COMPUTER NETWORKS

Computer Networks and the Internet

Team Networks

Department of Computer Science and Engineering

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Unit – 1 Computer Networks and the Internet

1.1 Introduction to Computer Networks
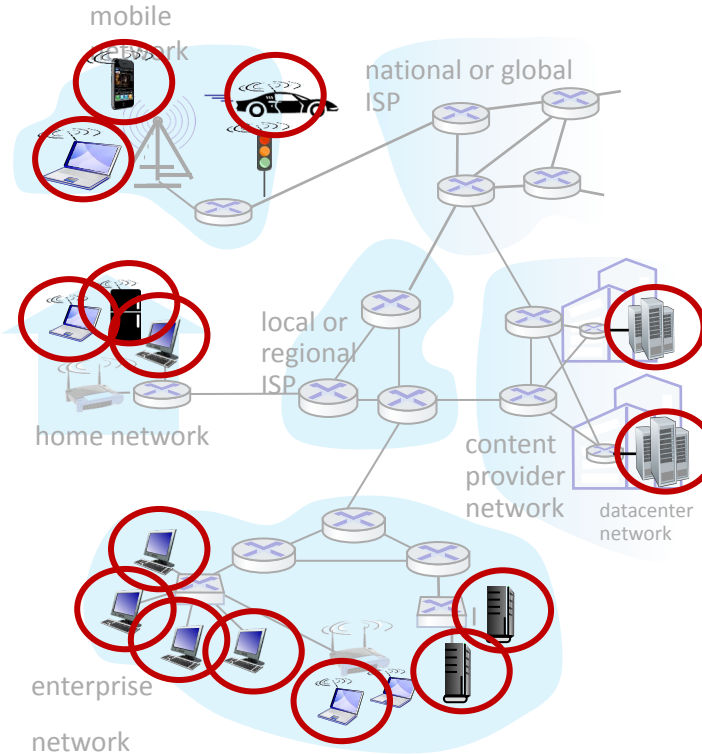
1.2 What is the Internet?

• A nuts-and-bolts and Services description, Protocol

1.3 Network edge

• End systems, Access networks, Physical media

Network Edge: A closer look at network structure

Network edge:

- Hosts: clients & servers
- Servers in data centers

Network Edge: A closer look at network structure

Network edge:

- Hosts: clients & servers
- Servers in data centers

Access networks, physical media:

