Link Layer: Wireless Media

Current Trend

- WLAN explosion

  → took many by surprise (close to a decade now)

- cellular telephony: 3G/4G

  → cellular providers, telcos, data in the same mix

  → all-in-one handheld: e.g., iPhone, Android

  → special purpose handhelds: e.g., Kindle ebook, iPad tablet

- 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

- boundary between local and wide area wireless blurring
  - → cellular (long-distance) vs. WLAN (short-distance)
  - → 802.16 (WiMax): competition to cellular
  - → aiming at 4G speed: 1 Gbps
  - → cellular (900 MHz–2 GHz), 2.4 and 5 GHz spectra: very busy
  - → super WiFi (or WiFi 2.0): sub-900 MHz spectrum (old analog TV), esp. 700 MHz; next frontier?
  - → typical devices: multiple air interfaces

- very short distances (wireless personal or home area networks)
  - → bluetooth, UWB, Zigbee: in general, 802.15
  - → e.g., UWB (802.15.3): 3.1–10.6 GHz
  - → wireless USB: get rid of pesky wires!
  - → also 60 GHz wireless networks
  - → 802.11n in the mix (e.g., entertainment networks—Apple TV)
  - → RFID (radio frequency identification): passive RFID does not require power
  - → many applications: bus/train card, wireless epay/credit card, inventory control, etc.

Wireless networks: where it's happening

Technology perspective:

- Bad news: multiple unsettled/evolving technologies, chaotic landscape

  → can quickly get confusing

- Good news: wireless broadband technology

  → based on what we already covered

  → OFDM, FDMA/TDMA, CDMA, CSMA

What remains:

  ⟶ networking features unique to wireless

  ⟶ specific wireless technologies

Wireless Communication: Features

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

$\longrightarrow$ NIC: also called air interface

- directed signal propagation: e.g., directed antenna or IR (infrared)
- undirected signal propagation: e.g., omni-directional antenna

$\longrightarrow$ mainly: microwaves (2–66 GHz)

$\longrightarrow$ target range: 100 MHz–10 GHz, 60 GHz

Key differences with wired communication:

- increased exposure to interference and noise

  → lack of physical shielding

- inter-user interference cannot be localized at switch

  → Ethernet evolution to switch doesn't apply

  → can be problem for QoS (e.g., VoIP, IPTV)

  ⟶ information is inherently exposed

  ⟶ bad for networking

  ⟶ bad for security

  ⟶ wireless transmission: peculiar properties

But: good for convenient access

  ⟶ trumps other concerns

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

  → analog TV spectrum: VHF, UHF

  → audio (FM), video (AM)
- GPS (Global Positioning System): 1.2276–1.57542 GHz

  ⟶ CDMA

  ⟶ ∼30 satellites (DoD), 10900 miles

  ⟶ navigation service: trilateration

- Cellular telephone: 824–849 MHz, 869–894 MHz
  - → AMPS: FDM, analog
  - → GSM: TDMA, digital
  - → IS-95: CDMA, digital
  - → TDMA and CDMA phones don't interoperate
- Cellular PCS: 1.85–1.99 GHz
  - → CDMA, TDMA

Ex.: 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

  → 802.11g also uses OFDM: does it make sense?

- WLAN: Bluetooth 2.4–2.4835 GHz
- WLAN: IEEE 802.11a 5.725–5.850 GHz

  → same for 802.11n

- WiMax: IEEE 802.16 2–66 GHz

  → 2.3, 2.5, 3.5 Ghz,

  → OFDM and TDMA based

- RFID: 902–928 MHz (aka 915 MHz)

  → CDMA's spread spectrum 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