Efficient Relaying Strategy Selection and Signal Combining using Error Estimation Codes

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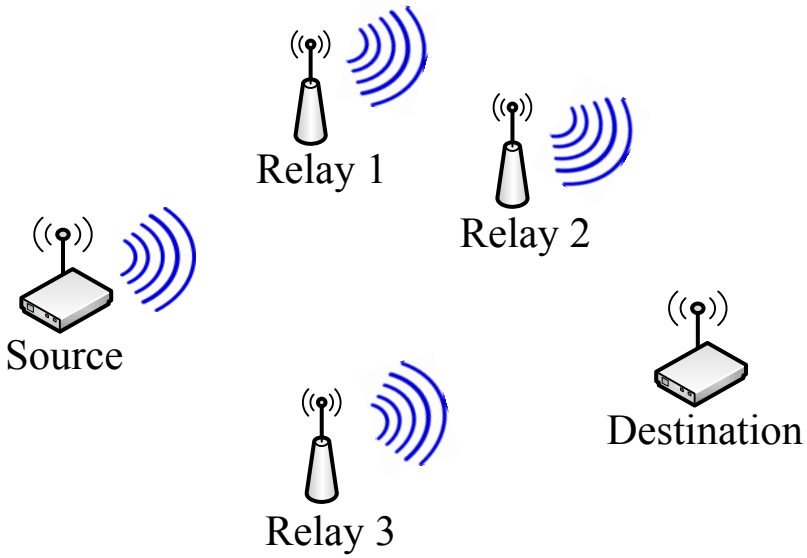
Summary

- Cooperative framework for a multi-relay network
- Error Estimation Codes for BER Estimation
  - Relaying Strategy Selection (AF or DF)
  - Combining algorithm at the destination
- Main Features
  - Explicit estimation of SNR not required
  - Source/Destination oblivious to the selected relaying strategy
- Experimental evaluation using software-defined radios

Outline

- System Model
- Overview of EEC
- Proposed cooperative framework
- Results

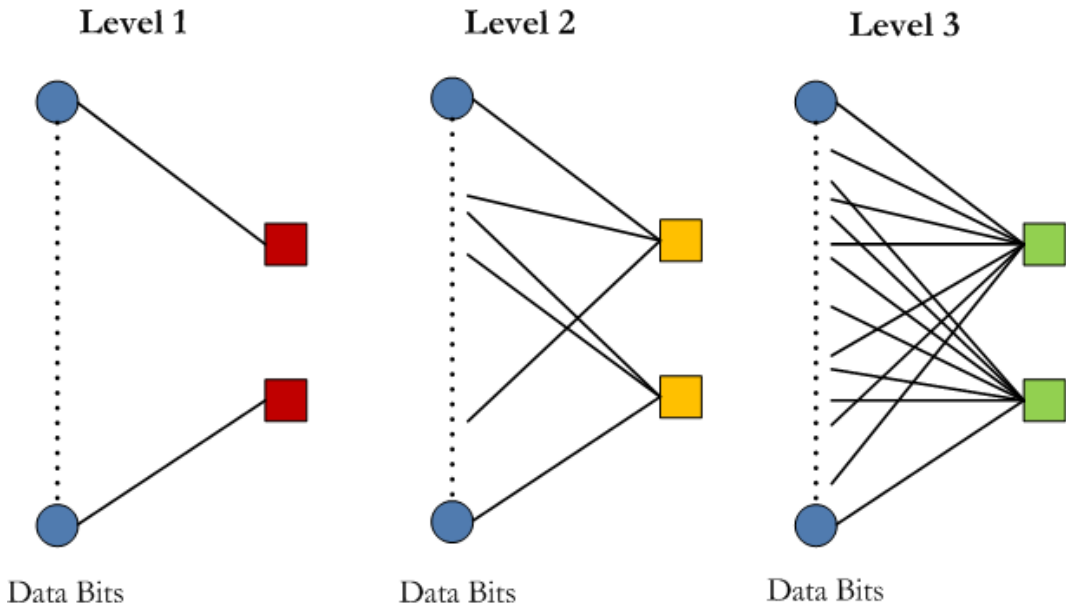
System Model



- Multiple half-duplex relays
- No two nodes can transmit simultaneously
- No CSI at the transmitter
- QPSK modulated transmissions

