tier technology and infrastructure for emerging regions

NSF intel

Long Distance Disruption-Tolerant Wireless Networks

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Goals

- Network connectivity in remote areas
- Use of Internet and non-Internet transports
- Low cost
- Easy setup
- Operation in harsh environments
  - disruption and high-delay tolerant

802.11 Challenges

- Per-packet ACK limits throughput over long distance
- CSMA/CA causes unwanted backoffs on transmit
- High packet loss at long distance due to collisions
- Much of the available hardware is too low power
- Some hardware difficulty to change from 802.11 standard
- Known problems for TCP (losses aren't congestion related)

Approach

- Leverage low-cost WiFi equipment with long-range antennas
- Start with router boxes running commodity OS (Linux)
- Replace conventional 802.11 WiFi MAC protocol
- Add TDM-based scheduling scheme among 802.11 nodes
- Add Delay Tolerant Networking (DTN) store/forward message layer

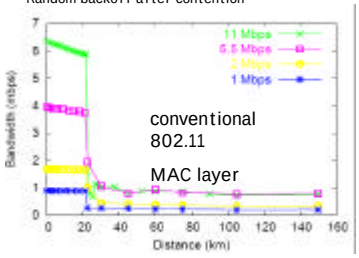
Disruption Challenges

- Applications assume e2e 'connections'
- Routing does not understand schedules
- Long-term disconnection causes failures
- End-to-end reliability poor w/high loss rates
- E2e performance poor w/high delays

Long-distance 802.11

802.11 Single Link Shortcomings

- Low throughput
  - RTS/CTS adds a roundtrip delay
  - Stop-and-wait protocol adds one more propagation delay
  - Control messages (RTC,CTS,ACK) expensive (header send at minimum datarate)
  - Random backoff after contention



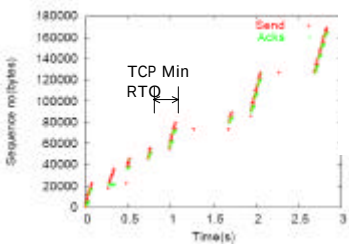
- PRISM 2.5 Radios
- UDP throughput
- With retries enabled
- Gradual drop as round trip time increases
- Sharp drop at 22 km
- Channel emulator
- RF isolated experiments

- High loss rates
  - Collisions occur due to high propagation delay
  - 10% at 20Km, 25% at 60Km due to collisions

TCP on 802.11 Lossy Link

20 km link over the bay from Berkeley to SF ; 20 % loss

- TCP : 372 Kbps
- UDP : 4.5 Mbps
- Frequent timeouts of 200 ms
- Lots of lost ACKs

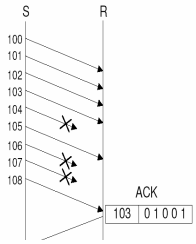


Multi-hop Shortcomings

- Interference among cards at same tower (which are on different WiFi networks)
- Communication not synchronized among cards on same tower
- Cross-talk among channels, if cards/antennae close

Improved Long-Distance MAC

- Bulked ACKs
  vs.
  ACKs at every packet



- Need for synchronization among cards at same tower:
  - Simultaneous SEND possible by disabling carrier sense
  - Simultaneous RECEIVE possible
  - SEND while other RECEIVEs not allowed !!
- Spatial Reuse TDMA (STDMA) can achieve synchronization, replaces CSMA/CA

Minimize TCP Problems

- Modifications similar to SNOOP, to cope with wireless losses without timing out

Hardware/Software Platform

- Hardware
  - Soekris, WRAP, RouterBOARD boards, w/ 266MHz Geode processor
  - High power Atheros and Prism chipset WiFi cards (300 & 400mw)
  - 24dB directional antennas, sometimes 1W amps
- Software
  - Our own Linux distribution based on Pebble Linux
  - Zebra routing
  - Cricket for SNMP data collection
  - Remote upgrades, administration and management
  - M0n0wall-based UI for configuration
  - MadWiFi / Atheros mods for long distance

DTN

- Delay Tolerant Networking
  - Store/forward overlay routing (like email with fancy routing, fragmentation, and security)
  - Operation over TCP/IP and non-TCP/IP network protocols
  - Active research group
    - http://www.dtnrg.org

India/Africa/Bay Area Testing