Modeling Cooperative Diversity in a Wireless Relay Channel

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Overview

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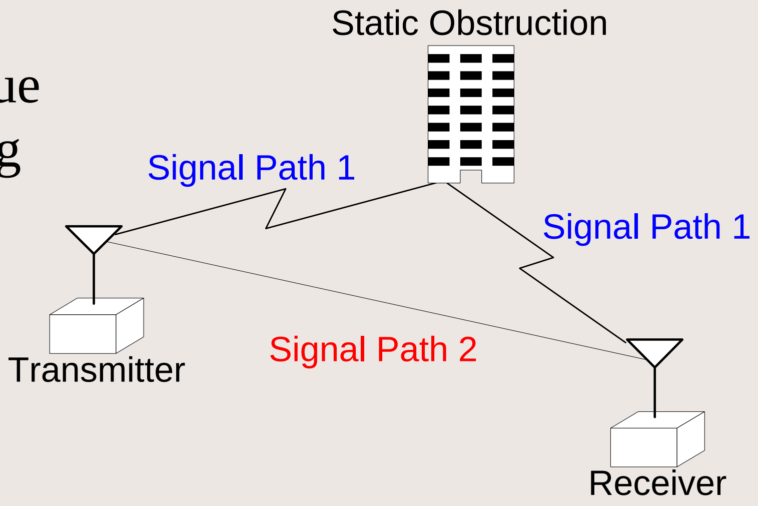
Problem Statement & Objectives

Problem:

How can we combat attenuation due to multiple destructively interfering signal paths in wireless channels?

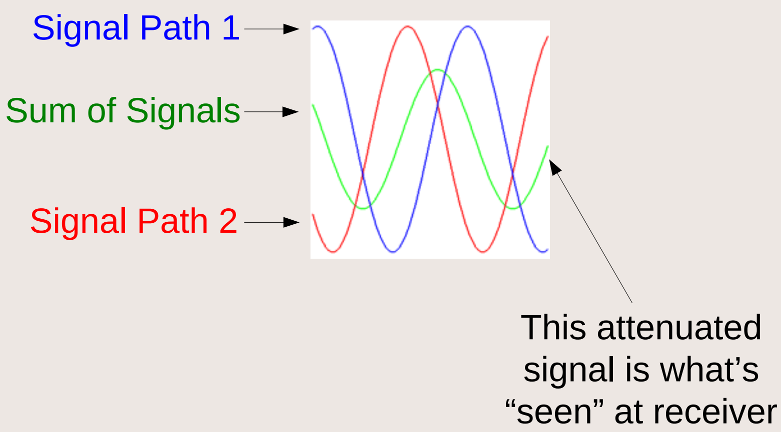
Well known issue in wireless systems known as

“**Multi-path Fading**”



Objective:

Develop software framework to model low energy/complexity solutions for combating multi-path fading

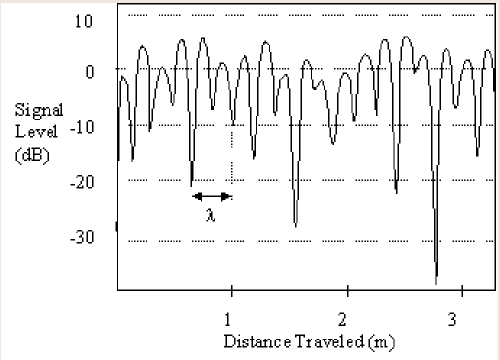


Background

- **Diversity:** Well-known solution to multi-path fading
  - Send copies of signal through <u>uncorrelated</u> paths to receiver
  - Signals combined at receiver; individual channel effects averaged
- Types of diversity
  - Spatial (*i.e.* traditional antenna arrays, MIMO)
  - Temporal (*i.e.* error correcting codes)
- Multi-path fading channel model
  - Rayleigh Fading: Envelope, R, of faded signal defined by:

