Precoder Design for Asymmetric Two-way AF Shared Relay

Rohit Budhiraja
Prof. Bhaskar Ramamurthi

Department of Electrical Engineering
Indian Institute of Technology Madras
May 29, 2013

Background

- Cooperative communication can lead to significant performance improvements in wireless systems.

- Conventional one-way relaying is an example.

Background

- Cooperative communication can lead to significant performance improvements in wireless systems.
- Conventional one-way relaying is an example.
- Half-duplex signaling in one-way relaying leads to loss of $\frac{1}{2}$ of spectral resources.
- Four channel uses are required for bidirectional data exchange.

Background

- Cooperative communication can lead to significant performance improvements in wireless systems.
- Conventional one-way relaying is an example.
- Half-duplex signaling in one-way relaying leads to loss of $\frac{1}{2}$ of spectral resources.
- Four channel uses are required for bidirectional data exchange.
- Two-way relaying requires two channel uses instead of four.[1]

Background

- Cooperative communication can lead to significant performance improvements in wireless systems.
- Conventional one-way relaying is an example.
- Half-duplex signaling in one-way relaying leads to loss of $\frac{1}{2}$ of spectral resources.
- Four channel uses are required for bidirectional data exchange.
- Two-way relaying requires two channel uses instead of four.[1]

Background

- Cooperative communication can lead to significant performance improvements in wireless systems.

- Conventional one-way relaying is an example.

- Half-duplex signaling in one-way relaying leads to loss of $\frac{1}{2}$ of spectral resources.

- Four channel uses are required for bidirectional data exchange.

- Two-way relaying requires two channel uses instead of four.[1]

[1] Rankov, B and Wittneben, A, "Spectral Efficient Protocols for Half-Duplex Fading Relay Channels", IEEE J. Sel. Areas Commun, vol. 25, no. 2, pp. 375–385, 2007.

Two-way relaying

- Two source nodes simultaneously transmit to the relay during first phase.

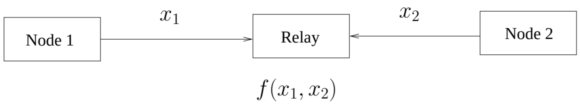

Figure: First phase of two-way relaying

Two-way relaying

- Two source nodes simultaneously transmit to the relay during first phase.

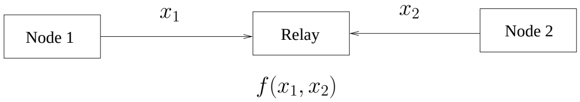

Figure: First phase of two-way relaying

- Relay broadcasts a function of the sum-signal during second phase.

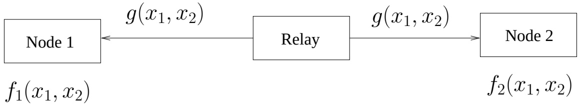

Figure: Broadcast phase of two-way relaying

Two-way relaying (Contd...)

- Two-way relaying is most appropriate when two nodes exchange data simultaneously.

Two-way relaying (Contd...)

- Two-way relaying is most appropriate when two nodes exchange data simultaneously.

- Simultaneous two-way data exchange need not happen in cellular systems.

Two-way relaying (Contd...)

- Two-way relaying is most appropriate when two nodes exchange data simultaneously.
- Simultaneous two-way data exchange need not happen in cellular systems.
- User might have uplink data to transmit but no downlink data to receive.

Two-way relaying (Contd...)

- Two-way relaying is most appropriate when two nodes exchange data simultaneously.
- Simultaneous two-way data exchange need not happen in cellular systems.
- User might have uplink data to transmit but no downlink data to receive.
- Two-way relaying will reduce to conventional one-way relaying.

Asymmetric Two-way relaying

- Consider infrastructure relay scenario, where multiple UEs are served through a relay.