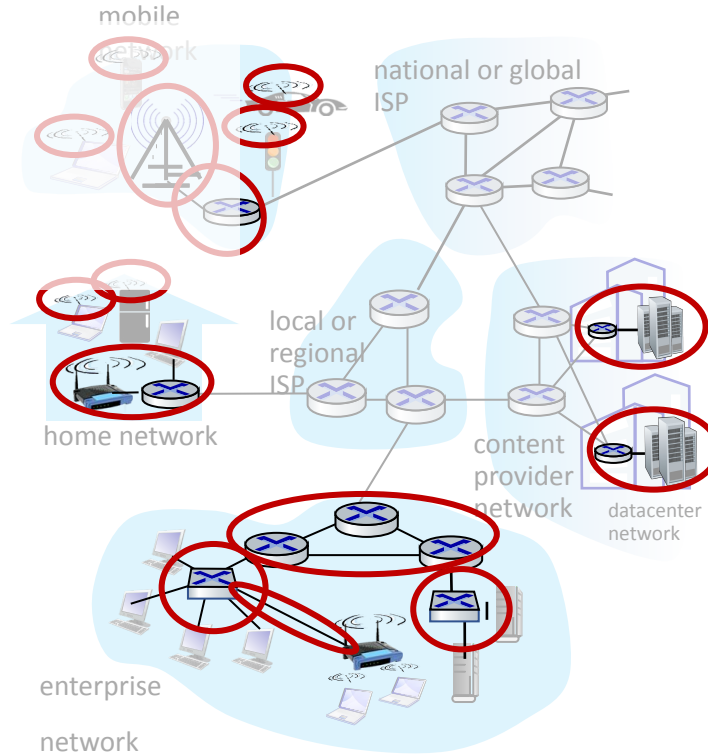- wired, wireless communication links

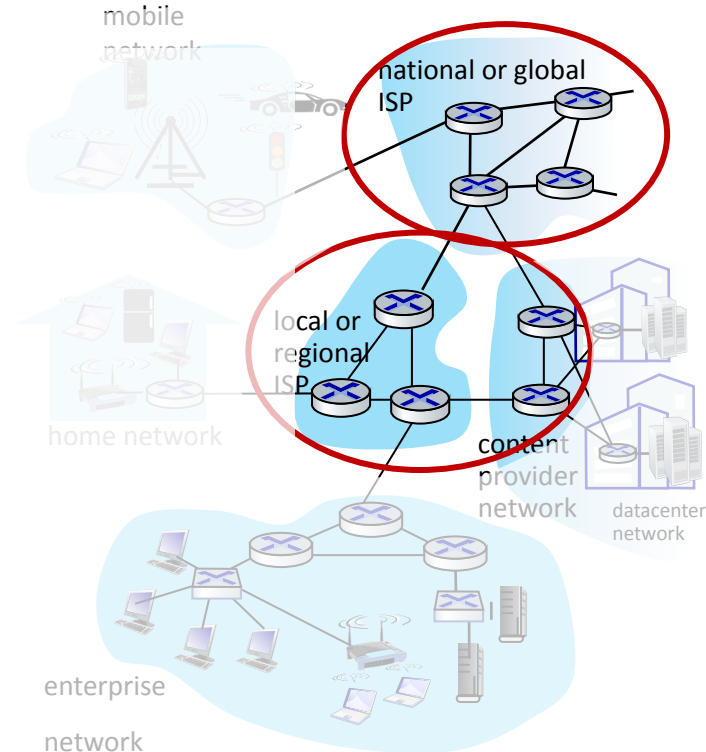## Network Edge: A closer look at network structure

Network edge:
- Hosts: clients and servers
- Servers in data centers

Access networks, physical media:
- wired, wireless communication links

Network core:
- interconnected routers
- network of networks

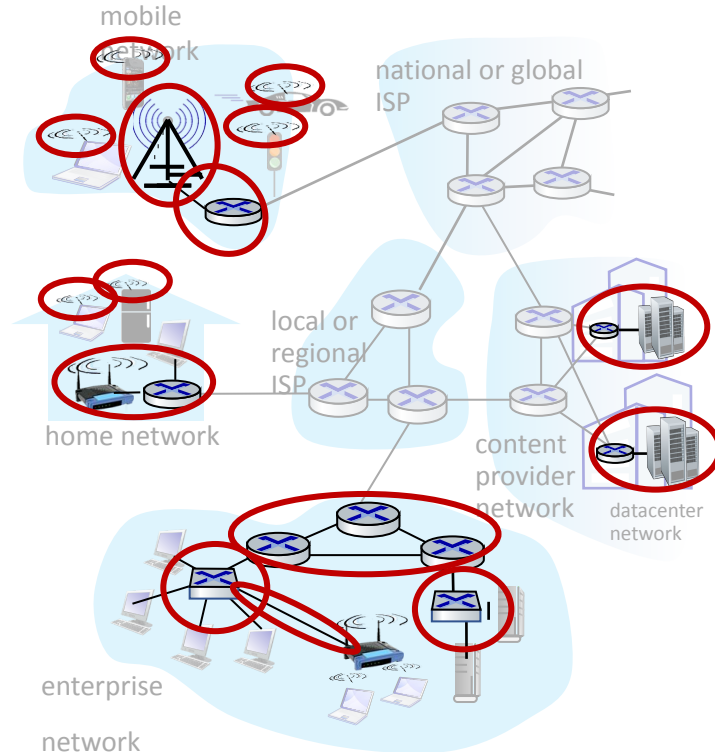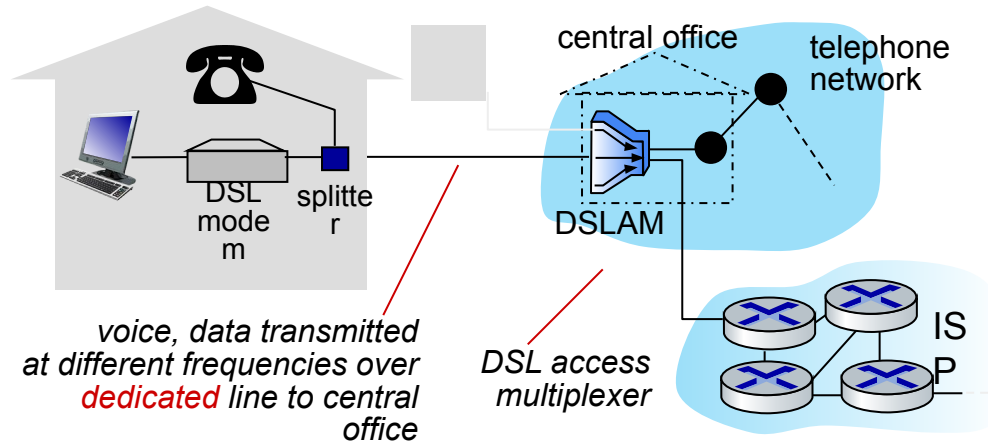## Network Edge: Access networks and Physical media

