Relaying Algorithms For Wireless Adhoc Networks

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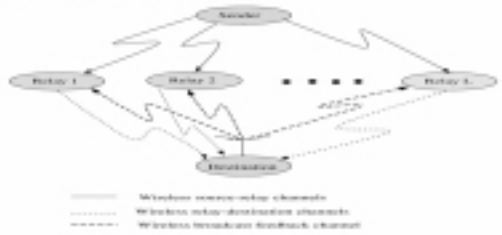
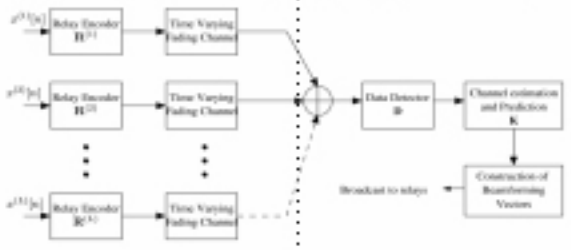
Problem Statement

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



Proposed System Model

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



Partially Coherent Beamforming Algorithm

- *Objective:* Minimize the outage probability

$$P_{out}(\gamma_{req}) = Prob(\gamma_i < \gamma_{req})$$

- 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 $\xi_{i+1|i}$.

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 ith frame

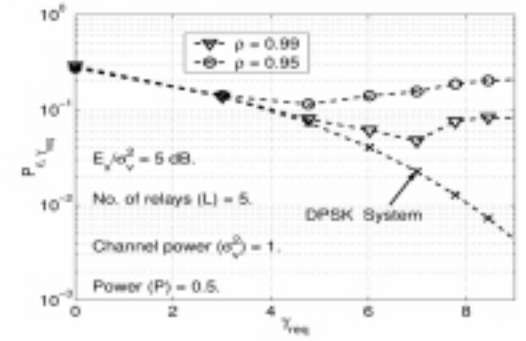
$$B_i = [\, \mathbf{b}_i[1] \;\; \mathbf{b}_i[2] \;\; \ldots \;\; \mathbf{b}_i[M] \,]$$

$$\mathbf{b}_i[j] = \left[\beta_i^{(1)}[j] \;\; \ldots \;\; \beta_i^{(k)}[j] \;\; \ldots \beta_i^{(L)}[j] \right]^T$$

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.

Simulations: Bit Error Probability



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

$$\gamma_i[j] = \frac{\mathbf{b}_i^H[j]\, A_{i|i-1}\, \mathbf{b}_i[j]}{\mathbf{b}_i^H[j]\, \mathcal{Q}_{i|i-1}\, \mathbf{b}_i[j] + \sigma_v^2}$$

subject to the constraint

$$||\mathbf{b}_i[j]||^2 = P.$$

- SNR depends on
  - Current beamforming vectors $\mathbf{b}_i[j]$.
  - Predicted channel parameters matrix $A_{i|i-1}$.
  - Estimated prediction error covariance matrix $\mathcal{Q}_{i|i-1}$.
- Quality of predicted channel estimates:

$$\xi_{i|i-1} \triangleq \max(\mathrm{diag}\{\mathcal{Q}_{i|i-1}\})$$

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.