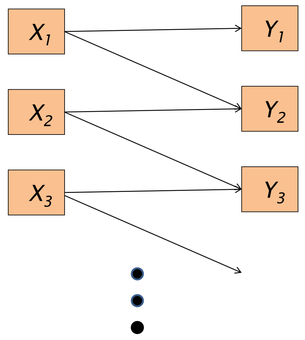
Cloud-Based Topological Interference Management:

A Case with no Cooperative Transmission Gain

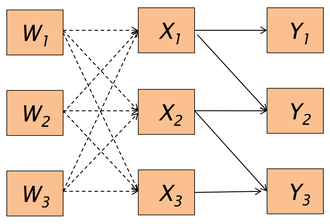
Aly El Gamal
ECE Department
Purdue University

Channel Model



- Wyner's linear model
- No channel state information at transmitters: *only knowledge of network topology*
- Channel coefficients are generic

Message Assignment



- W_i can be jointly transmitted by M transmitters
- $M=1$ → Cell Association
- $M>1$ → Design of backhaul for Cooperative Transmission

Capacity Criterion

- Sum Degrees of Freedom $\mathrm{DoF}(K,M)$
- Per User DoF

$$\mathrm{PUDoF}(M) = \lim_{K\to\infty} \frac{\mathrm{DoF}(K,M)}{K}$$

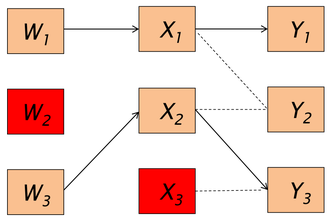
Main Result

Cooperative transmission does not increase the degrees of freedom in large linear networks with no CSIT

$$\mathrm{PUDoF}(M>1) = \mathrm{PUDoF}(M=1) = \frac{2}{3}$$

Why 2/3

TDMA is optimal

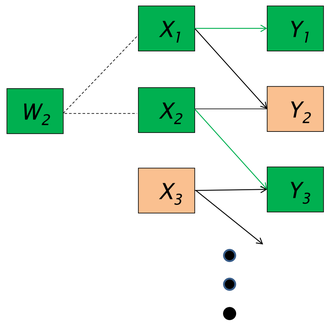


- Last transmitter in each cluster is inactive
- Best scheme for M=1 even with CSIT
- With CSIT, cooperation helps [Reference 1]

$$\mathrm{PUDoF}_{CSIT}(M) = \frac{2M}{2M+1}$$

- With no CSIT, cooperation does not help

Converse Argument

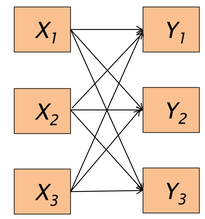


- Given the signals $Y_1, Y_3, Y_4, Y_6, \ldots$ we reconstruct all transmit signals
- Consider the first cluster (picture on left), we want to reconstruct W_2
- With no CSIT, Y_3 has access to a *statistically equivalent* version of X_2 as Y_2
- Similarly, Y_1 has access to an equivalent version of X_1 as Y_2

Note that interference cannot be canceled

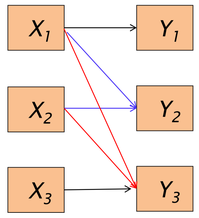
Notes for General Topologies

- Receivers with identical set of neighboring transmitters have one degree of freedom



PUDoF(M>1)=0

- Can allocating a message to a transmitter that is *not connected to intended receiver* be useful?
- How about if we let channel coherence times be different?



Coherence time 1

Coherence time 2

DoF= $\frac{3}{2}$

Same Coherence time DoF= 1

Concluding Remarks

- Cooperative transmission is not useful for linear interference networks with no CSIT
- Does the same conclusion apply for general network topologies?

References

[1] A. El Gamal, V. S. Annapureddy and V. V. Veeravalli "Interference Channels with Coordinated Multi-Point Transmission: Degrees of Freedom, Message Assignment, and Fractional Reuse", IEEE Transactions on Information Theory, vol. 60, no. 6, Jun. 2014

[2] X. Yi and D. Gesbert "Topological Interference Management with Transmitter Cooperation", IEEE International Symposium on Information Theory, Jul. 2014

[3] S. A. Jafar "Topological Interference Management through Index Coding", IEEE Transactions on Information Theory, vol. 60, no. 1, Jan. 2014