Q: How to connect end systems to edge router?

- Residential access networks
- Institutional access networks (school, company)
- Mobile access networks (WiFi, 4G/5G)

What to look for:

- Transmission rate (bits per second) of access network?
- Shared or dedicated access among users?

Network Edge: Access Networks - Digital Subscriber Line (DSL)

voice, data transmitted at different frequencies over dedicated line to central office
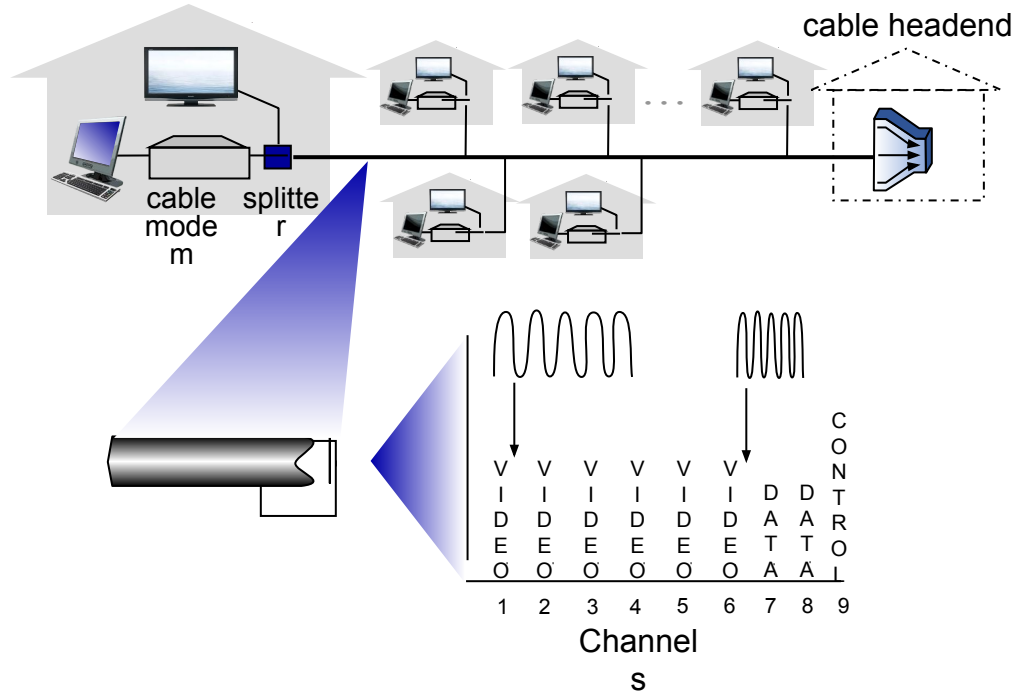
DSL access multiplexer

- 24-52 Mbps – downstream transmission rate
- 3.5-16 Mbps – upstream transmission rate
- Asymmetric access

- use *existing* telephone line to central office DSLAM
  - **data** over DSL phone line goes to Internet
  - **voice** over DSL phone line goes to telephone net
- A high-speed downstream channel, in the 50 kHz to 1 MHz band
- A medium-speed upstream channel, in the 4 kHz to 50 kHz band
- An ordinary two-way telephone channel, in the 0 to 4 kHz band

