On Multiple Access Channels with Bidirectional Links

Ahmad Khoshnevis, Debashis Dash, Ashutosh Sabharwal
Rice University, Houston, TX

INTRODUCTION

Motivation:

Often feedback resources are taken for free
- Usefulness when resources are accounted for ?
- Configurations which should use feedback ?

Definition (Bidirectional Link)

- Half duplex links
(TDD: forward and feedback channels)
- Power constrained nodes (AWGN)
- Noisy Channel

MODEL

Additional features:

- Power constrained feedback by the receiver
- Compression by subtracting decoded information

Hidden Node Topology

CODING SCHEME

m_1 ... $x_1(i,j)$ ... $y(i,j,k,l)$

m_2 ... $x_2(k,l)$

η fraction of time

$(1-\eta)$ fraction of time

- Loss in rate in the first and last blocks is negligible if B is large
- Each message takes 2 adjacent blocks to get decoded

THIRD NODE HAS NO DATA TO SEND

DATA (NEW + INCREMENTAL)	FEEDBACK
ηT	$(1-\eta)T$

Effect of feedback

For a given η,
- The rate region gets reduced (red)
- Feedback increases the sum rate (green)
- The convex hull (over all η) of all the achievable rate points gives a bigger region than the standard MAC (blue)

$$(1-\eta)\frac{1}{2}\log(1+\frac{P_f}{N})$$

To offset the time sharing effect:
P_f has to nullify the effect of η

Hence Pf is exponentially bigger than P.

Rate region plots

THIRD NODE HAS MULTICAST DATA

DATA (NEW + INCREMENTAL)	DATA + FEEDBACK
ηT	$(1-\eta)T$

$P_f = \gamma P_3$

3-d Rate region plots

η: MAC vs MC
$\eta \rightarrow 1$
- Less feedback
  Less Gain
$\eta \rightarrow 0$
- Less time spent in the forward direction
  Less Gain

Sum rate (symm) vs multicast rate

Better Gain:
- Higher SNR
- Higher power in MC

FEEDBACK INDUCED COOPERATION

Feedback helps in increasing cooperation between the users by making their messages correlated.

Ozarow's Capacity for noiseless FB:
$$\frac{E[X_1 X_2]}{\sqrt{P_1 P_2}} = \rho$$

Our scheme:
$$\frac{E[X_1 X_2]}{\sqrt{P_1 P_2}} = \frac{\alpha_1 \overline{\alpha_1} \overline{\beta_1} \lambda_1 P_1 + \alpha_2 \overline{\alpha_2} \overline{\beta_2} \lambda_2 P_2}{\sqrt{P_1 P_2}}$$

CONCLUSIONS

- Gains available, but at exponentially more resources if the receiver has no data to send
  - Greater gain by superposition than TDD
- Greater gain obtained at higher SNR and specifically if the receiver has higher power

Contact Information
(e-mail): {farbod,ddash,ashu} @rice.edu
http://www.ece.rice.edu
http://cmc.rice.edu