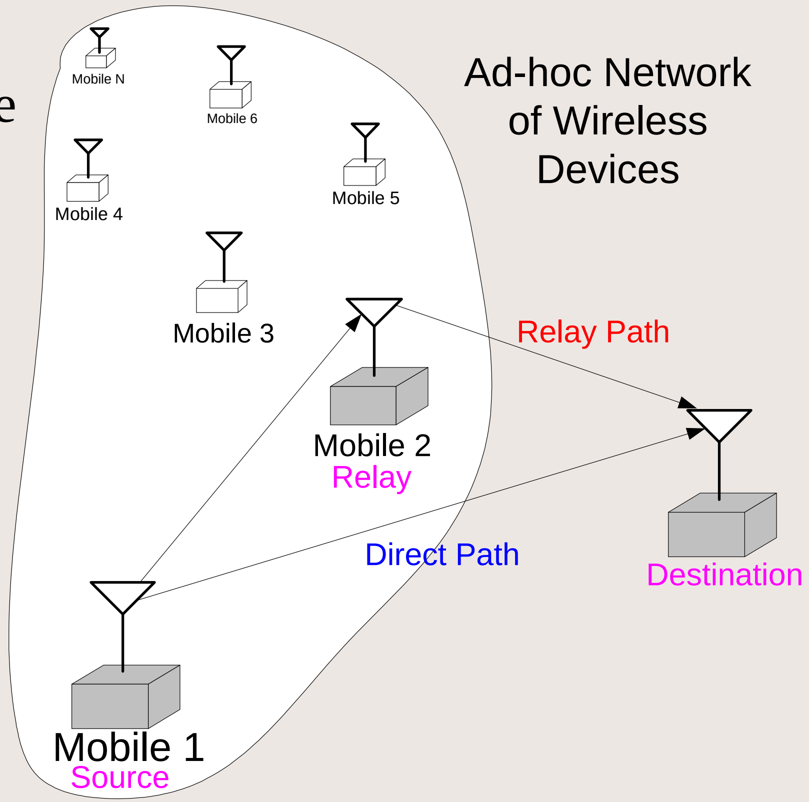
$$R = \sqrt{X^2 + Y^2}$$

where X and Y are independent zero-mean Gaussian random variables with unit variance



Cooperative Diversity

- Achieves spatial diversity
- Wireless nodes distributed in space (*i.e.* ad-hoc network)
- Nodes cooperate by retransmitting each others signals
- Collection of nodes becomes a "distributed antenna array"
- Relay nodes may:
  - amplify-and-forward
  - decode-and-forward



Modeling Cooperative Diversity with LabVIEW

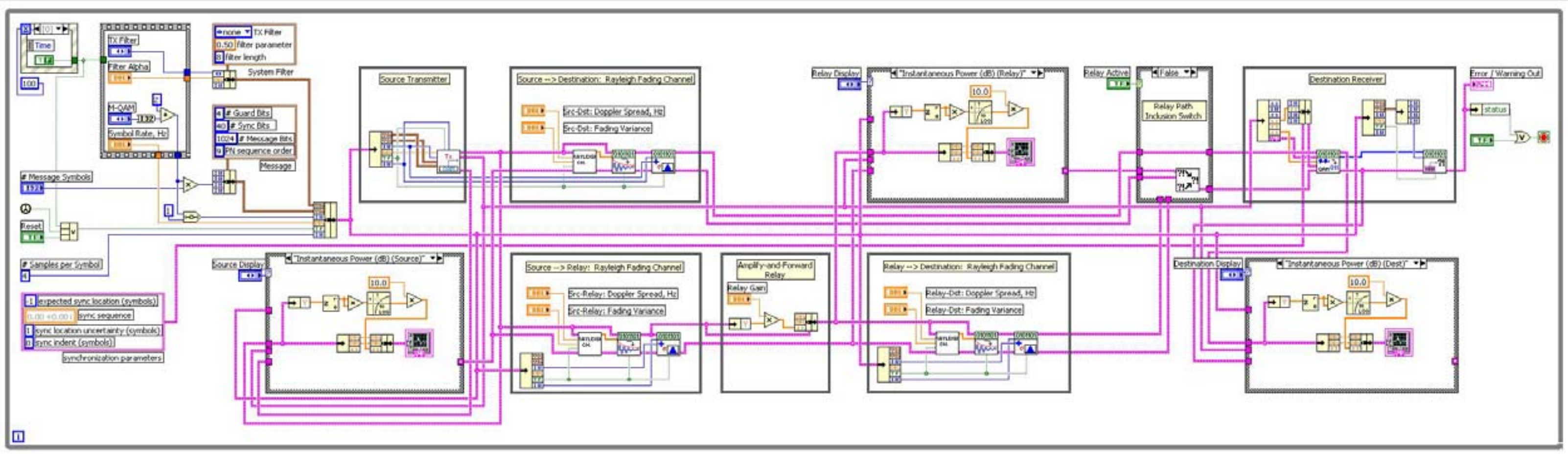
- Why LabVIEW?
  - native dataflow language
  - extensive signal processing functions
  - modulation toolkit available
  - recommended by Behnaam Aazhang, one of the fathers of cooperative diversity
- Entire system (*i.e.* nodes and channels) modeled as Synchronous Dataflow (SDF)

Modeling Amplify-and-Forward Relaying

- Strict SDF (w/ no shared buffers)
- Nodes
  - 1Kb messages
  - 16 QAM modulation
  - Root raised cosine pulse shaping with $\alpha = 0.5$
- Channels
  - Multi-tap (variable) FIR filters
  - Made uncorrelated by differing random seeds
  - Additive White Gaussian Noise with $E_b / N_0 = 10 dB$

Demonstration

- Cooperative diversity with amplify-and-forward relay channel in LabVIEW



- Available for download soon:

http://www.ece.utexas.edu/~icaza

Conclusion

- Cooperative Diversity achieves spatial diversity with less complexity and power than traditional antenna arrays
- Modeled effectively as SDF with LabVIEW
- Moving forward
  - Add temporal diversity/coding (*i.e.* distributed turbo codes [Valenti, 2003])
  - Investigate adaptive protocols for cooperation

Thank You!