1.264 Lecture 22

Telecom: wireless technology

Long range: satellite

Metro range: cellular telephony

Short range: wireless LANs

Long-range wireless: satellite communications

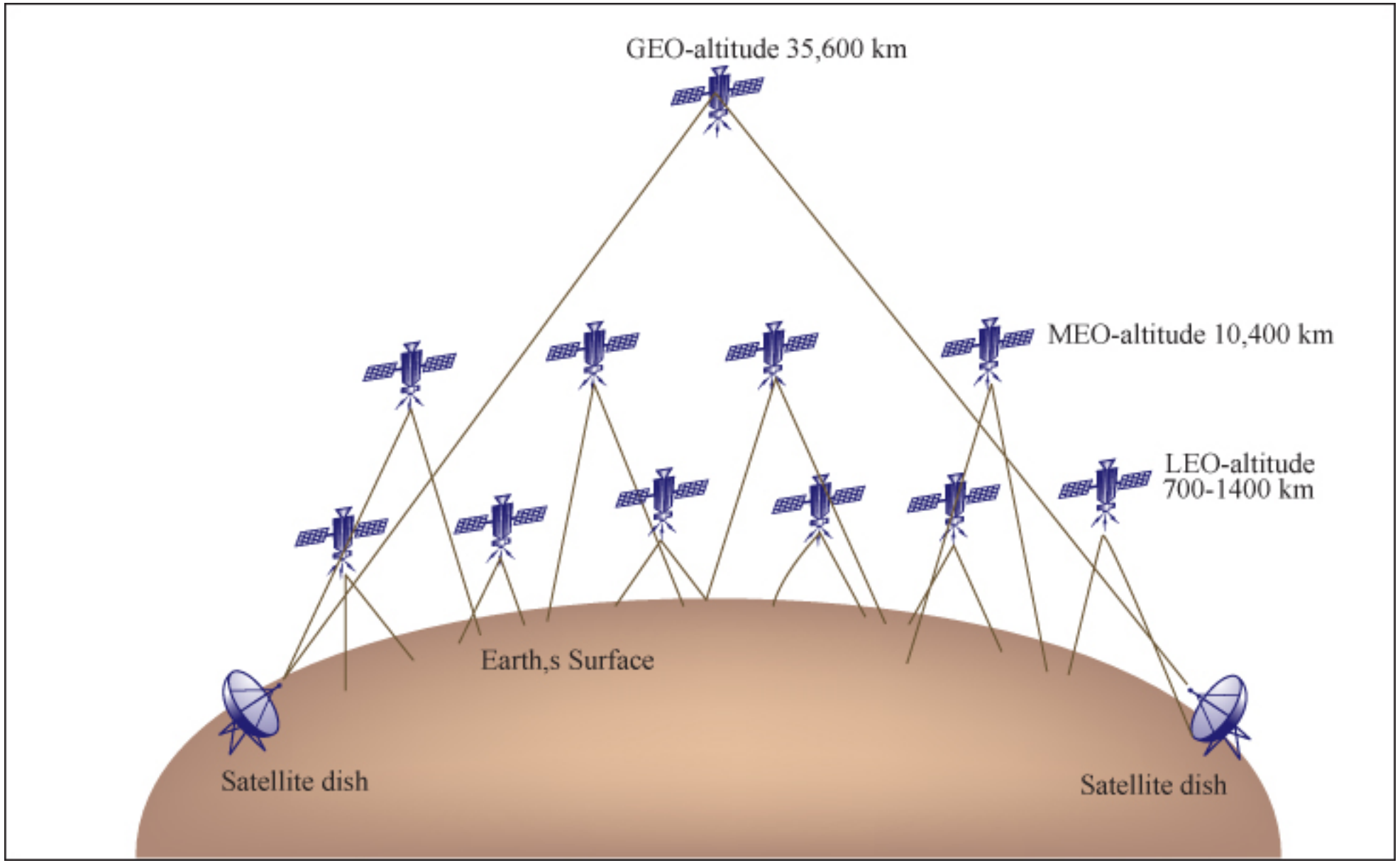


Figure by MIT OCW.