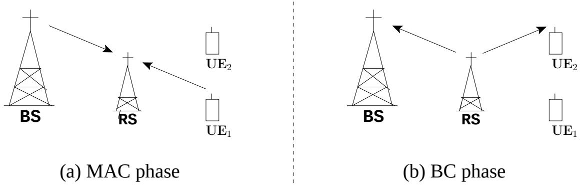

Figure: Asymmetric two-way relaying.

Asymmetric Two-way relaying

- Consider infrastructure relay scenario, where multiple UEs are served through a relay.

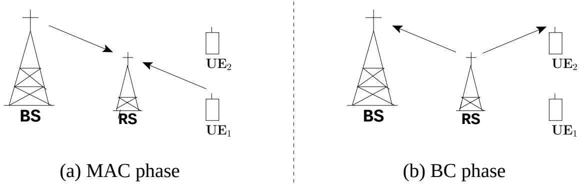

Figure: Asymmetric two-way relaying.

- Two single-antenna UEs want to communicate with a BS.

Asymmetric Two-way relaying

- Consider infrastructure relay scenario, where multiple UEs are served through a relay.

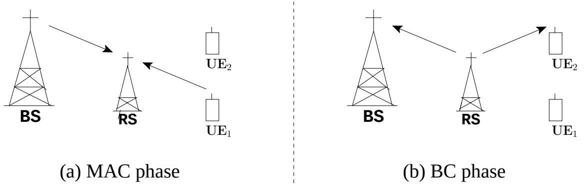

Figure: Asymmetric two-way relaying.

- Two single-antenna UEs want to communicate with a BS.

- UE_1 has data to be sent to the BS. UE_2 wants to receive data from BS.

Asymmetric Two-way relaying (Contd...)

- Leads to problem of asymmetric back-propagating interference (BPI).

Asymmetric Two-way relaying (Contd...)

- Leads to problem of asymmetric back-propagating interference (BPI).
- BS can cancel the BPI, while Downlink single-antenna UE (UE_2) cannot.

Asymmetric Two-way relaying (Contd...)

- Leads to problem of asymmetric back-propagating interference (BPI).
- BS can cancel the BPI, while Downlink single-antenna UE (UE_2) cannot.
- We have proposed a precoder to cancel the asymmetric back-propagating interference for UE_2.[2]

[2] Rohit Budhiraja, Karthik KS and Bhaskar Ramamurthi "Linear Precoders for Two-way Asymmetric Multiuser Relaying in Cellular Systems", Proc. IEEE Int. Conf. Communications (ICC), 2013

Asymmetric Two-way relaying (Contd...)

- Leads to problem of asymmetric back-propagating interference (BPI).
- BS can cancel the BPI, while Downlink single-antenna UE (UE_2) cannot.
- We have proposed a precoder to cancel the asymmetric back-propagating interference for UE_2.[2]
- Proposed precoder is shown to be better than the conventional ZF and MMSE precoders.

[2] Rohit Budhiraja, Karthik KS and Bhaskar Ramamurthi "Linear Precoders for Two-way Asymmetric Multiuser Relaying in Cellular Systems", Proc. IEEE Int. Conf. Communications (ICC), 2013

Asymmetric Two-way relaying for a shared relay

- Data-flow asymmetry problem is extended to shared relay in this work.[3]

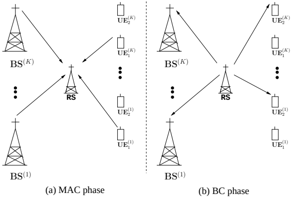

Figure: Illustration of asymmetric two-way shared relaying.

[3] S.W. Peters, A.Y. Panah, K.T. Truong and R.W Heath "Relay architectures for 3GPP LTE-Advanced", EURASIP J. Wireless Commun. and Netw.

Asymmetric Two-way relaying for a shared relay

- Data-flow asymmetry problem is extended to shared relay in this work.[3]

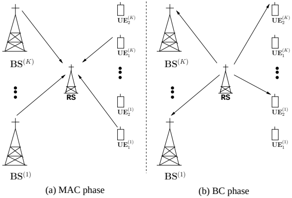

Figure: Illustration of asymmetric two-way shared relaying.

