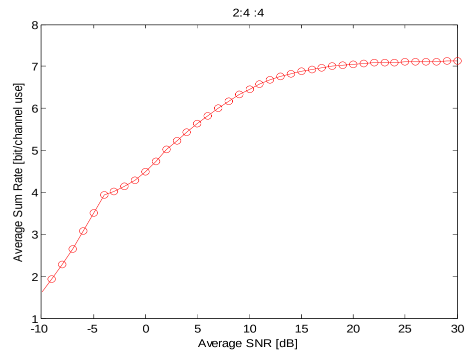


Fig.5.4.Optimal beamforming design for 2:4:4 scenario

5.5. OPTIMAL BEAMFORMING DESIGN 2:2:1 and 2:2:4 SCENARIOS

The optimal beam forming design for 2:2:4 scenario achieves the maximum achievable information rates when compared to 2:2:1 scenario

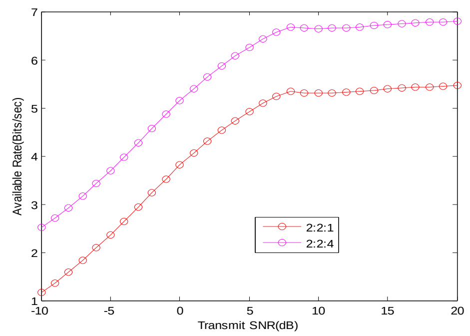


Fig.5.5.Optimal beam forming design for 2:2:4 and 2:2:1 scenario

5.6.OPTIMAL BEAMFORMING DESIGN 2:4:1 and 2:4:4 SCENARIO

The optimal beam forming design for 2:4:4 scenario achieves the maximum achievable information rates when compared to 2:4:1 scenario

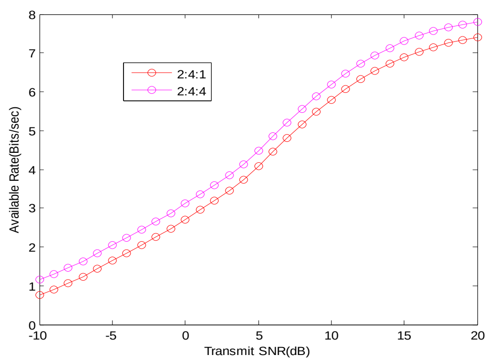


Fig.5.6.Optimal beam forming design for 2:4:1 and 2:4:4 Scenario

V.CONCLUSION& FUTURE WORKS

In this work, considered the beam forming design for MIMO DF Relay channels, where both the source node and relay node are equipped with multiple antennas, an efficient scheme is developed to solve the optimization problem and determine the optimal beam forming vector for MIMO DF relay networks. Like previous work on beam forming design of MIMO DF channels, this beam forming design was based on the exact capacity formulation, which can achieve high accuracy. As an ongoing effort, we can extent the beam forming design to the scenario where all the three nodes are equipped with multiple antennas as a future work**.** We can extend this to the beam forming design to the scenario where we can implement this MIMO concept using someother pre-coder designs in future work and also we can implement the different scenarios practically in future.

REFERENCES

[1] Sumayya Ali , Smitha K M,"Optimal Cooperative Beam forming Design for MIMO Relay Channels", International Conference on Emerging Trends in Engineering, Science and Technology (ICETEST- 2015), Procedia Technology 24 (2016) 796 – 803,2016.

[2] J. Y. Ryu, W. Choi, and D. I. Kim, "Partial stream relaying in MIMO relay communications", IEEE Trans. Veh. Technol., vol. 62, no. 1, pp. 205–218, Jan. 2013.

[3] E. Monroy, S. Choi, and B. Jabbari, "A practical transmission scheme for half-duplex decode-and-forward MIMO relay channels", in Proc. IEEE Globe com Workshops, Anaheim, CA, USA, , pp. 100–104,Dec. 2012

[4] Z. Chen, H. Liu, and W.Wang, "Optimal transmit strategy of a two-hop decode-and-forward MIMO relay system with mean and covariance feedback", IEEE Communication. Lett., vol. 14, no. 6, pp. 530–532, Jun. 2010.

[5] N. D. Suraweera and K. C. B. Wavegedara, "Distributed beam forming techniques for dual-hop decode-and-forward MIMO relay networks", in Proc. IEEE ICIIS, Kandy, Sri Lanka, , pp. 125–129. Aug. 16–19, 2011.

[6] J. Y. Ryu and W. Choi, “Balanced linear precoding in decode-and-forward based MIMO relay communications”, IEEE Trans. Wireless Communication., vol. 10, no. 7, pp. 2390–2400, Jul. 2011.

[7] Z. F. Xu, P. Y. Fan, H. C. Yang, K. Xiong, M. Lei, and S. Yi, “Optimal beam forming for MIMO decode-and-forward relay channels”, GLOBECOM 2012: 4548–4553, in Proc. IEEE Globe com, , pp. 4548–4553,Dec. 2012.

[8] S. Vishwakarma and A. Chockalingam, “Decode-and-forward relay beam forming for secrecy with imperfect CSI and multiple eavesdroppers”, in Proc. IEEE SPAWC, Cesme, Turkey, , pp. 439–443.,Jul. 2012.

[9] Y. Lu, N. Yang, H. Y. Dai, and X. X. Wang, “Opportunistic decode- and-forward relaying with beam forming in two-wave with diffuse power fading”, IEEE Trans. Veh. Technol., vol. 61, no. 7, pp. 3050–3060, Jul. 2012.

[10] Y. Rong and F. Gao, “Optimal beam forming for non-regenerative MIMO relays with direct link”, IEEE Communication. Lett., vol. 13, no. 12, pp. 926–928, Dec. 2009.

[11] H. B. Wang, W. Chen, and J. B. Ji, “Efficient linear transmission strategy for MIMO relaying broadcast channels with direct links”, IEEE Wireless Communication. Lett., vol. 1, no. 1, pp. 14–17, Feb. 2012.

[12] D. H. N. Nguyen, H. H. Nguyen, and D. H. Tuan, “Distributed beam forming in relay-assisted multiuser communications”, in Proc. IEEE ICC, Dresden, Germany, pp. 1–5, Jun. 2009.

[13] Shu F, Tong J J, You X H, et al, “Adaptive robust Max-SLNR precoder for MU-MIMO-OFDM systems with imperfect CSI”, Science China Information Sciences, vol. 59, no. 6, pp 1-14, June,2016.

[14] Riihonen T, Werner S, Wichman R, “Mitigation of loopback self-interference in full-duplex MIMO relays”, IEEE Transactions on Signal Processing, vol. 59, no. 12, pp 5983-5993, December,2011.

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