G 364: Mobile and Wireless Networking

CLASS 1
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M-W, 11:40am-1:20pm, 109 Rob
Aims of the Class

- Introduction to the two main wireless architectures:
  - Ad hoc (all-mobile) networks
  - Cellular networks
- Techniques and protocols
- Fundamental problems and solutions
- Some enabling technologies
Wireless & Mobile Networks

- **Wireless networks**: a set of nodes that communicate by exchanging packets via radio waves over a shared wireless medium.
- **First big problem**: Accessing the shared wireless channel.
- **Need for (a wireless) Media Access Control**: wireless MAC.
Media Access Control (MAC)

Position of MAC protocols within a simplified protocol stack
MAC Design

Design and complexity of a MAC protocol is affected by:

1. Network architecture
2. Communication model
3. Duplexing mechanism
Network Architecture

The network architecture defines

- The structure of the network
- Where the intelligence resides

Two major kinds

- Centralized or cellular
- Distributed or ad hoc
Centralized Architecture, 1

Specialized nodes = base stations (BS)
- Each BS has a given coverage area or cell (cellular networks)
- BS coordinates and controls all communications in its cell

Wireless node or mobile host (MH)
- Follows the instruction of the BS it is visiting
Centralized Architecture, 2
Centralized Architecture, 3

- **Downlink** = unshared channel from BS to MH
- **Uplink** = channel from MH to BS shared by all MHs in a BS cell
- **Asymmetry**: BS counts more than the MH
  - Leads to a simplified design of the MH
  - Leads to a simplified design of network protocols (MAC, routing, ...)
- **Problems**: Deployment, single point of failure
Ad Hoc Networks, 1

- No fixed infrastructure
- Service coverage defined by node proximity and Radio Frequency (RF) characteristics
- Nodes communicate in a peer-to-peer fashion
- Every node is a switch
Ad Hoc Networks, 2

Ad hoc architecture
Ad Hoc Networks, 3

- **Characteristics:**
  - Rapidly deployable
  - Easily configured
  - More robust

- **Potential drawbacks**
  - Distributed control
  - Neighbor knowledge
  - All-mobility is a challenge
Communication Models

- Refers to the overall level of synchronization in the wireless system
- Determine when channel access can occur
- Two basic communication models:
  - Synchronous
  - Asynchronous
Synchronous Model, 1

- Slotted channel consisting of discrete time intervals (slots)
- Slots are usually grouped into a larger time frame, cyclically repeated
- Nodes are synchronized on the frame
- Communication occurs within a slot
Synchronous Model, 2

“Best” for providing Quality of Service, QoS (voice)

“Easy” for the centralized architecture

Not easy for the ad hoc architecture

- Distributed time synchronization can be ineffective
- When possible, use of Global Positioning System receivers
Asynchronous Model

- Less restrictive: No “common clock” (no time slots)
- Communication happens “on-demand”
- QoS provisioning and bandwidth managements are more involved
- Applications: file transfer, sensor networking, ad hoc networks
Duplexing, 1

- How transmission (TX) and reception (RX) events are multiplexed together
- Time Division Duplexing (TDD)
  - Alternate TX and RX at different times on the same frequency band
- Frequency Division Duplexing
  - TX and RX happen in two different bands
Duplexing, 2

TDD is simpler, but
- Requires a level of synchronization
- Introduces additional overhead (switching between TX and RX)

FDD requires
- Additional hardware
- More complex frequency management
Wireless Issues

- Architecture, communication model and duplexing define the framework where wireless MAC (wMAC) protocols are defined.
- wMAC protocol design must take into accounts the unique characteristics of the wireless medium.
Boundaries and Interference

- Due to physical layer problems
  - No definite boundaries for radio waves
  - \(\rightarrow\) higher Bit Error Rate (BER)
  - Asymmetric channel qualities
- Concept of “neighbors:” nodes within each other transmission range: Only neighbors detects the carrier on the channel
- Attenuation of signal strength depending on node distance
Hidden Terminal Problem

- A hidden node is in the range of the receiver and not in the range of the transmitter.
- Node C is hidden to node A: Collisions limit the channel efficiency.
Exposed Terminal Problem

- An exposed node is in the range of the transmitter and not in the range of the receiver.
- Node C is exposed to node A: C can be denied access till A is done → bandwidth is under-utilized.
Propagation Delay et Al.

- Time needed for the transmitted packet to reach the receiver
  - Affect carrier sensing-based protocols
  - Affect slot size → Additional overhead
- **Half duplexing**: A node can either be in TX or in RX mode at a time
  - Collision detection is more involved
  - Hardware switching time becomes significant
Assignments

- Wireless MAC handout, to page vii
- Updated information on the class web page:
  www.ece.neu.edu/courses/eceg364/2004sp