Satellite applications

- Not competition for mobile telephony
  - Iridium, Teldesic not successful: too expensive
- Global positioning system (GPS)
- Communications with ships at sea
  - Morse service ended last year for commercial vessels
- Trucking and rail information systems
- Direct broadcast TV
- Video programming (TV stations, CATV distribution)

Satellite links

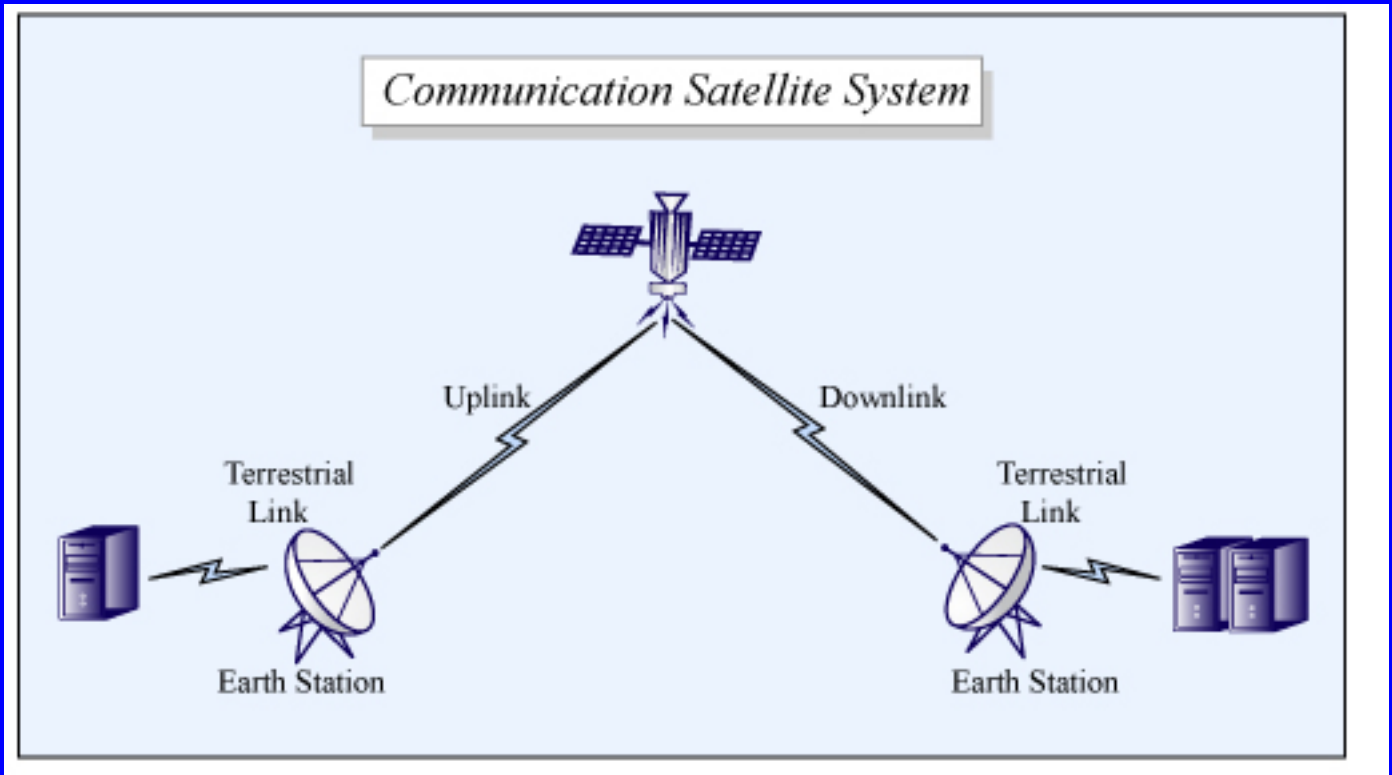


Figure by MIT OCW.

