G 364: Mobile and Wireless Networking

CLASS 1

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M-W, 11:40am-1:20pm, 109 Rob

Aims of the Class

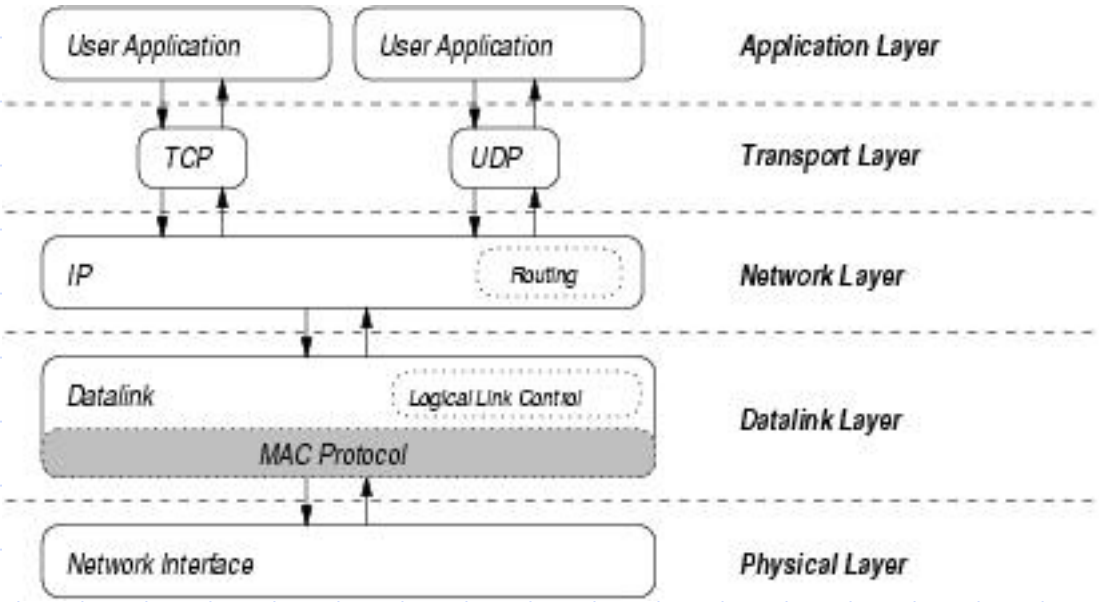
- Introduction to the two main wireless architectures:
  - Ad hoc (all-mobile) networks
  - Cellular networks
- Techniques and protocols
- Fundamental problems and solutions
- Some enabling technologies

