Two-way Relaying with Multiple-Antenna Relay Stations

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One-way Relaying:
e.g., providing access to shadowed areas

2 hops →
double number of radio resources required for amplify-and-forward relaying
MIMO Two-way Relaying

- number of antennas at N1 and N2: \( M^{(1)} = M^{(2)} = M \)
- number of antennas at RS: \( M_{RS} \geq 2M \)

CSI available at RS \( \rightarrow \) design of a transceive filter

**Receive processing**
- \( G_R \) "separates" signals \( \hat{x}^{(1)} \) and \( \hat{x}^{(2)} \) at the RS

**Mapping matrix** \( G_{\Pi} \)
- N1 shall be provided with \( x^{(2)} \) and N2 shall be provided with \( x^{(1)} \)

**Transmit processing**
- \( G_T \) "transmits" \( x^{(2)} \) in the direction of N1 and \( x^{(1)} \) in the direction of N2
CSI in MIMO Two-way Relaying

- CSI is only required at the RS
- no CSI feedback channel required since the RS can estimate channels $H^{(1)}$ and $H^{(2)}$ in case of TDD
- reduced effort if RS uses same channel coefficients for transmit and receive filter matrix (e.g. ZF, MMSE)
Different SNR\(^{(1)}\) and SNR\(^{(2)}\) on the first hops, e.g., SNR\(^{(1)}\) >> SNR\(^{(2)}\)

\[ (1 - \beta)P_{RS} \quad \beta P_{RS} \]

\[ 0 \leq \beta \leq 1 \]

⇒ at the RS, put more transmit power into the data stream which is dedicated to N2 than in the data stream which is dedicated to N1
Sum Rate depending on $\beta$

SNR$^{(1)} = 5$dB

SNR$^{(2)} = 16$dB

SNR$^{(2)} = 5$ dB

SNR$^{(2)} = 0$dB

more power for RS $\rightarrow$ N1

more power for RS $\rightarrow$ N2

β
Optimization Problem

\[ \beta_{opt} = \arg \max_{\beta} \left\{ C^{(1\rightarrow 2)} + C^{(2\rightarrow 1)} \right\} \]

subject to: \( 0 \leq \beta \leq 1 \) \rightarrow Numeric optimization

Approximation:
\[ \bar{C}^{(1\rightarrow 2)} = \frac{1}{2} \log_2 \left( 1 + \text{SNR}^{(1\rightarrow 2)}_{ov} \right) \]

\[ \beta_{app} = \frac{\text{SNR}^{(1)} + 1 - \sqrt{(\text{SNR}^{(1)} + 1)(\text{SNR}^{(2)} + 1)}}{\text{SNR}^{(1)} - \text{SNR}^{(2)}} \]
Sum Rate for Approximation

\[ \text{SNR}^{(1)} = 5 \text{dB} \]

\[ \beta_{\text{opt}} \]

\[ \beta_{\text{app}} \]

\[ \beta = 0.5 \]
MIMO two-way relaying avoids loss of factor 2 for the network sum rate compared to one-way relaying

Network sum rate may be increased by non-uniform power distribution at the RS for different SNRs

- Reduction of CSI signaling effort in the network
- Radio resource allocation in multiple-access AF / DF relay networks
- Asymmetric traffic