Overview of EEC: Encoding

- n data bits are divided into l levels
- Parity bit at level i : binary addition of 2^i-1 random data bits
- Same number of parity bits at each level



- Parity bits uniformly spread in the packet

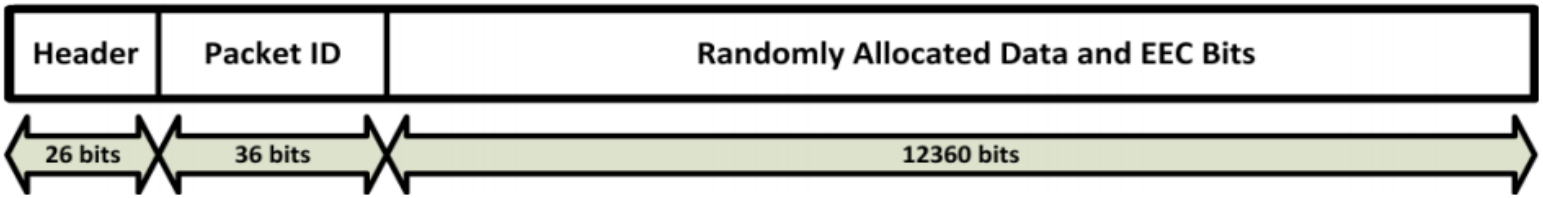
Binbin Chen et al "Efficient Error Estimating Coding: Feasibility and Applications," Proceedings of ACM SIGCOMM, Sept. 2010.

Overview of EEC: Decoding

- Same random seed at the decoder and encoder
- Compute the fraction of failed parity checks at each level
- BER estimated from these computations
- Provable guarantees

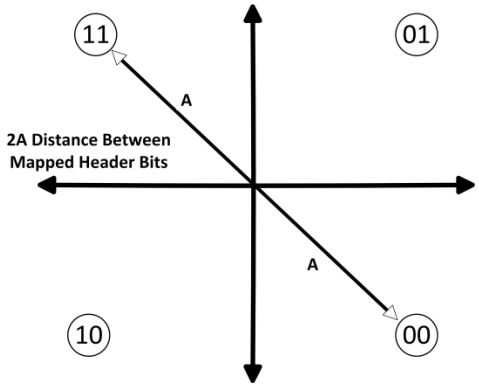
Binbin Chen et al "Efficient Error Estimating Coding: Feasibility and Applications," Proceedings of ACM SIGCOMM, Sept. 2010.

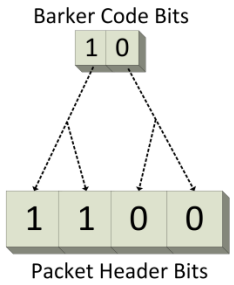
Proposed Cooperative Framework



Packet Format

- Data : 12000 bits
- EEC Parity: 360 bits
- Packet ID : 36 bits
- Baseband Modulation: QPSK
- Header : 26-bit repeated Barker Sequence





Proposed Cooperative Framework

Relaying Strategy

- Locate Headers/Barker Sequences
- Form a BER estimate using detected EEC bits
- If BER < Threshold*, DF cooperation
  - Send packet with detected data bits
- Else, AF cooperation
  - Header mapped to QPSK
  - Forward analog samples of Data + EEC bits

* Threshold is computed empirically

Proposed Cooperative Framework

Decoding Strategy

- Locate Headers/Barker Sequences
  - Multiple copies of the same packet
- Form BER estimate of each copy using EEC bits
- Combine copies according to the rule

