



Relaying Algorithms For Wireless Adhoc Networks

Mohamed Abdallah and Haralabos Papadopoulos

Problem Statement

- Efficient information relaying in wireless ad-hoc networks.
- System Constraints
 - Limited processing.
 - Limited bandwidth \Rightarrow Relays communicate over time-varying shared channel.

Proposed System Model

- $\{x^{(1)}[n], x^{(2)}[n], \dots, x^{(L)}[n]\}$: Correlated versions of the sender information-bearing signal $x[n]$ at the relays.

Partially Coherent Beamforming Algorithm

- Objective:** Minimize the outage probability

$$P_{out}(\gamma_{req}) = \text{Prob}(\gamma_i < \gamma_{req})$$
- Two-Stage heuristic Algorithm:**
 - Compute the maximum value of SNR, $\gamma_{i,max}$, at the receiver.
 - Stage I** ($\gamma_{req} < \gamma_{i,max}$): construct the beamforming vectors that satisfy γ_{req} .
 - Stage II** ($\gamma_{req} \geq \gamma_{i,max}$): select orthogonal beamforming vectors to minimize $\xi_{i+1|j}$.

Design Objective

- Focus on relays-destination wireless system.
- Optimize the levels of the instantaneous received SNR at the destination to achieve a desired *uncoded bit error probability* P_e performance.

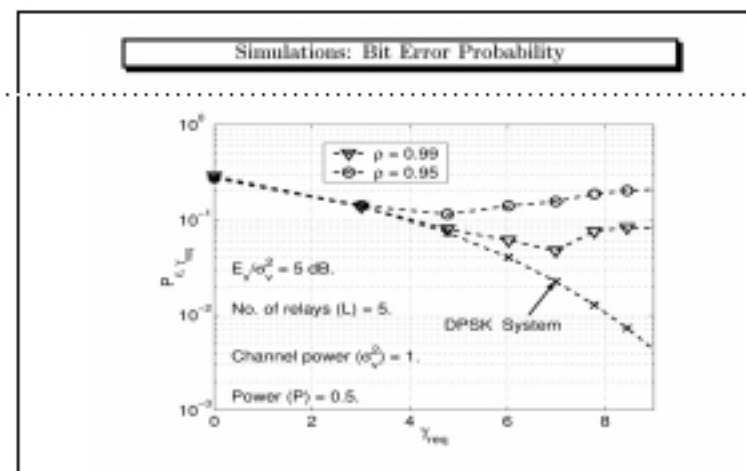
Beamforming Design Challenges

- Construct beamforming matrix B_i for the i th frame

$$B_i = [b_i[1] \ b_i[2] \ \dots \ b_i[M]]$$

$$b_i[j] = [\beta_i^{(1)}[j] \ \dots \ \beta_i^{(k)}[j] \ \dots \ \beta_i^{(L)}[j]]^T$$

k = relay index; i = Frame index
 j = data slot index within a frame.
- Desired level of received SNR for the current frame.
- Reliable predicted channel estimates for the future data frames.



Beamforming Algorithms

- Relaying algorithms are based on *beamforming*.
- Beamforming requires these parameters:
 - Channel state information (CSI) of relays-destination channels.
 - Correlations between the noisy estimates of information-bearing signal at the relays.
- Q:** Obtain these parameters under limited-bandwidth constraint?
 - Limit the usage of pilot tones.

SNR Optimization

- Constructing beamforming vectors to optimize

$$\gamma[j] = \frac{\mathbf{b}_i^H[j] A_{q_{i-1}} \mathbf{b}_i[j]}{\mathbf{b}_i^H[j] Q_{q_{i-1}} \mathbf{b}_i[j] + \sigma^2}$$
 subject to the constraint

$$\|\mathbf{b}_i[j]\|^2 = P.$$
- SNR depends on
 - Current beamforming vectors $\mathbf{b}_i[j]$.
 - Predicted channel parameters matrix $A_{q_{i-1}}$.
 - Estimated prediction error covariance matrix $Q_{q_{i-1}}$.
- Quality of predicted channel estimates:

$$\xi_{q_{i-1}} \triangleq \max(\text{diag}\{Q_{q_{i-1}}\})$$

Summary

- Developing optimized partially coherent beamforming algorithms that achieve a desired P_e .
- Preliminary investigation suggests that there exists a tradeoff between the achievable level of SNR and the quality of predicted channel estimates.
- Planning to explore our findings to study the correlated signal estimates and for a limited-bandwidth feedback channel.