- BSs can cancel the back-propagating interference (BPI), but not IUI.

[3] S.W. Peters, A.Y. Panah, K.T. Truong and R.W Heath "Relay architectures for 3GPP LTE-Advanced", EURASIP J. Wireless Commun. and Netw.

Asymmetric Two-way relaying for a shared relay

- Data-flow asymmetry problem is extended to shared relay in this work.[3]

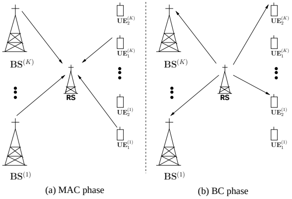

Figure: Illustration of asymmetric two-way shared relaying.

- BSs can cancel the back-propagating interference (BPI), but not IUI.

- Downlink UEs cannot cancel both BPI and IUI.

[3] S.W. Peters, A.Y. Panah, K.T. Truong and R.W Heath “Relay architectures for 3GPP LTE-Advanced”, EURASIP J. Wireless Commun. and Netw.

System model

- BSs and UEs have one antenna each.

System model

- BSs and UEs have one antenna each.
- x_1^k and x_2^k: Data transmitted by $\mathrm{UE}_1^{(k)}$ and $\mathrm{BS}^{(k)}$ to the relay during phase-1.

System model

- BSs and UEs have one antenna each.
- x_1^k and x_2^k: Data transmitted by $\mathrm{UE}_1^{(k)}$ and $\mathrm{BS}^{(k)}$ to the relay during phase-1.
- $\mathbf{h}_1^k$ and $\mathbf{h}_2^k$: Uplink channels observed by the relay from $\mathrm{UE}_1^{(k)}$ and $\mathrm{BS}^{(k)}$.

System model

- BSs and UEs have one antenna each.
- x_1^k and x_2^k: Data transmitted by $\mathrm{UE}_1^{(k)}$ and $\mathrm{BS}^{(k)}$ to the relay during phase-1.
- $\mathbf{h}_1^k$ and $\mathbf{h}_2^k$: Uplink channels observed by the relay from $\mathrm{UE}_1^{(k)}$ and $\mathrm{BS}^{(k)}$.
- $\mathbf{y}_r = \sum_{k=1}^{K} \mathbf{H}_k \mathbf{x}_k + \mathbf{n}_r$: Sum-signal received by the relay during phase-1.

System model

- BSs and UEs have one antenna each.
- x_1^k and x_2^k: Data transmitted by $\mathrm{UE}_1^{(k)}$ and $\mathrm{BS}^{(k)}$ to the relay during phase-1.
- $\mathbf{h}_1^k$ and $\mathbf{h}_2^k$: Uplink channels observed by the relay from $\mathrm{UE}_1^{(k)}$ and $\mathrm{BS}^{(k)}$.
- $\mathbf{y}_r = \sum_{k=1}^{K} \mathbf{H}_k \mathbf{x}_k + \mathbf{n}_r$: Sum-signal received by the relay during phase-1.
- Here $\mathbf{H}_k = \left[\mathbf{h}_1^k \ \mathbf{h}_2^k\right]$ and $\mathbf{x}_k = \left[x_1^k \ x_2^k\right]^T$.

System model

- BSs and UEs have one antenna each.
- x_1^k and x_2^k: Data transmitted by $\text{UE}_1^{(k)}$ and $\text{BS}^{(k)}$ to the relay during phase-1.
- $\mathbf{h}_1^k$ and $\mathbf{h}_2^k$: Uplink channels observed by the relay from $\text{UE}_1^{(k)}$ and $\text{BS}^{(k)}$.
- $\mathbf{y}_r = \sum_{k=1}^{K} \mathbf{H}_k \mathbf{x}_k + \mathbf{n}_r$: Sum-signal received by the relay during phase-1.
- Here $\mathbf{H}_k = \left[\mathbf{h}_1^k \ \mathbf{h}_2^k\right]$ and $\mathbf{x}_k = \left[x_1^k \ x_2^k\right]^T$.
- Signal transmit by the relay: $\mathbf{x}_r = \mathbf{W}\mathbf{y}_r$.