Network Edge: Access Networks: Cable-based access

cable headend

cable modem

splitter

V V V V V V D D C
I I I I I I A A O
D D D D D D T T N
E E E E E E A A T
O O O O O O R
O O O O O O O
1 2 3 4 5 6 7 8 9

Channels

Frequency division multiplexing (FDM): different channels transmitted in different frequency bands

Network Edge: Access Networks: Cable-based access

cable headend

cable modem termination system

CMTS

ISP

data, TV transmitted at different frequencies over *shared* cable distribution network
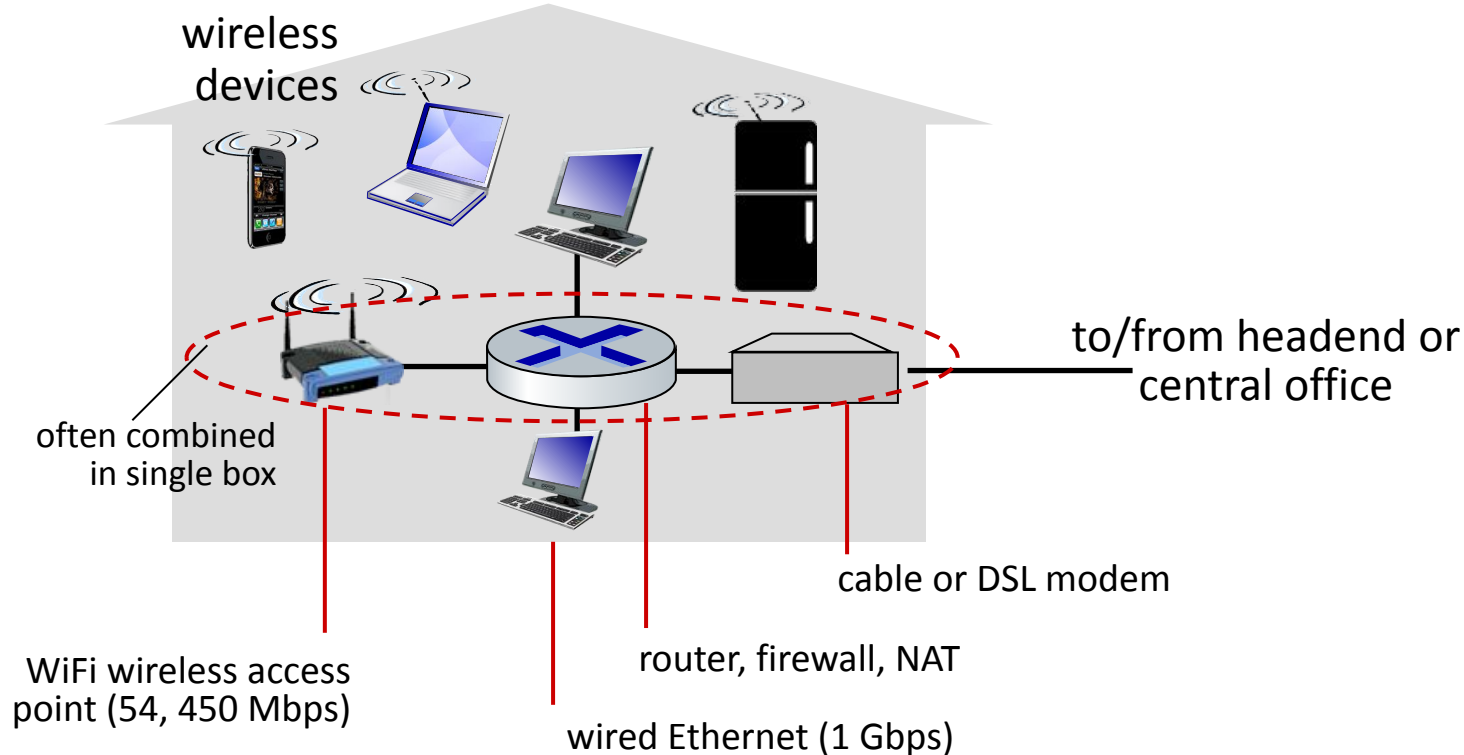
- HFC: hybrid fiber coax
  - Asymmetric:

    up to 40 Mbps – 1.2 Gbs downstream transmission rate,

    30-100 Mbps upstream transmission rate

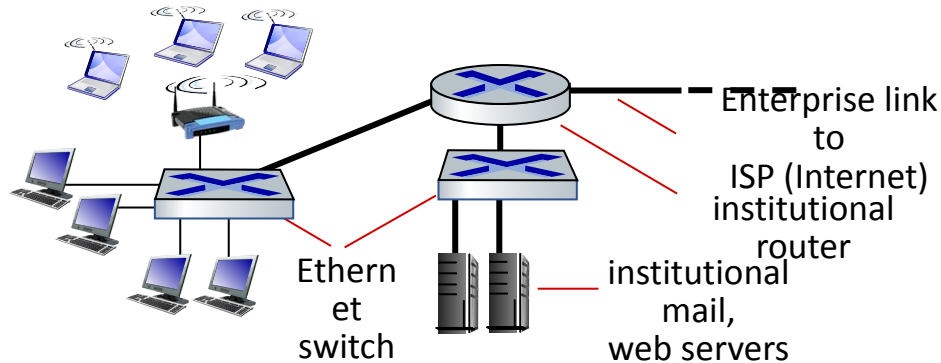- Network of cable, fiber attaches homes to ISP router
  - homes *share access network* to cable headend

Network Edge: Access Networks – Home access

wireless devices

often combined in single box

to/from headend or central office

cable or DSL modem

router, firewall, NAT

WiFi wireless access point (54, 450 Mbps)

wired Ethernet (1 Gbps)

Network Edge: Access Networks – Enterprise networks

Enterprise link to ISP (Internet)

institutional router

Ethernet switch

institutional mail, web servers

- companies, universities, etc.
- mix of wired, wireless link technologies, connecting a mix of switches and routers (we'll cover differences shortly)
    - Ethernet: wired access at 100Mbps, 1Gbps, 10Gbps
    - WiFi: wireless access points at 11, 54, 450 Mbps

Network Edge: Wireless Access Networks

Shared *wireless* access network connects end system to router

- via base station aka "access point"

Wireless local area networks (WLANs)

- typically within or around building (~100 ft)
- 802.11b/g/n (WiFi): 11, 54, 450 Mbps transmission rate
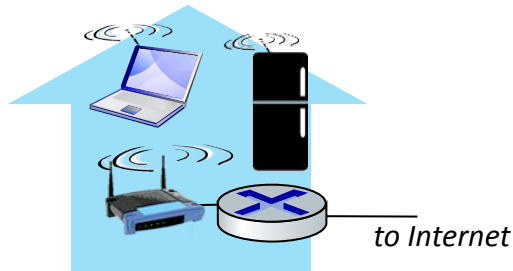
Wide-area cellular access networks

- provided by mobile, cellular network operator (10's km)
- 10's Mbps
- 4G cellular networks (5G coming)

to Internet

to Internet

Hosts: Send packets of data

Host sending function:

- takes application message

- breaks into smaller chunks, known as *packets*, of length *L* bits

- transmits packet into access network at *transmission rate R*
  - link transmission rate, aka link *capacity, aka link bandwidth*

two packets, *L* bits each

2 1

host

R: link transmission rate
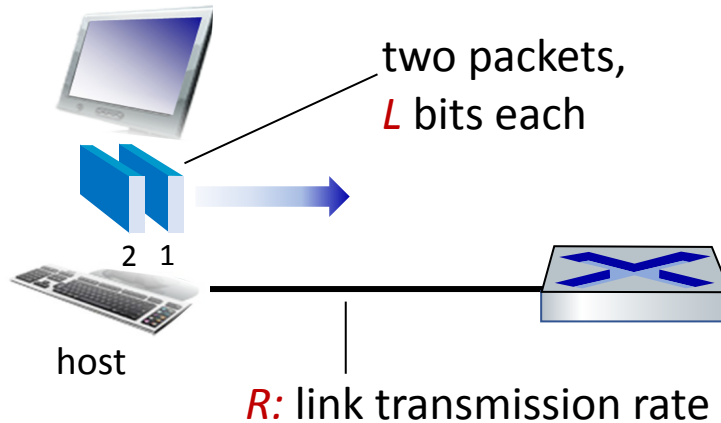
$$\text{packet transmission delay} = \text{time needed to transmit } L\text{-bit packet into link} = \frac{L \text{ (bits)}}{R \text{ (bits/sec)}}$$

