Self Organizing and Self-Healing Ad-hoc Networks

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Presented at WLAN 2001
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Example Problem

- \( N \) radios on a terrain
- Each moving
- No Fixed Infrastructure
- High-Speed Data Communication
- Mobile Voice and Video
- Cheap and Reliable
The Hidden Terminal Problem

- A transmits to B, while C transmits to D
- Results in one or both transmissions failing
- Very common event, alas!
- How could A or C know when to transmit?

A and C can’t hear each other

Their transmissions collide at B and D, and both packets are lost
Channel Access Mechanisms

**RTS / CTS Approach**

- Receiver directed
- D cues off B’s CTS
- Complex state machines
- Behaves like CSMA
  (Doesn’t work for broadcast)

**Timeslot Approach**

- Transmitter directed
- Good features of TDMA
- Needs sync’d clocks
- Very hard distributed algorithm

**Note that A and C must be coordinated!**
Delay vs. Throughput Tradeoff

*High Power* means low network throughput

*Low Power* means long end-to-end delay

Single, High-Power Transmission

- 38 other radios blocked

Multi-Hop, Low Power Transmissions

- 14 other radios blocked

Interference Area
“Proactive” Routing Protocols

Link State (SPF)

- **Good Points**
  - Global Knowledge
  - Allows QOS Routing
  - Multicast is “easy”

- **Bad Points**
  - Scales poorly
  - Global bursts of control traffic

Distance Vector

- **Good Points**
  - Less Control Traffic
  - “Local Repair”
  - Simple to Code

- **Bad Points**
  - Control traffic is hard to estimate
  - QOS is hard
  - Multicast is hard
“On-Demand” Routing Protocols

1. Flood Search. (Optimized by caching.)
   - Good Points
     - No global knowledge
     - Allows local repair
     - Scales with Traffic Flows
   - Bad Points
     - Repair routes are suboptimal
     - Bad interactions with TCP
     - Multicast is complicated
     - Denial of Service attacks

2. Path Discovery. (Optimized by pruning.)

3. Traffic. (Source routed.)
A Hierarchical Ad Hoc Network

- Cluster Member
- Cluster Head
- Backbone Link
- RTS / CTS Waveform
- Per-frame Power Control
- Hierarchical Link-State Routing
- Spatial reuse with good end-to-end delay
Ad Hoc Network with Unmanned Aircraft
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### Ad Hoc Network with Drone Aircraft

- **GBS, LEOs**
- **Drone Nodes**
- **ATM Radios**
- **High Mobility Backbone**
- **Handheld Voice/Data Nodes**