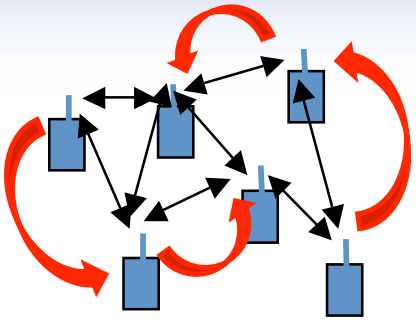
Feedback and Directed Information in Wireless Networks

A. Goldsmith (joint with H. Permuter and T. Weissman)

FLoWS

STATUS QUO



Role of feedback links in capacity of wireless channels and networks not well understood.

Feedback often modelled in terms of (imperfect/quantized) CSI at the transmitter, but not clear CSI is the best thing to send on a FB channel

Insight and appropriate coding strategies are largely absent

NEW INSIGHTS

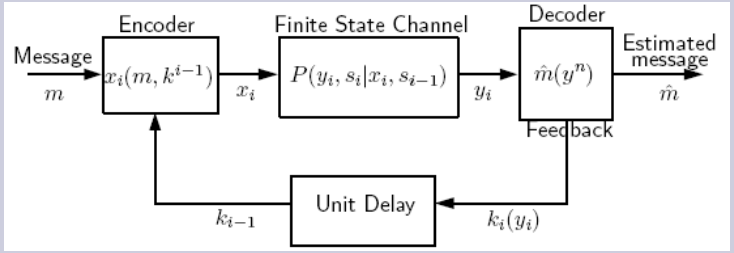
Directed information is a dual for mutual information on finite-state Markov channels with feedback

The source-channel separation theorem holds for time-invariant determinist feedback

If channel state known at encoder and decoder, then feedback does not increase capacity

ACHIEVEMENT DESCRIPTION

MAIN RESULT:



- For finite-state Markov channels with feedback, capacity is based on directed information rather than mutual information.

$$\lim_{n\to\infty}\frac{1}{n}\max_{p(x^n||k^{n-1})} I(X^n \to Y^n) \geq C_{FB} \geq \lim_{n\to\infty}\frac{1}{n}\max_{p(x^n||k^{n-1})} \min_{s_0} I(X^n \to Y^n|s_0)$$

- **HOW IT WORKS:**
- Directed information I(X→Y) is the natural extension of mutual information for channels with output feedback.

$$I(X^n \to Y^n) \triangleq \sum_{i=1}^{n} I(X^i; Y_i|Y^{i-1})$$

- Many techniques from Gallager's capacity proof for FSC without FB can be used in our proof, but not all.

ASSUMPTIONS AND LIMITATIONS:

- The feedback is the channel output with unit delay and no noise. Bounds are only tight for indecomposable channels

END-OF-PHASE GOAL

- Determine if directed information can be used to obtain capacity of finite state broadcast channels
- Investigate application of directred information to general wireless networks with feedback

COMMUNITY CHALLENGE

Graduate Level:

Extensions for wireless networks.

Prize level:

Capacity results for multihop networks with noisy and delayed feedback

Directed Information a powerful tool for finding capacity of wireless channels with feedback