Diagonalized Two-way MIMO AF Relaying for Non-Simultaneous Traffic in Cellular Systems

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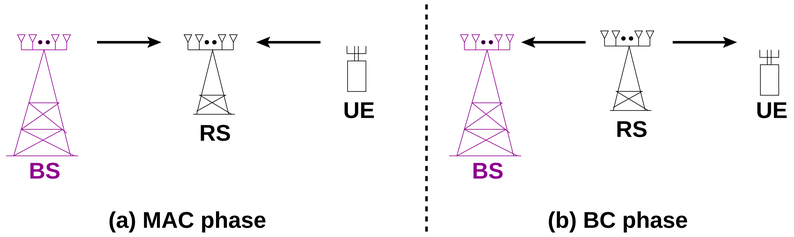
Problem Motivation - Simultaneous Traffic Requirements in Two-Way Relay (TWR)

- MAC phase in TWR: BS and UE simultaneously transmit to relay.
- Relay receives the sum of signals transmitted by BS and UE.
- BC phase: Relay broadcasts a function of its received sum-signal.

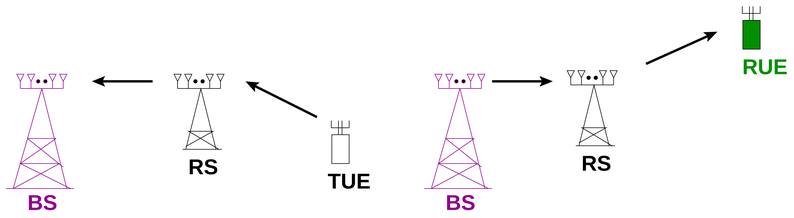


(a) MAC phase (b) BC phase

- BS and UE can cancel back-propagating interference.
- TWR assumes UE simultaneously needs uplink and downlink data.
- UE need not require uplink and downlink data simultaneously.

Non-Simultaneous Traffic in Cellular Systems

- Example 1: User TUE uploading a Facebook video.
- TUE only sends data to BS and does not demand data from BS.
- Example 2: User RUE watching a Netflix movie.
- RUE only demands data from BS and does not send data to BS.



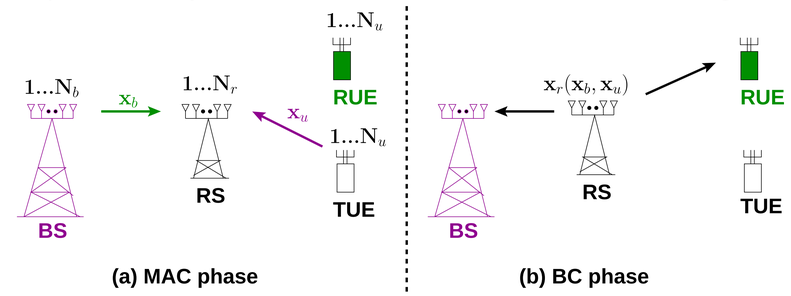
(1) Transmit−only User (2) Receive−only User

Non−simultaneous traffic scenarios

- BS cannot perform TWR either with TUE or RUE.
- BS can serve TUE and RUE using one-way relaying (OWR).
- BS requires 4 channel uses with OWR.

Non-Simultaneous Two-way Relaying

- MAC phase: Both TUE and BS transmit data signals to the relay.
- BC phase: Relay broadcasts a function of its received sum-signal.



(a) MAC phase (b) BC phase

- BS nees only 2 channel uses to serve both TUE and RUE.
- Back-propagating interference (BI) experienced by
  - BS – self-data transmitted in MAC phase. Can cancel it.
  - RUE – not its self-data, but TUE's MAC-phase data.
- RUE cannot cancel BI without knowing TUE's data.
- RUE can cancel BI if it overhears TUE.
- What if RUE cannot overhear TUE – relevant for cellular systems.
  - Use existing ZF/MMSE precoders at relay to cancel BI.
  - ZF/MMSE precoders are suboptimal – cancel BI for both BS and RUE.

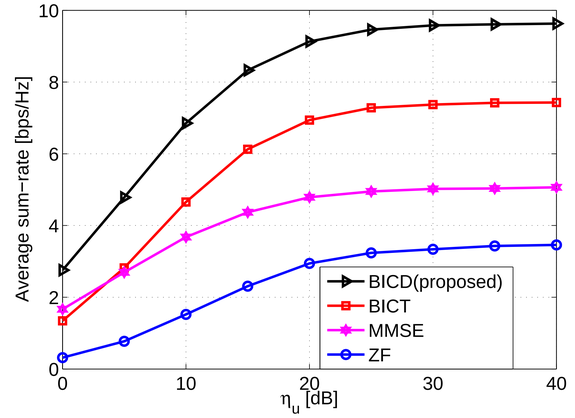
BICT Precoder at the Relay [1, 2]

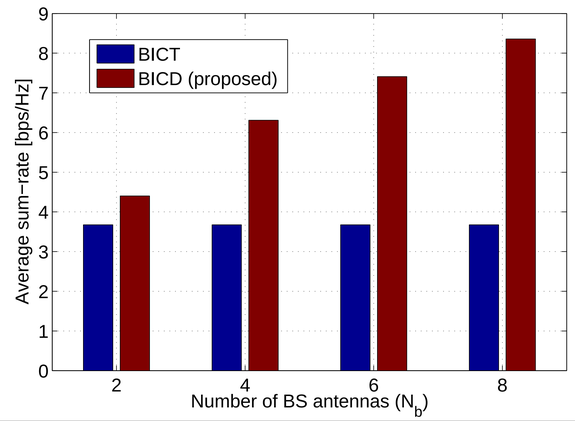
- Cancels BI for RUE alone.
- Triangularizes MIMO channels for BS and RUE.
  - BS and RUE perform successive cancellation (SC) to decode data.
- SC can lead to error propagation in practical systems.
- Precoder forces number of BS antennas = number of UE antennas.
- Does not precode at BS and TUE – lacks beamforming gain.

Proposed BICD Design

- Jointly constructs linear precoders at BS, TUE and relay.
- Uses linear receivers to diagonalize MIMO channels – avoids SC.
- Number of BS antennas $\geq$ number of UE antennas – practical.
- Provides beamforming gains over BICT precoder.

Performance Improvement of BICD Design





Summary of the Proposed Design

- Cancels BI and diagonalizes MIMO channels for non-simultaneous TWR.
- Works for more general antenna config. than existing designs.
- Provides significant performance improvement.

References

[1] R. Budhiraja, Karthik KS, and B. Ramamurthi, "Linear precoders for non-regenerative asymmetric two-way relaying in cellular systems," accepted for publication in *IEEE Trans. Wireless Commun.*

[2] ——, "Precoder design for asymmetric multi-user two-way AF relaying in cellular systems," in *Proc. IEEE Int. Conf. Commun. (ICC)*, Budapest, Hungary, Jun. 2013, pp. 5909–5913.

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