What is the target of MAC

- Find a schedule for node transmission that maximizes concurrency/throughput
  - Concurrency in correct reception; concurrency in transmission is easy :-)
  - Eliminate (or minimize) collisions
  - Additional requirements: fairness, minimize power, honor QoS guarantees
- Collisions
  - Overlap of two or more transmissions on the same channel, at the same time at a receiver (overlap in time, space and channel)
  - Recall that signal power decays with distance

Complicating Factors

- Collision detection is not possible due to the power differential between transmitted and received signals
- Carrier sense (CSMA) is not very useful
  - Sensed transmission is at the sender, but need it at the receiver
- Errors are frequent:
  - need FEC, and/or ARQ
  - In any case, errors play an important role in determining MAC performance

General Tradeoffs in MAC Design

- Wireless MAC complicated by connectivity pattern
  - reachability is a function of location and transmission power
- Contention based or reservation based
  - Contention: access without coordination, hope it works – may have collisions
  - Reservation: nodes agree apriori on an order for transmission
- Centralized vs. distributed
- Single channel vs. multiple channel
- Several other considerations...

Today – MAC

- Recall: Medium Access Protocol are needed to arbitrate access to a shared channel
- How is the use of the available bandwidth arbitrated?
- Statically Create Channels (e.g., TDMA, FDMA, CDMA?)
  - In any of the channelization techniques, how do you coordinate between the nodes such that there are no conflicts?
    - Who assigns channels? How do transmitters and receivers find each other?
- The problem is difficult, and has different solutions depending on whether the network is cellular, last hop data network or ad hoc network
Cellular Networks

- Base stations carefully positioned to provide coverage of cells
  - “Can you hear me now?”
- Multiple channels used (FDMA/TDMA shifting to CDMA, OFDMA and hybrids), each capable of supporting a voice conversation
- Base stations are expensive units with complex circuitry
  - Capable of sending and receiving on multiple channels and manage call establishment and call optimization (e.g., power control, beacon channels, hand-off)
- Medium access is centralized: each base station controls channel assignment
- Is there an available channel? New calls vs. roaming

Data Networks

- Recall: last hop vs. ad hoc networks
- Last Hop look like cellular networks; can the base station simply regulate access in the same way?
  - Data traffic is different from voice traffic
    * Bursty (and self-similar)
    * Number of mobiles may be small
  - Access points are much simpler and cheaper
    * cannot listen and transmit on multiple channels concurrently
    * Not managed centrally
- Does it make sense to allocate channels?

Single Channel Abstraction

- Virtually all commercial data MAC protocols so far rely on a single channel with omni-directional antennas
  - Partly because of FCC restrictions
  - Partly because of hardware complexity and cost necessary for multiple channel operation or directional antennas
- IEEE 802.11N, SuperG (channel bonding) are exceptions
- So, we will discuss omni with one channel as the base case first
Centralized vs. distributed protocols

- Centralized: rely on the base station to arbitrate the medium
  - Example: IEEE 802.11 Point Control Function Access model
  - Reservation based

- Distributed protocols
  - Nodes contend for using the medium
  - Simple and suitable for ad hoc operation as well
  - Can have collisions

Ad Hoc Operation

- No Base Station to take care of us; solutions must be distributed
  - Reservation or contention?
- Complex interference pattern; connectivity is not uniform

Last hop mode

- Sign up with the basestation
- Mobility handled via hand-off to another basestation (soft vs. hard hand-off)
- Both centralized and distributed may be used
  - For centralized, collisions still possible among neighboring cells
    * separate into multiple channels; usually manually (complicates roaming?)
    * Typically no power control (it complicates things; we’ll see later)
- In practice, distributed mode is used even in last hop networks

Looking a little deeper

- Reception range: for a signal to be received, its power should be higher than reception threshold (function of the receiver circuitry)
- Signal does not magically "die off" when it reaches the reception limit; it continues to interfere with other receptions
- Capture: for a signal to be received with no collision, its signal power ratio to interfering transmissions (and noise) should be higher than a capture threshold
- Alternative view: SNIR defines Bit Error Rate

Centralized vs. distributed protocols
Ad Hoc Operation

- Initially, widespread agreement that it should be distributed/contention based
- Single channel as well
- Assumptions questioned later; some emerging TDMA/reservation and hybrid protocols
- How can access be arbitrated?
  - How about ALOHA?
  - Ethernet like? CSMA/CD?

Plan for Covering MAC

- Focus on contention based protocols
- Interleave discussion of "concepts" with coverage of important standards
  - Need a volunteer to present Bluetooth paper next class
  - I will cover Zigbee and UWB
- We’ll use a tutorial on Ad hoc MAC issues by Nitin Vaidya