Link Layer: Wireless Media

Current Trend

• WLAN explosion (also called WiFi)
  → took most by surprise
• cellular telephony: 3G/4G
  → cellular providers, telcos, data in the same mix
  → all-in-one handheld: e.g., Apple iPhone
• self-organization by citizens for local access
  → free WiFi hot spots
• large-scale hot spots: coffee shops, airport lounges, trains, university/enterprise campuses, cities, etc.
  → part of everyday life
  → difficult to turn back clock
• boundary between local and wide area wireless blurring
  → cellular (long-distance) vs. WLAN (short-distance)
  → 802.16 (WiMax): designed to compete with cellular; different version WiBro (Korea)

• also very short distances ("wireless personal area networks")
  → bluetooth, UWB, Zigbee: in general, 802.15
  → 802.11n also in the mix (e.g., Apple TV)
  → 2.4 and 5 GHz spectra: very busy

Integral part of the Internet:
  → where it’s happening
Wireless Communication: Background

Use electromagnetic waves in wireless media (air/space) to transmit information.

→ NIC: also called air interface

• directed signal propagation: e.g., directed antenna or IR (infrared)

• undirected signal propagation: e.g., omni-directional antenna

→ mainly: microwaves (2–66 GHz)

→ focus: 2–10 GHz
Key differences with wired communication:

- increased exposure to interference and noise
  → lack of physical shielding

- inter-user interference cannot be localized at switch
  → cannot use buffering
  → problem for QoS (e.g., VoIP)

  → information is inherently exposed
  → bad for networking
  → bad for security
  → good for convenient access (trumps others)
signal propagation and variation is more complex
  \[\rightarrow\] attenuation (also in wired)
  \[\rightarrow\] refraction, absorption, reflection, diffraction
  \[\rightarrow\] multi-path fading
  \[\rightarrow\] mobility (extreme: bullet train)

Network bandwidth: polarized
  \[\rightarrow\] high and low bandwidth coexist
  \[\rightarrow\] e.g., 10 Gbps and 11 Mbps
  \[\rightarrow\] shrinking (e.g., 802.11n) but slowly
  \[\rightarrow\] speed mismatch: makes things challenging
  \[\rightarrow\] i.e., weakest link
Electromagnetic spectrum (logarithmic scale):

- **Radio Wave**: 9 kHz–300 GHz
- **Microwave**: 1 GHz–1 THz
- **Wireless**: concentration ~0.8 GHz–6 GHz
- **Optical fiber**: ~200 THz; 25 THz bandwidth
Miscellaneous spectrum allocations (U.S.):

→ FCC (Federal Communications Commission)

- AM Radio: 0.535 MHz–1.7 MHz
- FM Radio: 88 MHz–108 MHz
- TV: 174 MHz–216 MHz, 470 MHz–825 MHz
  → audio (FM), video (AM)
- GPS (Global Positioning System): 1.2276 GHz–1.57542 GHz
  → CDMA
  → 24 satellites (DoD), 10900 miles
  → navigation service: trilateration
• Cellular telephone: 824 MHz–849 MHz, 869 MHz–894 MHz
  → AMPS: FDM, analog
  → GSM: TDMA, digital
  → IS-95: CDMA, digital
• PCS: 1.85 GHz–1.99 GHz
  → CDMA, TDMA

E.g., quad-band phone
  → works at different frequency bands
  → loosely called: 800, 900, 1800, 1900 MHz
• WLAN: IEEE 802.11b 2.4 GHz–2.4835 GHz
  → CSMA/CA
  → same frequency range for 802.11g
• WLAN: Bluetooth 2.4 GHz–2.4835 GHz
• WLAN: IEEE 802.11a 5.725 GHz–5.850 GHz
• WiMax: IEEE 802.16 2 GHz–66 GHz
  → TDMA based
• Satellite: C-band 3.7 GHz–4.2 GHz (downlink), 5.925 GHz–6.425 GHz (uplink)
  → TDMA based

• Satellite: Ku-band 11.7 GHz–12.2 GHz (downlink), 14 GHz–14.5 GHz (uplink)

• Many other frequency bands
  → cf. FCC chart
  → www.ntia.doc.gov/osmhome/allochrt.pdf