System model (Contd...)

- $\mathbf{g}_1^k$ and $\mathbf{g}_2^k$: Downlink channels seen by $\mathrm{UE}_2^{(k)}$ and $\mathrm{BS}^{(k)}$ respectively.

System model (Contd...)

- $\mathbf{g}_1^k$ and $\mathbf{g}_2^k$: Downlink channels seen by $\mathrm{UE}_2^{(k)}$ and $\mathrm{BS}^{(k)}$ respectively.

- Signals received by $\mathrm{UE}_2^{(k)}$ and $\mathrm{BS}^{(k)}$, y_1^k and y_2^k during phase-2

$$y_i^k = \left(\mathbf{g}_i^k\right)^T \mathbf{x}_r + n_i^k, \qquad i = 1, 2. \tag{1}$$

System model (Contd...)

- $\mathbf{g}_1^k$ and $\mathbf{g}_2^k$: Downlink channels seen by $\mathrm{UE}_2^{(k)}$ and $\mathrm{BS}^{(k)}$ respectively.

- Signals received by $\mathrm{UE}_2^{(k)}$ and $\mathrm{BS}^{(k)}$, y_1^k and y_2^k during phase-2

$$y_i^k = \left(\mathbf{g}_i^k\right)^T \mathbf{x}_r + n_i^k, \qquad i = 1, 2. \tag{1}$$

- Maximum rates observed by $\mathrm{BS}^{(k)}$ and $\mathrm{UE}_2^{(k)}$ are given respectively as:

$$R_b^k = \log\left(1 + \mathrm{SNR}_b^k\right), R_u^k = \log\left(1 + \mathrm{SNR}_u^k\right). \tag{2}$$

System model (Contd...)

- $\mathbf{g}_1^k$ and $\mathbf{g}_2^k$: Downlink channels seen by $\text{UE}_2^{(k)}$ and $\text{BS}^{(k)}$ respectively.

- Signals received by $\text{UE}_2^{(k)}$ and $\text{BS}^{(k)}$, y_1^k and y_2^k during phase-2

$$y_i^k = \left(\mathbf{g}_i^k\right)^T \mathbf{x}_r + n_i^k, \qquad i = 1, 2. \tag{1}$$

- Maximum rates observed by $\text{BS}^{(k)}$ and $\text{UE}_2^{(k)}$ are given respectively as:

$$R_b^k = \log\left(1 + \text{SNR}_b^k\right), R_u^k = \log\left(1 + \text{SNR}_u^k\right). \tag{2}$$

- $R_{sum} = \frac{1}{2}\sum_{k=1}^{K} R_b^k + R_u^k$ is the system sum-rate.

System model (Contd...)

- $\mathbf{g}_1^k$ and $\mathbf{g}_2^k$: Downlink channels seen by $\mathrm{UE}_2^{(k)}$ and $\mathrm{BS}^{(k)}$ respectively.

- Signals received by $\mathrm{UE}_2^{(k)}$ and $\mathrm{BS}^{(k)}$, y_1^k and y_2^k during phase-2

$$y_i^k = \left(\mathbf{g}_i^k\right)^T \mathbf{x}_r + n_i^k, \qquad i = 1, 2. \tag{1}$$

- Maximum rates observed by $\mathrm{BS}^{(k)}$ and $\mathrm{UE}_2^{(k)}$ are given respectively as:

$$R_b^k = \log\left(1 + \mathrm{SNR}_b^k\right), R_u^k = \log\left(1 + \mathrm{SNR}_u^k\right). \tag{2}$$

- $R_{sum} = \frac{1}{2}\sum_{k=1}^{K} R_b^k + R_u^k$ is the system sum-rate.
  - Used for performance comparison.

Problem Description

- Design of precoder to cancel the BPI and IUI for downlink UEs and IUI for the BS.

Problem Description

- Design of precoder to cancel the BPI and IUI for downlink UEs and IUI for the BS.