Satellite data

- Delay:
  - 250 milliseconds (1/4 second) delay between two Earth stations communicating via GEO satellite
  - Noticeable for voice communications
  - Requires special treatment of data
    - TCP/IP will assume network congestion or dropped packets with these delays; must use special parameters or equipment to spoof acknowledgements
- Rain absorption
- Sun transit outage at equinoxes
- Power is limited on satellite
  - Limited signal to noise ratio, limits bandwidth
  - DBS satellites are overpowered to allow small consumer antennas; overall system costs are high

Satellite services

- Voice, fax paging (Iridium) still available
  - 10 kbps Internet access data rate
- Inmarsat for marine applications
  - 300,000 ships, vehicles, aircraft
  - 432 kbps Internet access data rate
- Very small aperture terminal (VSAT)
  - Used for point of sales terminals in remote or rural areas
  - 9.6 kbps to 64 kbps typically

Metro-range wireless services

- Mobile telephony is dominant; alternatives are:
  - Specialized mobile radio (SMR), used primarily for local dispatch
    - About 3,000 licensed SMR providers in US (taxi, trucking..)
    - Nextel bought many SMR providers and created national network: radio, cell phone, data, messaging
    - Nextel uses variation on GSM cellular technology
  - Private mobile radio service (police, fire, railroads…)
    - Shared frequencies among all users
    - Base stations, repeaters; squelch or tone control
    - Trunking radio (multiple channels) used by larger organizations
      - One control channel to which all units listen
      - Talk channel then designated
  - These options use spectrum less well than cell phones

Mobile (cellular) telephony

- We cover US technology and practice (European GSM differs)
- A cell phone is a radio
- Before cell phones, there was mobile radio, with one tower per metro area and about 25 channels
  - Car phones had to be high powered but for little usage
- Cellular telephony divides a metro area into cells for much, much more capacity
- 832 channels in standard cellular radio spectrum band
  - Up to 5 more bands allocated via auction for new carriers in US
  - Both analog and digital telephony in use
  - Phone can operate on any of these 1,664+ channels
    - Dual- or tri- mode phones can operate digital or analog as well
- Cellular switches are called Mobile Telephone Switching Offices, or MTSOs
  - Functions same as standard switch, plus handoff across cells

