Cooperative Communication Adds Bandwidth Flexibility to Fixed Multiplexing Radio Networks

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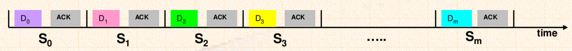
Fixed Multiplexing Radio Network (TDMA)

- Radio network consists of *m* sources, S_0, $S_1, \ldots, S_m$
- All the sources send to the same destination
- One single broadcast radio channel is available and shared by all the sources

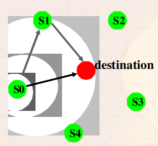
Fixed Multiplexing

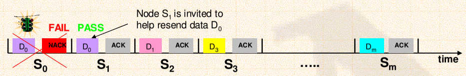
The radio channel is divided into time slots, and every source node is reserved one slot for transmission of data frames



Cooperative ARQ Protocol

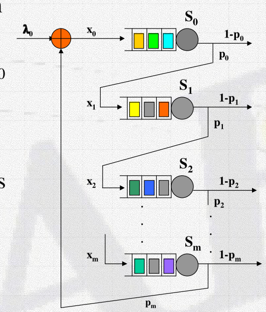
Nodes other than the source and destination can help deliver the data frame to the destination correctly





Saturation Throughput Gain

- Only S_0 sends data to the destination
- λ_0 is the arrival rate for data to S_0
- $S_1, \ldots, S_m$ help transmit data for S_0, if S_0 data transmission fails
- $p_0, p_1, \ldots, p_m$ are the frame error probabilities
- $x_0, x_1, \ldots, x_m$ are the frame transmission rates

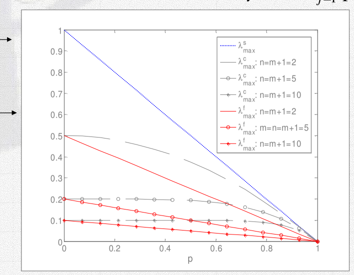


Assuming: $p_0 = p_1 = \ldots = p_m = p$

Saturation throughput with cooperation: $\lambda^c_{\max} = \frac{(1-p)\sum_{j=0}^{m} p^j}{n}$

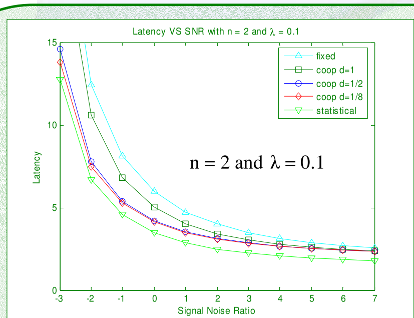
Saturation throughput without cooperation: $\lambda^f_{\max} = \frac{(1-p)}{n}$

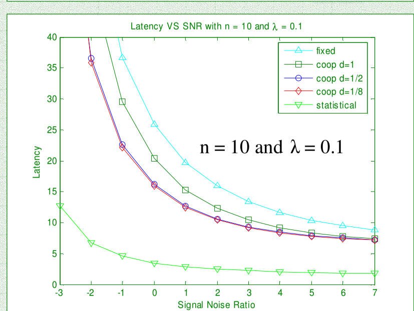
Throughput gain: $\gamma^{cf} = \sum_{j=1}^{m} p^j$



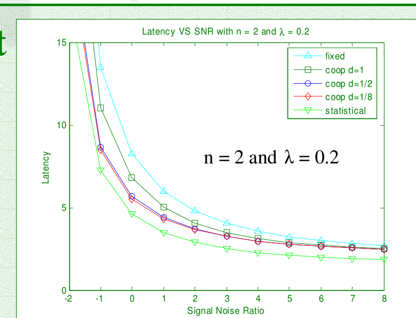
Network Latency Improvement

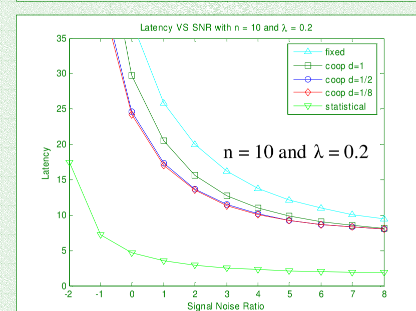
Results by simulation





- 3 systems compared
  - Perfect statistical multiplexing
  - TDMA without cooperation
  - TDMA with cooperation
    - –Only one relay per source
    - –Priority given to cooperation
- Assumptions:
  - Sources are equidistant from the destination, with distance: d
  - Distance between sources: d/8,d/2,d
  - Arrival rates: $\lambda_0 = \lambda_1 = \ldots \lambda_{n-1} = \lambda/n$
  - Number of nodes: *n*





Summary

The use of cooperative communications helps:

- Improve the radio channels capacity thanks to spatial diversity
- Alleviate the main drawbacks of fixed multiplexing, yielding asymptotically optimal flexible bandwidth allocation
- Improve Saturation throughput &
- Improve network latency in degraded signal quality channels