- Precoder structure: $\mathbf{W} = \mathbf{MDF}$, where

Problem Description

- Design of precoder to cancel the BPI and IUI for downlink UEs and IUI for the BS.

- Precoder structure: $\mathbf{W} = \mathbf{MDF}$, where
  - $\mathbf{F}$: Uplink precoder matrix

Problem Description

- Design of precoder to cancel the BPI and IUI for downlink UEs and IUI for the BS.

- Precoder structure: $\mathbf{W} = \mathbf{MDF}$, where
  - $\mathbf{F}$: Uplink precoder matrix
  - $\mathbf{D}$: Permutation and power-normalization matrix, and

Problem Description

- Design of precoder to cancel the BPI and IUI for downlink UEs and IUI for the BS.

- Precoder structure: $\mathbf{W} = \mathbf{MDF}$, where
  - $\mathbf{F}$: Uplink precoder matrix
  - $\mathbf{D}$: Permutation and power-normalization matrix, and
  - $\mathbf{M}$: Downlink precoder matrix.

Problem Description

- Design of precoder to cancel the BPI and IUI for downlink UEs and IUI for the BS.

- Precoder structure: $\mathbf{W} = \mathbf{MDF}$, where
  - $\mathbf{F}$: Uplink precoder matrix
  - $\mathbf{D}$: Permutation and power-normalization matrix, and
  - $\mathbf{M}$: Downlink precoder matrix.

- $\mathbf{F} = \begin{bmatrix} \mathbf{F}_1^T & \mathbf{F}_2^T & \cdots & \mathbf{F}_K^T \end{bmatrix}^T$ and $\mathbf{M} = \begin{bmatrix} \mathbf{M}_1 & \mathbf{M}_2 & \cdots & \mathbf{M}_K \end{bmatrix}$ are individual uplink and downlink precoders.

Problem Description

- Design of precoder to cancel the BPI and IUI for downlink UEs and IUI for the BS.

- Precoder structure: $\mathbf{W} = \mathbf{MDF}$, where
  - $\mathbf{F}$: Uplink precoder matrix
  - $\mathbf{D}$: Permutation and power-normalization matrix, and
  - $\mathbf{M}$: Downlink precoder matrix.

- $\mathbf{F} = \begin{bmatrix} \mathbf{F}_1^T & \mathbf{F}_2^T & \cdots & \mathbf{F}_K^T \end{bmatrix}^T$ and $\mathbf{M} = \begin{bmatrix} \mathbf{M}_1 & \mathbf{M}_2 & \cdots & \mathbf{M}_K \end{bmatrix}$ are individual uplink and downlink precoders.

- $\mathbf{D} = \text{diag}\{\mathbf{D}_1, \mathbf{D}_2, \cdots, \mathbf{D}_K\}$. Permutation matrix $\mathbf{D}_k$ is given as:

$$\mathbf{D}_k = \begin{bmatrix} 0 & \beta \\ \beta & 0 \end{bmatrix}.$$ β is used to normalize the relay power.

Precoder design

- Two-step precoder design

Precoder design

- Two-step precoder design
  1. Precoder to block-diagonalize the channel matrix to cancel the IUI[4] .

[4] Erhan Ylmaz, Randa Zakhour, David Gesbert and Raymond Knopp "Multi-Pair Two-Way Relay Channel with Multiple Antenna Relay Station", Proc. IEEE Int. Conf. Communications (ICC), 2010.

Precoder design

- Two-step precoder design

  1. Precoder to block-diagonalize the channel matrix to cancel the IUI[4] .
  2. Precoder to cancel the BPI for UE_2^k from the IUI-free channel

[4] Erhan Ylmaz, Randa Zakhour, David Gesbert and Raymond Knopp "Multi-Pair Two-Way Relay Channel with Multiple Antenna Relay Station", Proc. IEEE Int. Conf. Communications (ICC), 2010.

