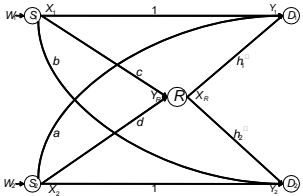


Motivation

- **Cooperation and interference** play important roles in future communication networks.
- **Interference relay channel**: characterize both cooperation and interference.
- Best strategy for the general case: unknown.



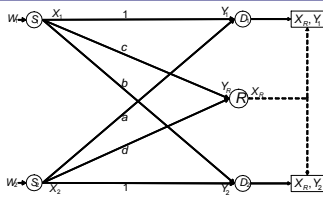
Known Results

- Achievable rate using DF [Sahin-Erkip 2007]
 - Cognitive relaying with one-sided interference [Sahin-Erkip 2008]
 - Interference channel with a cognitive relay [Sriram Sridharan, Sriram Vishwanath et al 2008]
 - Interference channel with a relay [Sahin-Erkip 2009]
 - Interference channel with an infrastructure relay [Sahin-Erkip 2009]
 - Interference forwarding [Maric-Goldsmith 2008]
- For the general fully connected case, no good outerbound is known.

Methodology

- Assume the relay has ample amount of power.
- Relay power $\rightarrow \infty \Rightarrow$ obtain an **outerbound** for the channel.
- How good is it?
- Potent relay model is equivalent as SIMO interference channel where two receivers share a common antenna.
- Is recent technologies from the interference channel useful?
- Consider weak & strong interference cases.

Channel Model



$$Y_1 = X_1 + aX_2 + Z_1$$

$$Y_2 = bX_1 + X_2 + Z_2$$

$$Y_R = cX_1 + dX_2 + Z_R$$

Weak Interference

- Use "smart" and "useful" genie [Annappureddy-Veeravalli 2008].
- $$S_1 = bX_1 + bN_1, S_2 = aX_2 + aN_2$$
- $$S_R = cX_1 + cN_3, T_R = dX_2 + dN_4$$
- Give **minimum but sufficient** amount of information to receivers such that i.i.d. Gaussian inputs maximize the capacity.
 - "Useful" in the sense that i.i.d. Gaussian distributed inputs satisfying the power constraints maximize the sum rate.

Weak Interference (contd.)

$$n(R_1 + R_2) \leq I(X_1^n, Y_1^n, X_R^n) + I(X_2^n, Y_2^n, X_R^n) \leq I(X_1^n, Y_1^n, X_R^n, Y_R^n) + I(X_2^n, Y_2^n, X_R^n, Y_R^n) = I(X_1^n, Y_1^n, Y_R^n) + I(X_2^n, Y_2^n, Y_R^n) \leq I(X_1^n, Y_1^n, S_1^n, S_R^n) + I(X_2^n, Y_2^n, S_2^n, T_R^n) \leq nI(X_1; Y_1, Y_R, S_1, S_R) + nI(X_2; Y_2, Y_R, S_2, T_R) = I(X_1; Y_1, Y_R, S_1, S_R) + I(X_2; Y_2, Y_R, S_2, T_R) = I(X_1; Y_1, Y_R) + I(X_2; Y_2, Y_R)$$

• "Smart" in the sense that the genie information does not increase the capacity too much --- guarantee the "minimum amount of information".

Weak Interference (contd.)

- To guarantee the existence of such genie, we need

$$\frac{\rho_1^2}{(1+a^2P_2)^2} + \frac{c^2\rho_3^2}{(1+d^2P_2)^2} \geq \frac{b^2}{1-\rho_2^2} + \frac{c^2}{1-\rho_4^2}$$

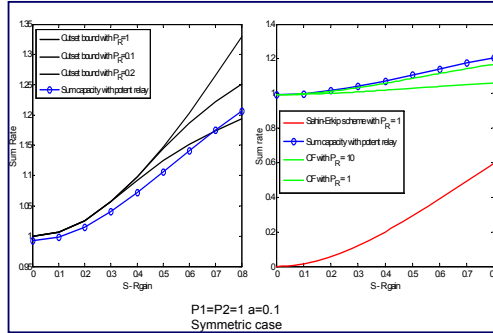
$$\frac{\rho_2^2}{(1+b^2P_1)^2} + \frac{d^2\rho_4^2}{(1+c^2P_1)^2} \geq \frac{a^2}{1-\rho_1^2} + \frac{d^2}{1-\rho_3^2}$$

- $\rho_1, \rho_2, \rho_3, \rho_4 \in [0,1]$
- Symmetric case shows us this condition implies weak interference.

- The sum capacity outerbound is

$$C_\Sigma = \frac{1}{2} \log\left(1 + \frac{(ac-d)^2 P_1 P_2 + P_1 + c^2 P_1}{(a^2 + d^2) P_2 + 1}\right) + \frac{1}{2} \log\left(1 + \frac{(bd-c)^2 P_1 P_2 + d^2 P_2 + P_2}{(c^2 + b^2) P_1 + 1}\right)$$

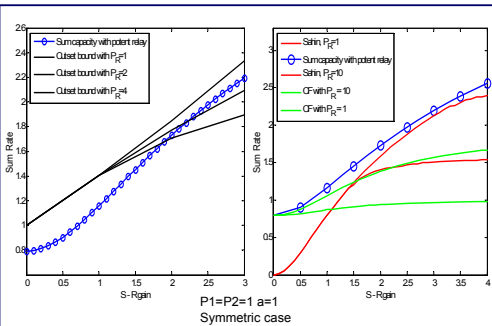
Performance under Weak Interference



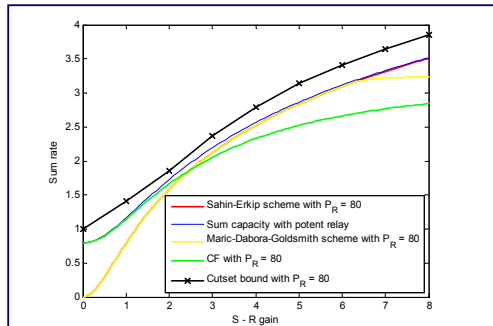
Strong Interference

- When interference is **strong**, i.e., $a \geq 1, b \geq 1$
 - The channel has the same capacity as a compound SIMO MAC with two antennas at each receiver, where one common one is shared between the two receivers.
 - The capacity of the compound SIMO MAC is
- $$R_1 \leq \frac{1}{2} \log(1 + P_1 + c^2 P_1)$$
- $$R_2 \leq \frac{1}{2} \log(1 + P_2 + d^2 P_2)$$
- $$R_1 + R_2 \leq \frac{1}{2} \min\{\log(1 + (ac-d)^2 P_1 P_2 + (c^2 + 1) P_1 + (d^2 + a^2) P_2), \log(1 + (bd-c)^2 P_1 P_2 + (d^2 + 1) P_2 + (c^2 + d^2) P_1)\}$$
- Can serve as an outerbound for the Gaussian interference relay channel.

Performance under Strong Interference



Performance when relay has large power



Conclusions

- The outerbound obtained is **tighter** than the cutset bound for GIFRC in the following scenarios:
 - When source-relay gains are weak.
 - When relay's power is large.
- CF scheme performs better than DF scheme when source-relay gain is weak.
- When relay's power is large, CF scheme is near optimal under weak source-relay gain.
- When relay's power is large, DF scheme is near optimal under strong source-relay gain.