Frequency reuse in cellular telephony

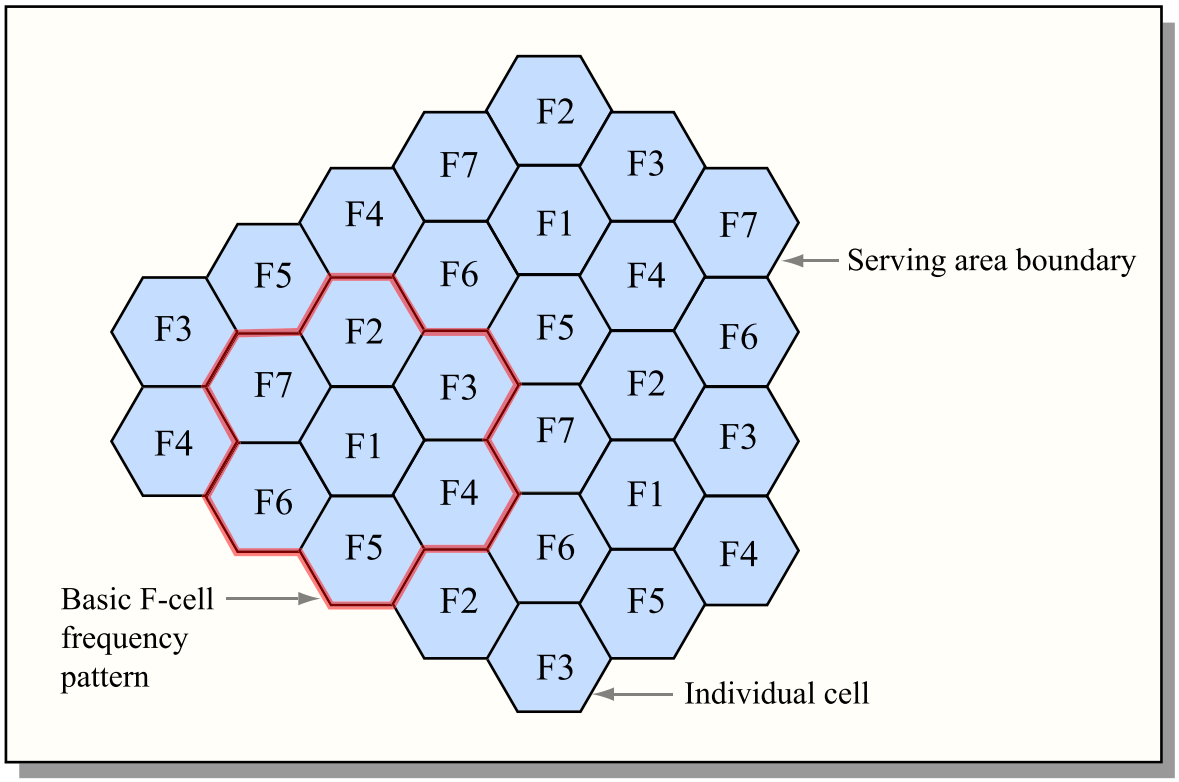


Figure by MIT OCW.

Each cell uses 1/7 of total channels= 119.

- **Analog calls take two channels: 60 max calls/cell**
- **Digital takes about 2/3 channel per call: 168 max calls/cell**

