**Data Link Layer + Wireless Networks**

* Ethernet
  + dominant, 10 Mbps -- 10 Gbps
  + Physical topology
    - Bus
      * collision domain
      * CSMA/CD
    - Star: active switch in centre
      * No sharing, no CSMA/CD
  + Connectionless: no handshaking
  + Unreliable: no ack
  + CSMA/CD with binary backoff
  + Frame structure
    - Peramle
    - Address (source and dest MAC)
    - Type
    - CRC
  + Many different Ethernet standards
* Ethernet switch
  + Link-layer device
  + Transparent: hosts are unaware of presence of switches
  + Plug-and-play, self-learning: switches do not need to be configured
* Switch: multiple simultaneous transmissions
  + Hosts have dedicated, direct connection to switch
  + Switches buffer packets
  + CSMA/CD, no collisions, full duplex
  + Switching: can transmit simultaneously, without collisions
* Switch forwarding table
  + Each switch has a switch table, each entry <host MAC, interface to reach host, time stamp>, like routing table
* Switch: self-learning
* Switch: frame filtering/forwarding
  + Record incoming link, MAC address of sending host
  + Index switch table using MAC destination address
  + Entry found/flood
* Switches vs routers
  + Both are store-and-forward
    - Router: network-layer devices
    - Switches: link-layer devices
  + Both have forwarding tables
    - Routers: compute tables using routing algorithms, IP addresses
    - Switches: learn forwarding table using flooding, learning, MAC addresses
* Wireless network
  + Wireless hosts: laptops, smartphone, run applications, may be stationary/mobile
  + Base station: typically connected to wired network, cell towers, 802.11 access point
  + Wireless link: typically used to connect mobiles to base station …
  + Infrastructure mode: base station connects mobiles into wired network, handoff
  + Ad hoc mode: no base stations
* Wireless link important differences from wired link
  + Decreased signal strength
  + Interference from other sources
  + Multipath propagation
* Host must associate with an AP
* 802.11
  + Passive scanning
    - APs: send beacon frames
    - H1: send request frame to selected AP
    - The AP: send response frame to H1
  + Active scanning
    - H1: broadcast probe request frame
    - APs: send probe response frame to H1
    - H1: send request frame to selected AP
    - The AP: send response frame to H1
* 802.11: CSMA, not CSMA/CD
* Multiple access: key points
  + No concept of a global collision
  + Collisions are at receiver, not sender
  + Goal of protocol: detect if receiver can hear sender
* 802.11 MAC Protocol: CSMA/CA
  + 802.11 sender
    - If sense channel idle for DIFS then transmit entire frame (no CD)
    - If sense channel busy then
      * Start random backoff time, timer counts down while channel idle, transmit when timer expires
      * If no ACK, increase random backoff interval, repeat
  + 802.11 receiver
    - If frame received OK
      * Return ACK after SIFS (ACK needed due to hidden terminal problem)
* Avoid data frame collisions completely using small reservation packets
  + Sender first transmits small RTS (request-to-send) packets to BS using CSMA
  + BS broadcasts CTS (clear-to-send) in response to RTS
  + CTS heard by all nodes
    - Sender transmits data frame
    - Other stations defer transmissions

