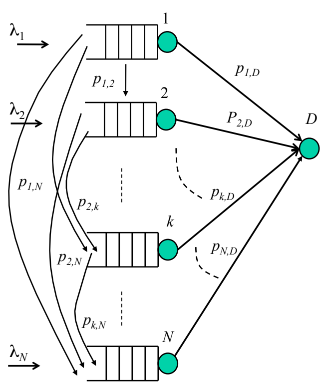
Cooperation in Wireless Networks

Beiyu Rong, Anthony Ephremides

Introduction, Motivation and Objective

- **Introduction**
  - Channel qualities: fading, shadowing, distance attenuation; interference
  - Wireless Multicast Advantage
- **Motivation**
  - Exploit spatial diversity through combined use of antennas belonging to different users
- **Objective**
  - To simply utilize relaying capability intelligently at the network protocol- level; Cross-layer design
  - Performance Analysis: Stable Throughput, Delay

A General Multiple-Access System



Exploit spatial diversity among the N users

- Multiple-Access: N users, unicast to the single common destination (D)
- Exogenous Bernoulli arrivals to each user, λ_i
- Erasure channel model:
  - Packet reception probability

$$p_{i,j} = \Pr\left[\frac{|h_{i,j}|^2 P_i}{N_j} > \gamma\right]$$

  - "Ordered" channel qualities

$$p_{N,D} > p_{N-1,D} > \cdots\cdots > p_{1,D}$$

- Feedback ACK is perfect

Opportunistic Cooperation Strategy

- User k transmits a packet,

1). If the destination successfully decodes the packet, the packet exits the network;

2). If the destination doesn't decode the packet, but some of k's subsequent users decode the packet, the one with the *best* channel to the destination will keep the packet and take responsibility to transmit it, all other users drop that packet (this can be done by checking ACKs);

3). Otherwise, if none of k's subsequent users nor the destination decodes the packet, the packet remains at k's queue for retransmission.

Opportunistic relaying & multi-hop relaying

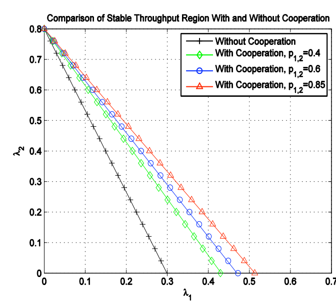
MAC Policy

- Conflict-free work-conserving policy
- TDMA scheduling, time allocation $\mathbf{\Omega} = (\omega_1, \omega_2, ..., \omega_N)$

Performance Analysis

- Characterized the *closed-form* expressions for the Stable Throughput Region, Average Delay

Numerical Results: Stale Throughput

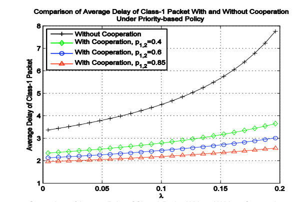


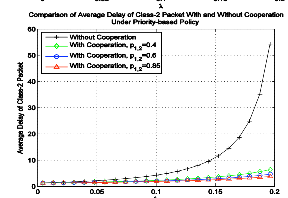
$p_{1,3} = 0.3,\ p_{2,3} = 0.8,\ p_{1,2} = 0.4, 0.6, 0.85$

- Both policies yield same stable throughput region under cooperation
- N users simultaneously increase stable throughput rate
- $p_{1,2}$ increases → region enlarges

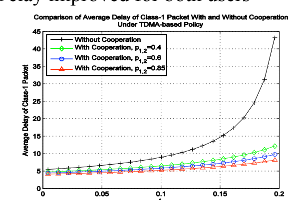
Average Delay

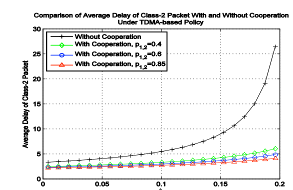
- Priority-based, prioritizes user 1's packets
- Delay improved for both users





- TDMA-based, optimization over (ω_1, ω_2)
- Delay improved for both users





Conclusion

- All users in the network can simultaneously have performance gains in terms of stable throughput and delay.