Cellular serving plan

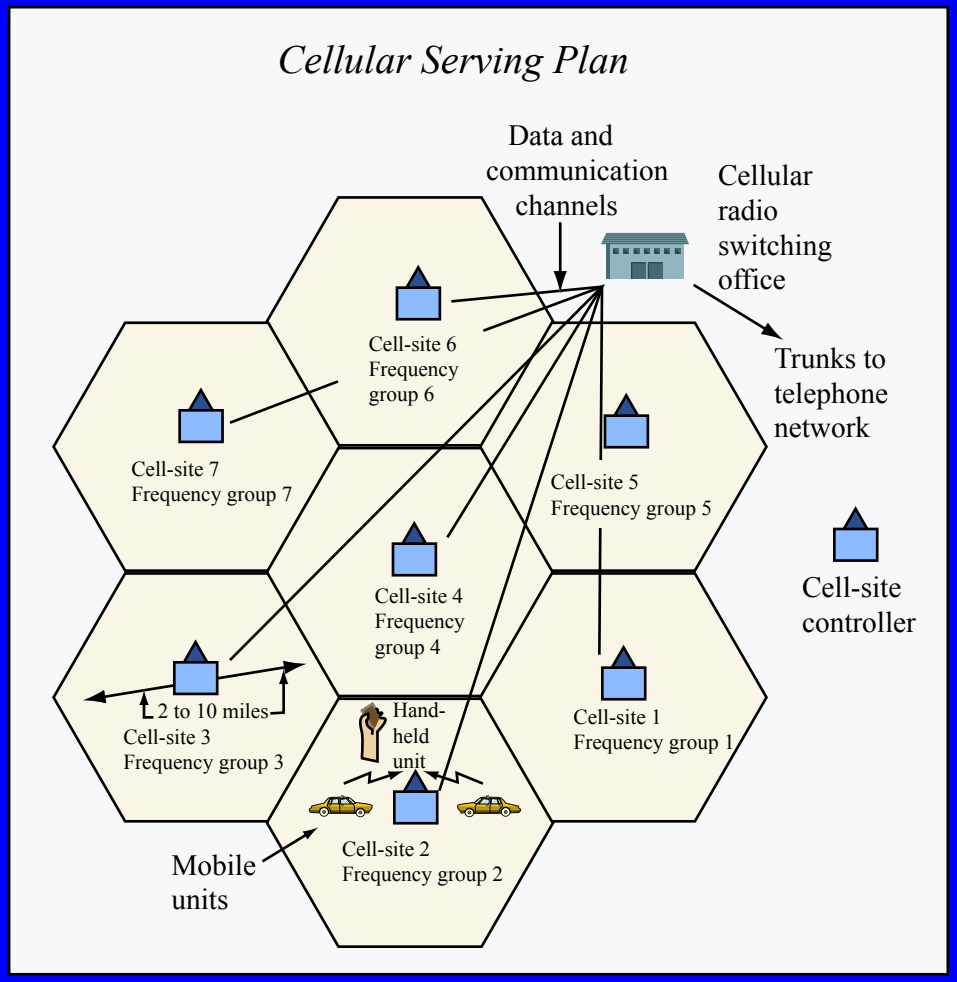


Figure by MIT OCW.

Simple honeycomb pattern rarely holds. Actual cell coverage highly variable.

Cellular operation issues

- Buildings often need amplifier or microcell
- Roaming
  - Expensive, awkward
- International compatibility
  - GSM market share is gaining is US, expected to approach 50%
  - US standard is CDMA, which appears to be falling behind in phones and features due to smaller scale
- Personal communication services (PCS)
  - Same technology as mobile telephony, but at a higher frequency

Cellular data

- First generation (1G) was analog
  - Still used in rural areas
  - Cellular modem needed, 9.6 kbps data rate
- Second generation (2G), current digital
  - Either modem or CPDP, 19.2 kbps data rate
- Third generation (3G), now being implemented
  - 2.5G available, data rate: 384 kbps fixed, 144 kbps mobile
  - 3G aims for 2 Mbps
    - UMTS and WCDMA standards in GSM phones
      - WCDMA initial offering data rate ~500 kbps
    - CDMA2000 1X EV-DO in CDMA (US) phones
      - 1X EV-DO provides 300-600 kbps, not 2 Mbps

Cellular data, cont

- Issues for cellular data rollout
  - Need more spectrum
  - Battery drain high on phone
  - Wireless application protocol (WAP)
    - Uses language similar to HTML called WML
    - Aimed at microbrowsers, small pages/files
    - Poorly implemented, services unreliable so far
    - Carriers, providers will probably need to move to full Web protocols (XHTML, XML, …)
  - Security
    - Varied, detailed issues in GSM, 1G, 2G, WAP…
  - Competition from WiFi, WiMax

Local area wireless services (LANs)

- **Motivations:**
  - **Improved mobility within campus or building**
  - **Reduced cost**
    - **Managing wiring: monitoring, moves/add/changes, repairs is expensive**
  - **802.11a/b/g WiFi technologies are prevalent**
    - **Effective within buildings**
    - **Unlikely to be effective metro area mesh: too many units required**
  - **802.16 WiMax technologies are being developed**
    - **Can serve metro areas; base units with 5-10km range**
  - **Multi-mode phones/devices are being developed**
    - **WiFi, cellular telephony/data, VoIP**

