Can Feedback Mitigate Interference?

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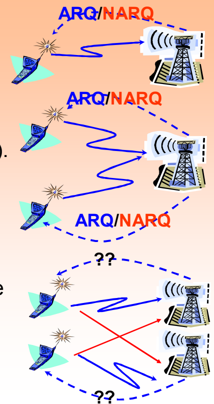
EECS Electrical Engineering & Computer Sciences — Wireless Foundations

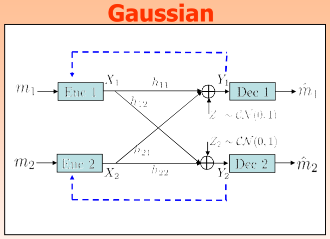
Feedback in Wireless Communications

- Point-to-point channels: capacity does not increase with feedback (Shannon `50s).
- Multiple-access channels (MAC): capacity does increase with feedback. However, the gain is bounded (beamforming) (Ozarow `80s).
- Feedback has been used only for reliable communications e.g., ARQ and HARQ.
- How about other channels where a receiver wants to decode only desired messages in the presence of interference?
- What does information theory say about the role of feedback?



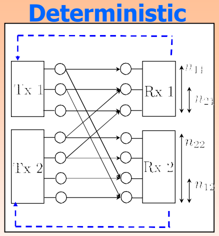
The Two-User Interference Channel with Feedback

Gaussian



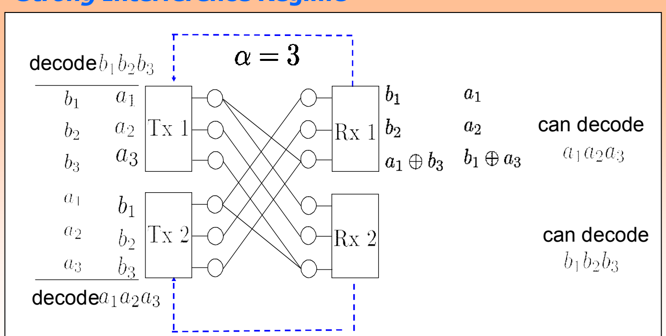
Characterized by four parameters:
SNR1, SNR2
INR2→1, INR1→2

Deterministic



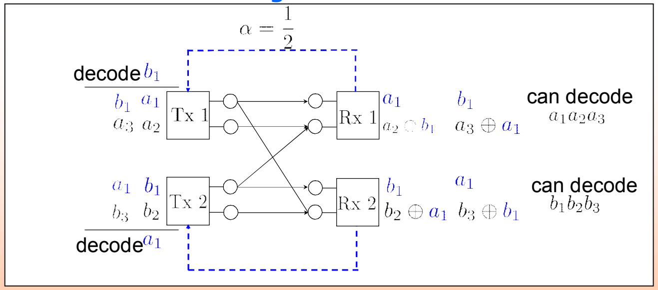
$n_{11} := \log \mathsf{SNR}_1$
$n_{22} := \log \mathsf{SNR}_2$
$n_{12} := \log \mathsf{INR}_{1\to2}$
$n_{21} := \log \mathsf{INR}_{2\to1}$

Strong Interference Regime

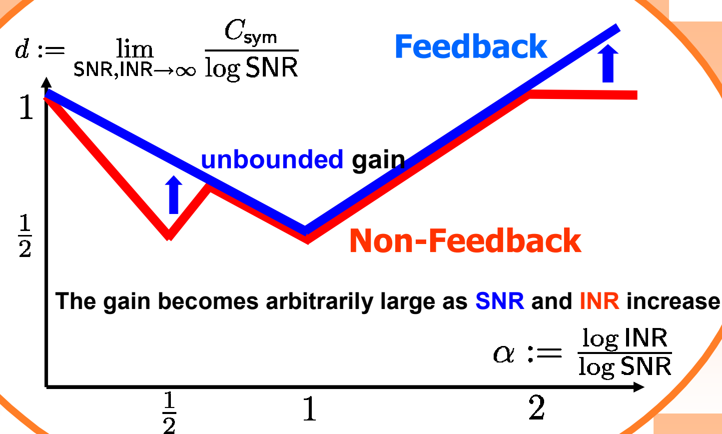


Feedback provides a better alternative path

Weak Interference Regime



Feedback maximizes resource utilization



Symmetric Feedback Capacity to Within 1 bit

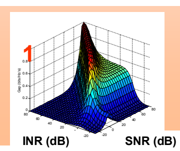
Our new scheme (inner bound) achieves

$$R_{\mathsf{sym}} = \max\left\{ \frac{1}{2}\log(1+\mathsf{INR}), \frac{1}{2}\log\left(\frac{(1+\mathsf{SNR}+\mathsf{INR})^2 - \frac{\mathsf{SNR}}{1+\mathsf{INR}}}{1+2\mathsf{INR}} \right) \right\}$$

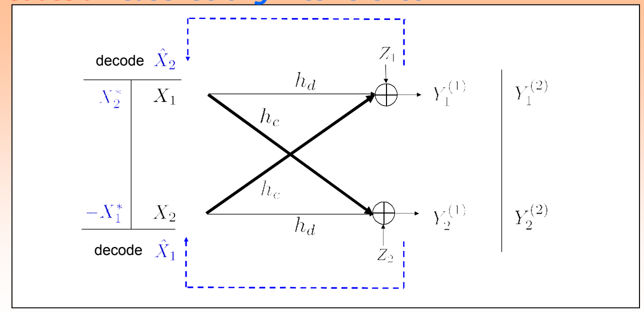
Our new outer bound is given by

$$C_{\mathsf{sym}} \le \frac{1}{2}\sup_{0\le\rho\le1}\left[\log\left(1+\frac{(1-\rho^2)\mathsf{SNR}}{1+(1-\rho^2)\mathsf{INR}}\right) + \log\left(1+\mathsf{SNR}+\mathsf{INR}+2\rho\sqrt{\mathsf{SNR}\cdot\mathsf{INR}}\right) \right].$$

The gap is at most 1 bit for *all* SNR and INR

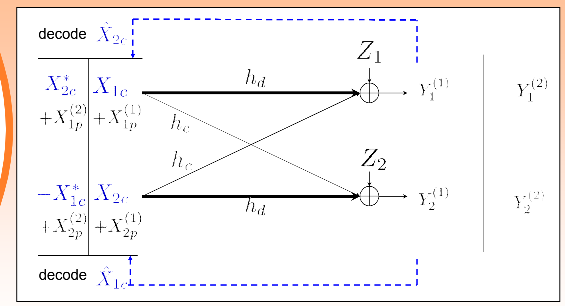


Gaussian Case: *Strong* Interference



Apply Alamouti Scheme

Gaussian Case: *Weak* Interference



Conclusion and Future Work

We characterized the feedback capacity region to within 2 bits.

We showed that feedback can provide unbounded gain.

The role of feedback is to maximize resource utilization and thus mitigate interference.

We need to show if feedback helps in practical feedback scenarios, e.g., where forward and feedback links share the same resources.