Precoder design

- Two-step precoder design
  1. Precoder to block-diagonalize the channel matrix to cancel the IUI[4] .
  2. Precoder to cancel the BPI for UE_2^k from the IUI-free channel

- To cancel the UL IUI, $\mathbf{F}_k^{(1)}$ should be in the null space of $\widetilde{\mathbf{H}}_k = \begin{bmatrix} \mathbf{H}_1 & \cdots & \mathbf{H}_{k-1} & \mathbf{H}_{k+1} & \cdots & \mathbf{H}_K \end{bmatrix}$.

[4] Erhan Ylmaz, Randa Zakhour, David Gesbert and Raymond Knopp "Multi-Pair Two-Way Relay Channel with Multiple Antenna Relay Station", Proc. IEEE Int. Conf. Communications (ICC), 2010.

Precoder design

- Two-step precoder design
    1. Precoder to block-diagonalize the channel matrix to cancel the IUI[4] .
    2. Precoder to cancel the BPI for UE_2^k from the IUI-free channel

- To cancel the UL IUI, $\mathbf{F}_k^{(1)}$ should be in the null space of $\widetilde{\mathbf{H}}_k = [\ \mathbf{H}_1 \quad \cdots \quad \mathbf{H}_{k-1} \quad \mathbf{H}_{k+1} \quad \cdots \quad \mathbf{H}_K\ ]$.

- To cancel the DL IUI, $\mathbf{M}_k^{(1)}$ should be in the null space of $\widetilde{\mathbf{G}}_k = [\ \mathbf{G}_1 \quad \cdots \quad \mathbf{G}_{k-1} \quad \mathbf{G}_{k+1} \quad \cdots \quad \mathbf{G}_K\ ]$.

[4] Erhan Ylmaz, Randa Zakhour, David Gesbert and Raymond Knopp "Multi-Pair Two-Way Relay Channel with Multiple Antenna Relay Station", Proc. IEEE Int. Conf. Communications (ICC), 2010.

Precoder design

- Two-step precoder design
  1. Precoder to block-diagonalize the channel matrix to cancel the IUI[4] .
  2. Precoder to cancel the BPI for UE_2^k from the IUI-free channel
- To cancel the UL IUI, $\mathbf{F}_k^{(1)}$ should be in the null space of $\widetilde{\mathbf{H}}_k = [\begin{array}{cccccc} \mathbf{H}_1 & \cdots & \mathbf{H}_{k-1} & \mathbf{H}_{k+1} & \cdots & \mathbf{H}_K \end{array}]$.
- To cancel the DL IUI, $\mathbf{M}_k^{(1)}$ should be in the null space of $\widetilde{\mathbf{G}}_k = [\begin{array}{cccccc} \mathbf{G}_1 & \cdots & \mathbf{G}_{k-1} & \mathbf{G}_{k+1} & \cdots & \mathbf{G}_K \end{array}]$.
- $\aleph(\widetilde{\mathbf{H}}_k)$ and $\aleph(\widetilde{\mathbf{G}}_k)$ are found using singular-value-decomposition.

[4] Erhan Ylmaz, Randa Zakhour, David Gesbert and Raymond Knopp "Multi-Pair Two-Way Relay Channel with Multiple Antenna Relay Station", Proc. IEEE Int. Conf. Communications (ICC), 2010.

Precoder design

- Two-step precoder design
  1. Precoder to block-diagonalize the channel matrix to cancel the IUI[4] .
  2. Precoder to cancel the BPI for UE_2^k from the IUI-free channel
- To cancel the UL IUI, $\mathbf{F}_k^{(1)}$ should be in the null space of $\widetilde{\mathbf{H}}_k = [\ \mathbf{H}_1 \quad \cdots \quad \mathbf{H}_{k-1} \quad \mathbf{H}_{k+1} \quad \cdots \quad \mathbf{H}_K\ ]$.
- To cancel the DL IUI, $\mathbf{M}_k^{(1)}$ should be in the null space of $\widetilde{\mathbf{G}}_k = [\ \mathbf{G}_1 \quad \cdots \quad \mathbf{G}_{k-1} \quad \mathbf{G}_{k+1} \quad \cdots \quad \mathbf{G}_K\ ]$.
- $\aleph(\widetilde{\mathbf{H}}_k)$ and $\aleph(\widetilde{\mathbf{G}}_k)$ are found using singular-value-decomposition.
- IUI-free channel can be viewed as multiple single-user-pair systems.