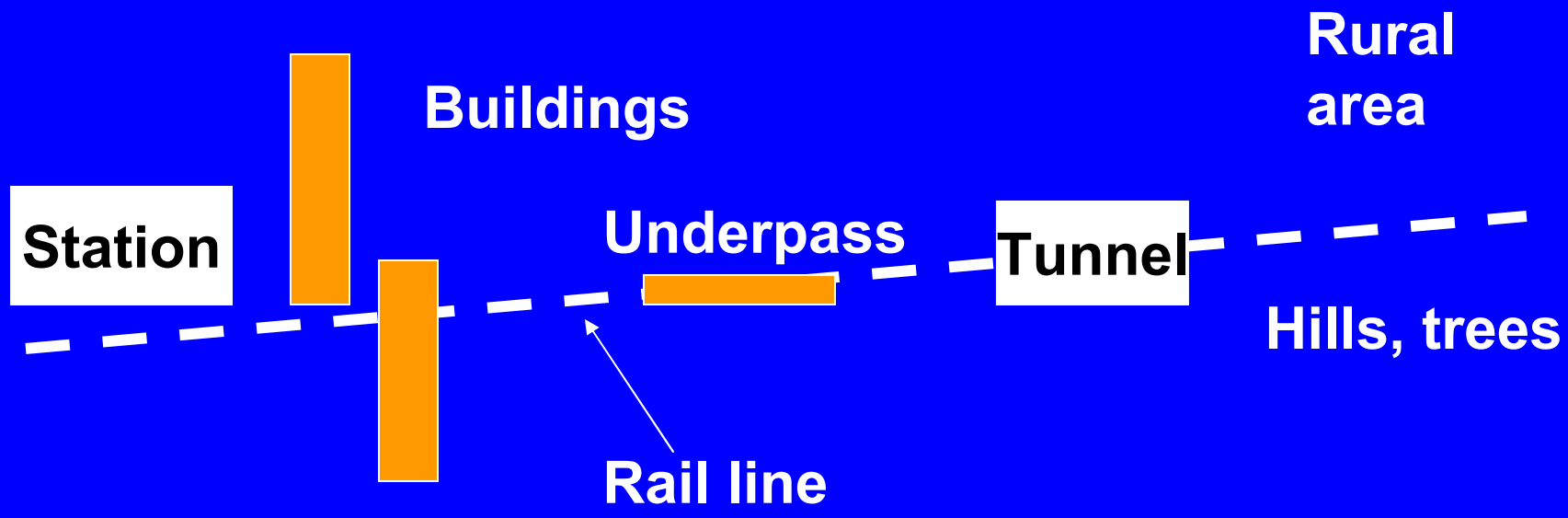
Wireless LAN issues

- 54 Mbps throughput rarely achieved
  - 60% utilization maximum (due to collisions, same as original Ethernet)
    - You saw this limit in 1.264 recitation
  - Walls, other impairments often reduce speed further
- Many organizations need more than 54 Mbps
  - Graphics, video, engineering collaboration, education…
- Security
  - Wired equivalent privacy (WEP) protocol fatally flawed
  - WiFi protected access (WPA) is short term fix
  - 802.11i (AES and other protocols) is long term fix
  - Corporate data is hard to secure against rogue APs, PCs,…
- Difficult to serve voice calls (VoIP) on wireless LAN
  - Excess delay due to packet collisions, packet loss, no QoS…

Exercise

- Design a system for an intercity rail passenger train to provide Internet access to its passengers and operating crew. Address each challenge:
  - Metro areas: frequent physical obstructions, such as underpasses, tall buildings
  - Tunnels
  - Rural areas: gaps in cellular coverage, trees, hills obstruct line of sight
  - Multiple applications: what to do when a user wants to download a 200MB file
  - Network changes: train goes through many networks of varying quality at varying speeds
  - Reception in passenger cars: metal car bodies affect signal

Exercise


Buildings
Rural area
Station
Underpass
Tunnel
Hills, trees
Rail line

Solution

- **Metro area:**
  - Cellular data and satellite services
  - Server on train chooses best signal, maintains continuity
- **Tunnels (short ones):**
  - Server on train caches Web content, handles email via store and forward
  - Long tunnels require leaky fiber and/or base stations
- **Rural areas:**
  - Cellular data and satellite services, same as metro area
- **Within train:**
  - Antennas mounted on multiple cars, wireless LAN between cars so any antenna can serve all cars
- **Applications:**
  - On train server manages traffic, ensures ‘fairness’
  - Server handles authentication and billing