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

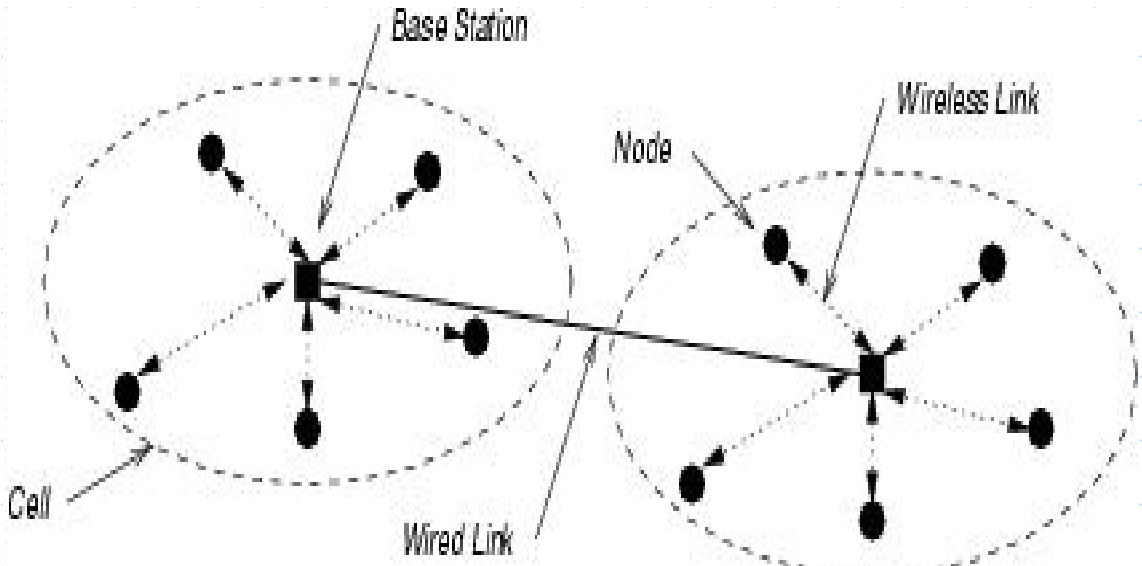
Network Architecture

- 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

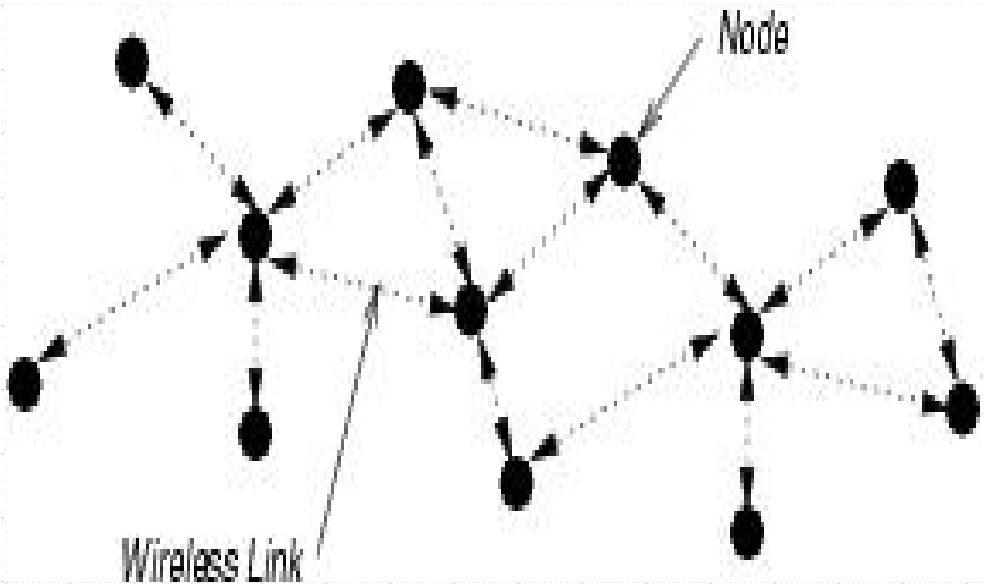
- Downlink = unshared channel from BS to MH
- Uplink = channel from MH to BS shared by hall MHs in a BS cell
- Asymmetry: BS counts more than the MH
  - Leads to a simplified design of the MH
  - Leads to a simplified design of network protocols (MAC, routing, …)
- Problems: Deployment, single point 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 if 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

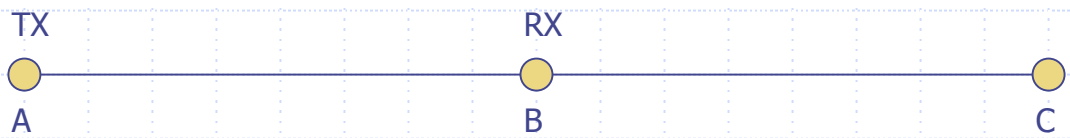
- Architecture, communication model and duplexing define the framework where wireless MAC (wMAC) protocols are defined
- wMAC protocol design must take into accounts the unique characteristics of the wireless medium

Boundaries and Interference

- Due to physical layer problems
  - No definite boundaries for radio waves
  - → 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

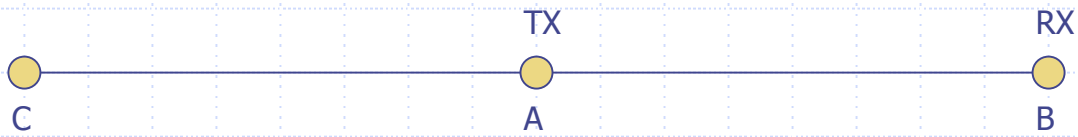
Hidden Terminal Problem

- 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