[4] Erhan Ylmaz, Randa Zakhour, David Gesbert and Raymond Knopp "Multi-Pair Two-Way Relay Channel with Multiple Antenna Relay Station", Proc. IEEE Int. Conf. Communications (ICC), 2010.

Precoder design (Contd...)

- Precoder designed to cancel the BPI for single-user-pair can be used[5].

[5] Rohit Budhiraja, Karthik KS and Bhaskar Ramamurthi "Linear Precoders for Two-way Asymmetric Multiuser Relaying in Cellular Systems", Proc. IEEE Int. Conf. Communications (ICC), 2013

Precoder design (Contd...)

- Precoder designed to cancel the BPI for single-user-pair can be used[5].
- Signal received by UE_2 and BS during the BC phase are re-written as:

$$
\begin{aligned}
\mathbf{y} &= \mathbf{GW}\left(\mathbf{Hx} + \mathbf{n}_r\right) + \mathbf{n} \\
&= \underbrace{\mathbf{GM}}_{\mathbf{G}_t}\,\mathbf{D}\,\underbrace{\mathbf{FH}}_{\mathbf{H}_t}\,\mathbf{x} + \underbrace{\mathbf{GWn}_r + \mathbf{n}}_{\mathbf{n}_t} \\
&= \mathbf{G}_t\mathbf{D}\mathbf{H}_t\mathbf{x} + \mathbf{n}_t
\end{aligned}
$$

[5] Rohit Budhiraja, Karthik KS and Bhaskar Ramamurthi "Linear Precoders for Two-way Asymmetric Multiuser Relaying in Cellular Systems", Proc. IEEE Int. Conf. Communications (ICC), 2013

Precoder design (Contd...)

- Precoder designed to cancel the BPI for single-user-pair can be used[5].

- Signal received by UE_2 and BS during the BC phase are re-written as:

$$
\begin{aligned}
\mathbf{y} &= \mathbf{GW}\left(\mathbf{Hx} + \mathbf{n}_r\right) + \mathbf{n} \\
&= \underbrace{\mathbf{GM}}_{\mathbf{G}_t}\,\mathbf{D}\,\underbrace{\mathbf{FH}}_{\mathbf{H}_t}\,\mathbf{x} + \underbrace{\mathbf{GWn}_r + \mathbf{n}}_{\mathbf{n}_t} \\
&= \mathbf{G}_t\mathbf{D}\mathbf{H}_t\mathbf{x} + \mathbf{n}_t
\end{aligned}
$$

- Precoders $\mathbf{M}_k^{(2)}$ and $\mathbf{F}_k^{(2)}$ should be designed such that $\mathbf{G}_t$ and $\mathbf{H}_t$ are lower-triangular and upper-triangular.

[5] Rohit Budhiraja, Karthik KS and Bhaskar Ramamurthi “Linear Precoders for Two-way Asymmetric Multiuser Relaying in Cellular Systems”, Proc. IEEE Int. Conf. Communications (ICC), 2013

Precoder design (Contd...)

- Precoder designed to cancel the BPI for single-user-pair can be used[5].
- Signal received by UE_2 and BS during the BC phase are re-written as:

$$\begin{aligned}\mathbf{y} &= \mathbf{GW}\left(\mathbf{Hx} + \mathbf{n}_r\right) + \mathbf{n} \\ &= \underbrace{\mathbf{GM}}_{\mathbf{G}_t}\,\mathbf{D}\,\underbrace{\mathbf{FH}}_{\mathbf{H}_t}\,\mathbf{x} + \underbrace{\mathbf{GWn}_r + \mathbf{n}}_{\mathbf{n}_t} \\ &= \mathbf{G}_t\mathbf{DH}_t\mathbf{x} + \mathbf{n}_t\end{aligned}$$

- Precoders $\mathbf{M}_k^{(2)}$ and $\mathbf{F}_k^{(2)}$ should be designed such that $\mathbf{G}_t$ and $\mathbf{H}_t$ are lower-triangular and upper-triangular.
  - **LQ** and **QR** factorizations are used.