Network Edge: Physical media

- **bit:** propagates between transmitter/receiver pairs

- **physical link:** what lies between transmitter & receiver

- **guided media:**
  - signals propagate in solid media: copper, fiber, coax

- **unguided media:**
 - signals propagate freely, e.g., radio

Twisted pair (TP)

- two insulated copper wires (STP & UTP)
  - Category 5: 100 Mbps, 1 Gbps Ethernet
  - Category 6: 10Gbps Ethernet

Network Edge: Physical media
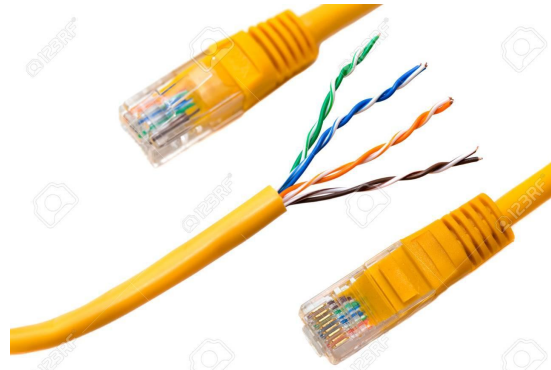
Coaxial cable:

- two concentric copper conductors

- concentric rather than parallel

- bidirectional

- broadband:
  - multiple frequency channels on cable
  - 100's Mbps per channel

Protective Plastic Cover
Inner Insulator
Braided Outer Conductor
Inner Conducting Core
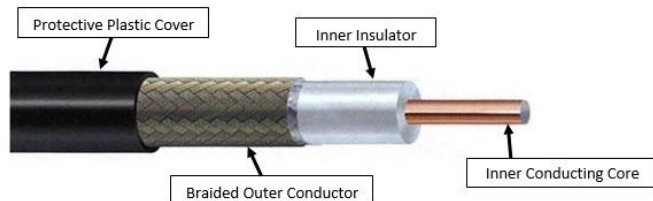
Fiber optic cable:

- glass fiber carrying light pulses, each pulse a bit

- high-speed operation:
  - high-speed point-to-point transmission (10's-100's Gbps)

- low error rate:
  - repeaters spaced far apart
 - immune to electromagnetic noise

Network Edge: Physical media
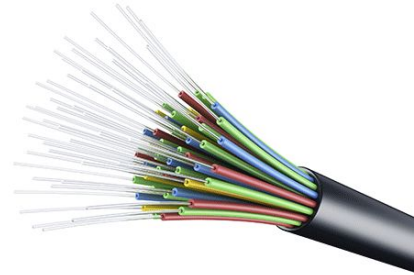
Wireless radio

- signal carried in electromagnetic spectrum

- no physical "wire"

- broadcast and "half-duplex" (sender to receiver)

- propagation environment effects:
  - reflection
  - obstruction by objects
  - interference

Radio link types:

- terrestrial microwave
  - up to 45 Mbps channels
- Wireless LAN (WiFi)
  - Up to 100's Mbps
- wide-area (e.g., cellular)
  - 4G cellular: ~ 10's Mbps
- satellite
  - up to 45 Mbps per channel
  - 280 msec end-end delay
  - geosynchronous vs. low-earth-orbit

Terrestrial Microwave

Earth

Satellite Microwave

Transmitting station on earth

Receiving station on earth
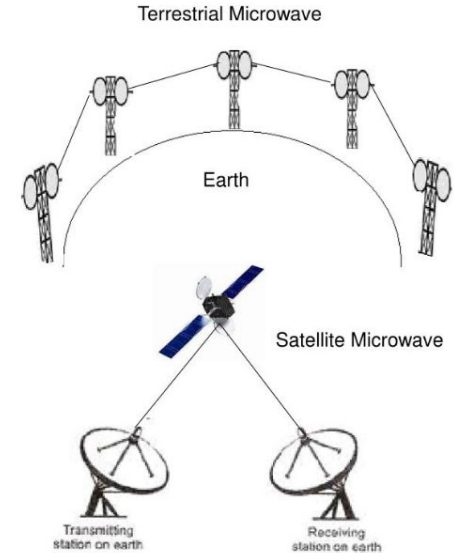
THANK YOU

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