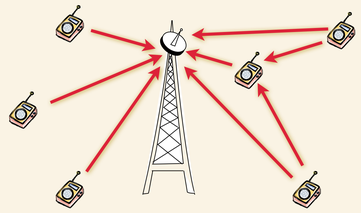
Feedback and Network Capacity

Mayank Bakshi, Michelle Effros
{mayank,effros}@caltech.edu
California Institute of Technology

Motivation



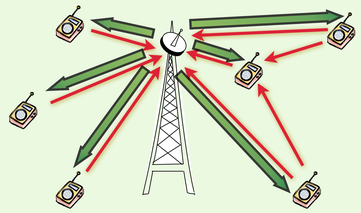
e.g. Sensor Network

Remote transmitters are limited by

- ➡ Transmission power - often rely on battery
- ➡ Computation power - limited processing and storage capability
- ➡ Insufficient knowledge of transmissions from other (possibly correlated) sources

The central unit is far less constrained!

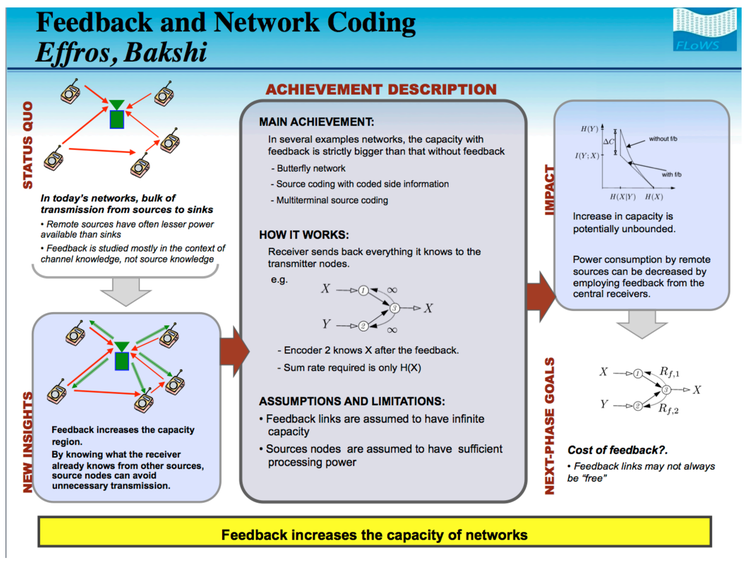
Our Approach



Central unit sends useful information back to each transmitter

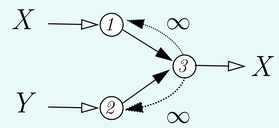
➡ The central unit has more power - assume infinite capacity on the feedback links

Main result: **feedback increases network capacity**



Results

Source Coding with Coded Side Information

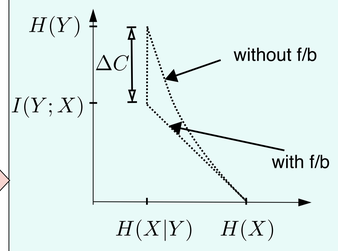


➡ Node 1 sends codeword to Node 3 assuming no feedback
➡ Node 3 sends the X codeword to Node 2
➡ Node 2 decodes X and sends the remaining part of X to Node 3

Feedback increases the capacity region

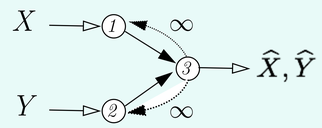
Without feedback	With feedback
$R_{13} \geq H(X\|U)$	$R_{13} \geq H(X\|Y)$
$R_{23} \geq I(Y;U)$	$R_{13} + R_{23} \geq H(X)$

for some U s.t. $U \to Y \to X$

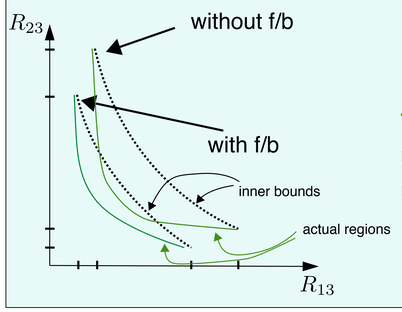


The improvement is potentially unbounded!

Multiterminal Source Coding

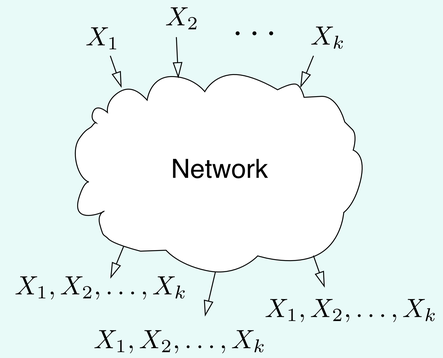


➡ Reconstructions are desired subject to distortion levels (D_X, D_Y)
➡ We obtain an inner bound by performing a conditional rate distortion coding based on the received codewords from the other source, which is not possible without feedback



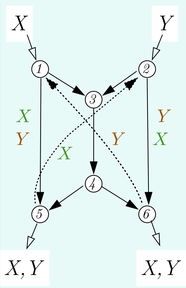
There are rate points in the region with feedback that are not achievable without feedback

Multicast with multiple sources



➡ cutset region is modified by adding feedback links
➡ without feedback the mincut between each source and sink pair has to be at least equal to the source entropy
➡ with feedback, the min-cut between each source and just one of the sinks needs to be at least equal to the source entropy.

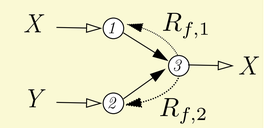
e.g. Butterfly Network



With feedback, the rate vector $\mathbf{R} = (R_e : e \in E)$ given by $R_{15} = R_{26} = H(X,Y), R_e = 0 \; \forall \; e \notin \{(1,5),(2,6)\}$ is feasible. This is not possible wihout feedback

Future directions

➡ We assumed infinite capacity for the feedback links. How do results change when these links have capacity constraints?



➡ Extend the result to more general networks and identify general principles involved in networks with feedback.