Network coding – beyond multicast

- Traditional algorithms rely on routing, based on wireline systems
- Wireless systems instead produce natural broadcast
- Can we use incidental reception in an active manner, rather than treat it as useless or as interference
- Complementary technique with respect to schemes such as UWB and MIMO that make use of additional, albeit possibly plentiful, resources over links
- Network coding seeks instead to use available energy and degrees of freedom fully over networks
Traditional algorithms rely on routing, based on wireline systems.
Wireless systems instead produce natural broadcast.
Can we use incidental reception in an active manner, rather than treat it as useless or as interference.
Complementary technique with respect to schemes such as UWB and MIMO that make use of additional, albeit possibly plentiful, resources over links.
Network coding seeks instead to use available energy and degrees of freedom fully over networks.
Network coding – beyond multicast

- Traditional algorithms rely on routing, based on wireline systems.
- Wireless systems instead produce natural broadcast.
- Can we use incidental reception in an active manner, rather than treat it as useless or as interference.
- Complementary technique with respect to schemes such as UWB and MIMO that make use of additional, albeit possibly plentiful, resources over links.
- Network coding seeks instead to use available energy and degrees of freedom fully over networks.

Extend this idea [Katabi et al 05]
Opportunistic Listening:
- Every node listens to all packets
- It stores all heard packets for a limited time
- Node sends Reception Reports to tell its neighbors what packets it heard
  • Reports are annotations to packets
  • If no packets to send, periodically send reports
Opportunistic Coding:
- Each node uses only local information
- Use your favorite routing protocol
- To send packet $p$ to neighbor $A$, XOR $p$ with packets already known to $A$
  - Thus, $A$ can decode
- But how to benefit multiple neighbors from a single transmission?
Efficient coding

Arrows show next-hop
Efficient coding

Bad Coding

C will get slate pkt but
A can’t get turquoise pkt

Arrows show next-hop
Efficient coding

OK Coding
Both A & C get a packet

Arrows show next-hop
Efficient coding

Best Coding
A, B, and C, each gets a packet

Arrows show next-hop
To XOR \( n \) packets, each next-hop should have the \( n-1 \) packets encoded with the packet it wants
But how does a node know what packets a neighbor has?

- Reception Reports
- But reception reports may get lost or arrive too late
- Use Guessing
  - If I receive a packet I assume all nodes closer to sender have received it
Beyond fixed routes

B heard S’s transmission

S transmitted

No need for A transmission

Route Chosen by Routing Protocol

**Opportunistic Routing [BM05]**

- Piggyback on reception report to learn whether next-hop has the packet
- Cancel unnecessary transmissions
How to overhear

- Ideally, design a collision detection and back-off scheme for broadcast channels
- In practice, we want a solution that works with off-the-shelf 802.11 drivers/cards

**Our Solution:** Pseudo Broadcast

Piggyback on 802.11 unicast which has collision detection and backoff
- Each XOR-ed packet is sent to the MAC address of one of the intended receivers
- Put all cards in promiscuous mode
• 40 nodes
• 400m x 400m
• Senders and receivers are chosen randomly
• Flows are duplex (e.g., ping)
• Metric:
  Total Throughput of the Network
Current 802.11

Net. Throughput (KB/s)

Number of flows in experiment
Opportunistic Listening & Coding

Number of flows in experiment

Net. Throughput (KB/s)
Add Opportunistic Routing

Number of flows in experiment

Net. Throughput (KB/s)

With Opportunistic Routing

Opportunistic Listening & Coding

No Coding

Number of flows in experiment
Our Scheme vs. Current (2-way Flows)

Net. Throughput (KB/s)

Our Scheme: Huge throughput improvement, particularly at high congestion.

No Coding
Completely random setting

- 40 nodes
- 400m x 400m
- Senders and receivers are chosen randomly
- Flows are one way
- Metric:
  - Total Throughput of the Network
Our Scheme vs. Current (1-way Flows)

Net. Throughput (KB/s)

A Unicast Network Coding Scheme that Works Well in realistic Situations