[5] Rohit Budhiraja, Karthik KS and Bhaskar Ramamurthi "Linear Precoders for Two-way Asymmetric Multiuser Relaying in Cellular Systems", Proc. IEEE Int. Conf. Communications (ICC), 2013

Precoder design (Contd...)

- Precoder designed to cancel the BPI for single-user-pair can be used[5].
- Signal received by UE_2 and BS during the BC phase are re-written as:

$$\begin{aligned}\mathbf{y} &= \mathbf{GW}\left(\mathbf{Hx} + \mathbf{n}_r\right) + \mathbf{n} \\ &= \underbrace{\mathbf{GM}}_{\mathbf{G}_t}\mathrm{D}\underbrace{\mathbf{FH}}_{\mathbf{H}_t}\mathbf{x} + \underbrace{\mathbf{GWn}_r + \mathbf{n}}_{\mathbf{n}_t} \\ &= \mathbf{G}_t\mathbf{DH}_t\mathbf{x} + \mathbf{n}_t\end{aligned}$$

- Precoders $\mathbf{M}_k^{(2)}$ and $\mathbf{F}_k^{(2)}$ should be designed such that $\mathbf{G}_t$ and $\mathbf{H}_t$ are lower-triangular and upper-triangular.
  - **LQ** and **QR** factorizations are used.
- $\mathbf{M}_k = \mathbf{M}_k^{(2)}\mathbf{M}_k^{(1)}$ and $\mathbf{F}_k = \mathbf{F}_k^{(2)}\mathbf{F}_k^{(1)}$

[5] Rohit Budhiraja, Karthik KS and Bhaskar Ramamurthi "Linear Precoders for Two-way Asymmetric Multiuser Relaying in Cellular Systems", Proc. IEEE Int. Conf. Communications (ICC), 2013

Sum-rate comparison between proposed and ZF precoder

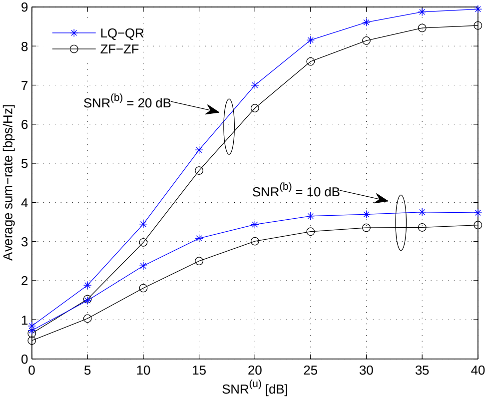

Figure: Average sum-rate comparison with two BSs and number of relay antennas = 4.

Conclusions

- Simultaneous exchange of two-way data traffic, assumed in two-way relaying, normally does not happen in the cellular systems.

Conclusions

- Simultaneous exchange of two-way data traffic, assumed in two-way relaying, normally does not happen in the cellular systems.
- Problem of data-flow asymmetry in shared two-way AF relaying is considered.

Conclusions

- Simultaneous exchange of two-way data traffic, assumed in two-way relaying, normally does not happen in the cellular systems.
- Problem of data-flow asymmetry in shared two-way AF relaying is considered.
- Novel precoder to jointly cancel the IUI and back-propagating interference is designed.

Conclusions

- Simultaneous exchange of two-way data traffic, assumed in two-way relaying, normally does not happen in the cellular systems.
- Problem of data-flow asymmetry in shared two-way AF relaying is considered.
- Novel precoder to jointly cancel the IUI and back-propagating interference is designed.
- Sum-rate performance is shown to be better for the proposed precoder than for the conventional ZF precoder.