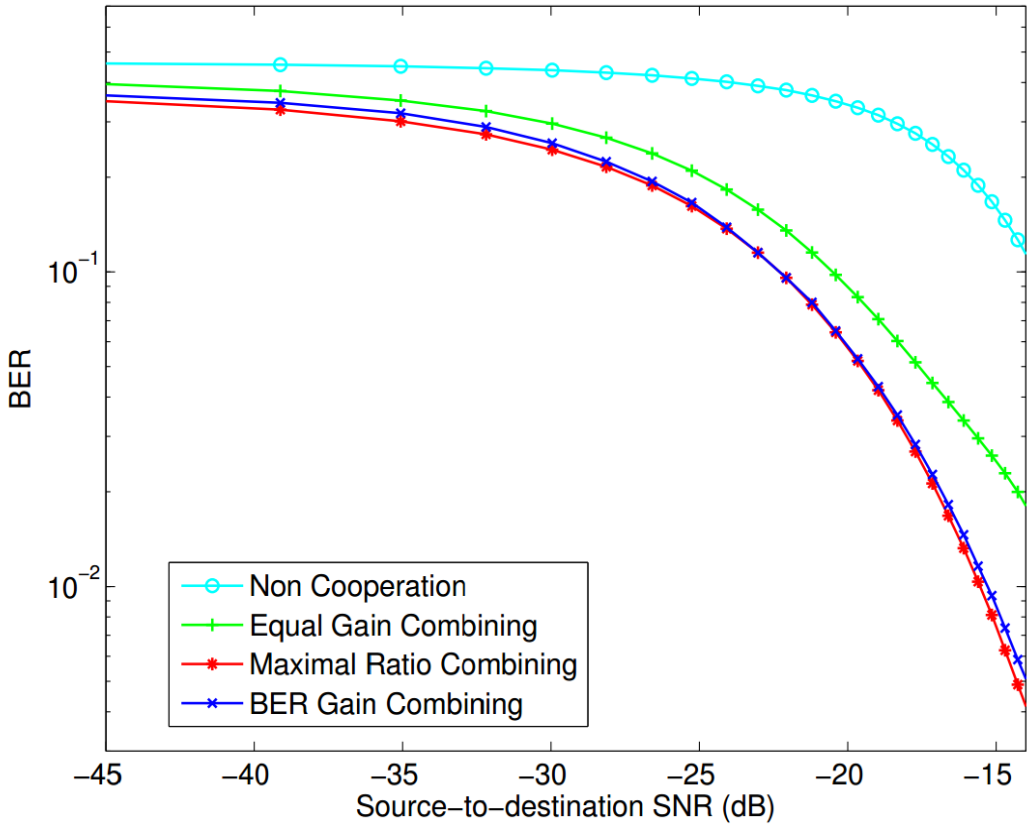
$$Y = \frac{(P_{sd})^{-1} Y_{sd} + \sum_{i=1}^{K} (P_{rd}^{i})^{-1} Y_{rd}^{i}}{(P_{sd})^{-1} + \sum_{i=1}^{K} (P_{rd}^{i})^{-1}}$$

- Form bit estimates on the combined copy

Main Features

- Benefits over Maximum Ratio Combining
  - No explicit knowledge of channel conditions required
  - Able to predict SNR over the entire channel length in contrast to pilot based estimates
  - Independent of AF/DF strategy adopted by the relays
- Benefits over EGC
  - Much better performance
- Performance gains of MRC with the simplicity comparable to EGC

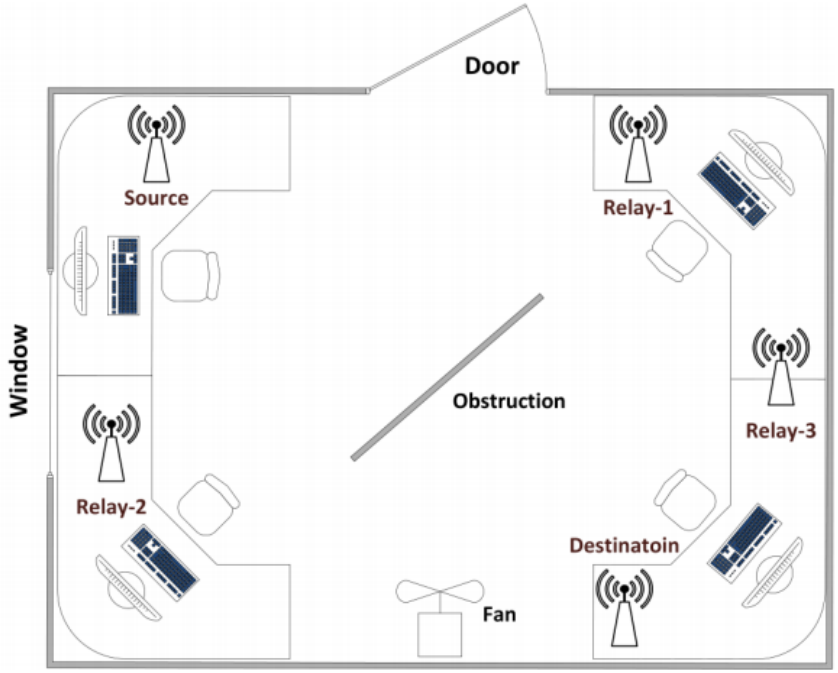
Results (Simulations)



