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Lecture 2

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Chapter 1.2 - Network Edge

End systems, access networks, links.

A Closer Look

- A **network edge** are the *hosts* (both clients and servers) and *servers* in a network.
- An **access network** or **physical media** connects edges in a network. The connection could be either *wired* or *wireless*.
- The **network core** is a set of interconnected routers. It is essentially a *"network of networks"*. (?)
- The end systems are connected to edge routers via:
  - residential access networks
  - institutional networks (school, company, etc.)
  - mobile access networks (cellular data)
- **Bandwidth** is the data transfer rate, in *bits per second*, of a network.

Access Networks

Digital Subscriber Line (DSL)

- Connecting to the central office DSLAM using existing *telephone lines*.
- Voice and data are transmitted over the line at *different frequencies*. This technique is called **Frequency Division Multiplexing** (FDM).
- Transmission rates are *asymmetric* with:
  - $<$ 10 Mbps upstream transmission rate
  - $<$ 25 Mbps downstream transmission rate

Cable Network

- Data is transmitted through the television *cable lines*, using **hybrid fiber coax** (HFC), to the ISP router.
- FDM is, once again, used to transmit channels at different frequency bands.
- A home shares access network to a *cable headend*.
- Transmission rates are *asymmetric* with:
  - $<$ 5 Mbps upstream transmission rate
  - $<$ 30 mbps downstream transmission rate

Enterprise Access Networks (Ethernet)

- It is typically used in companies, universities, etc.
- End systems today usually connect into the Ethernet switch.
- Transmission rates could be: 10 Mbps, 100Mbps, 1Gbps, 10Gbps.

Wireless Access Networks

- A shared access network that wirelessly connects end systems to the router using an **access point**.
- **Wireless LAN** connects devices *within a building* (100 ft.) using 802.11 b/g/n WiFi.
  - Transmission rates could be: 11, 54, or 450 Mbps.
- **Wide-area wireless access** is provided by *cellular operators* (10s km) using 3G, 4G: LTE.
  - Transmission rates are between 1 - 10 Mbps.

Physical Media

- A **bit** propogates between transmitter/receiver pairs.
- A **physical link** is a connection between the transmitter and the receiver.
- In **guided media**, signals are propagated in solid media such as *copper, fiber, coax* in a guided path.
- In **unguided media**, signals are propagated freely, such as with *radio*.

Cables

- **Twisted pair** cabling is a type of wiring where two insulated copper wires are *twisted together*.
  - Category 5 cables transmit in 100Mbps, or 1Gbps Ethernet.
  - Category 6 cables transmit in 10Gbps.
- **Coxial cables** are two concentric copper conductors. Data can be transmitted in both directions. It is **broadband**, so the cable has *multiple channels*.
- **Fiber optic cables** carry *light pulses* through glass fiber. Each pulse represents a bit. It is very high speed (10s-100s Gbps transmission rate), with a low error rate.

Radio

- Signals are carried in *electromagnetic waves*, and could travel both ways.
- Transmission could be affected by the environment, such as from reflection, physical objects, or other electromagnetic waves.
- **Terrestrial microwave** transmits in up to 45 Mbps channels.
- **LAN** (ex. WiFi) transmits in up to 54 Mbps.
- **Wide-area** (ex. cellular data) transmits at various speeds. 4G cellular transmits at 10 Mbps.
- **Satellite** has Kbps - 45 Mbps channels. Transmissions have a 270 ms end delay.