- AWGN channels
- S→R and R→D links 18 dB better

Experimental evaluations

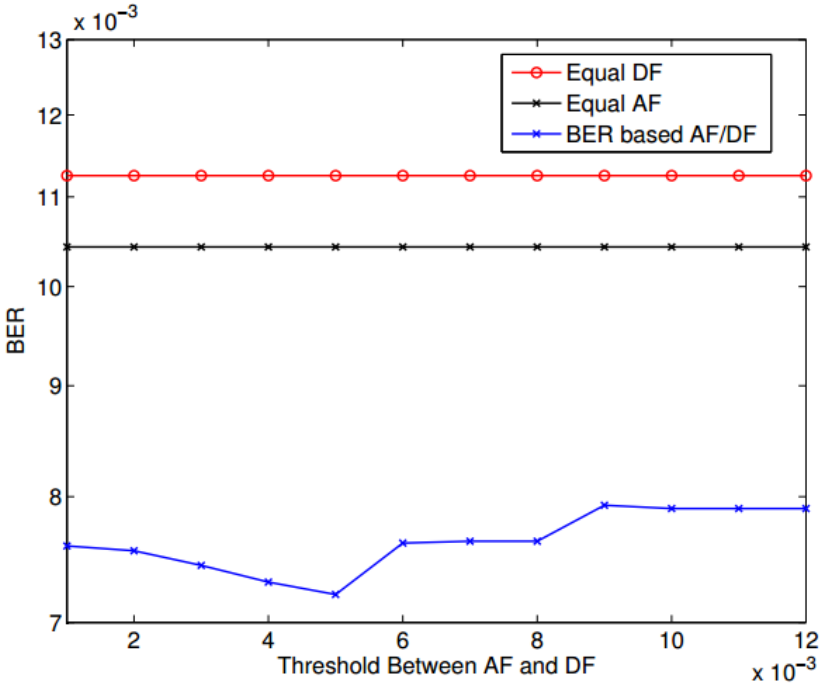
- USRP-1 devices connected to Windows-based PCs
- Baseband Processing in Matlab-Simulink



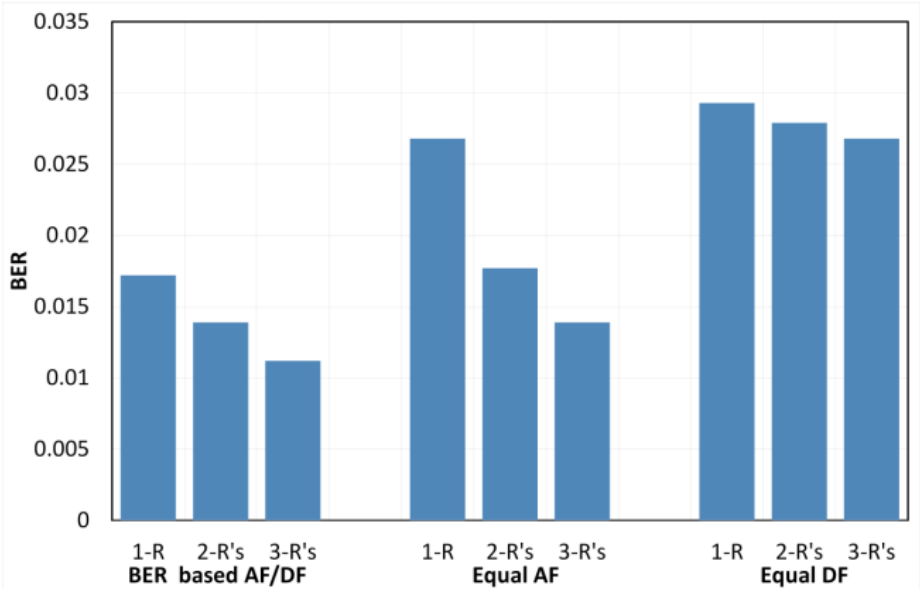
Floor map

Experimental Results

Single Relay



Multiple Relays



Thank you

Questions/Comments?