CS 3800: Computer Networks

Session 1: Introduction

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Outline of Lecture

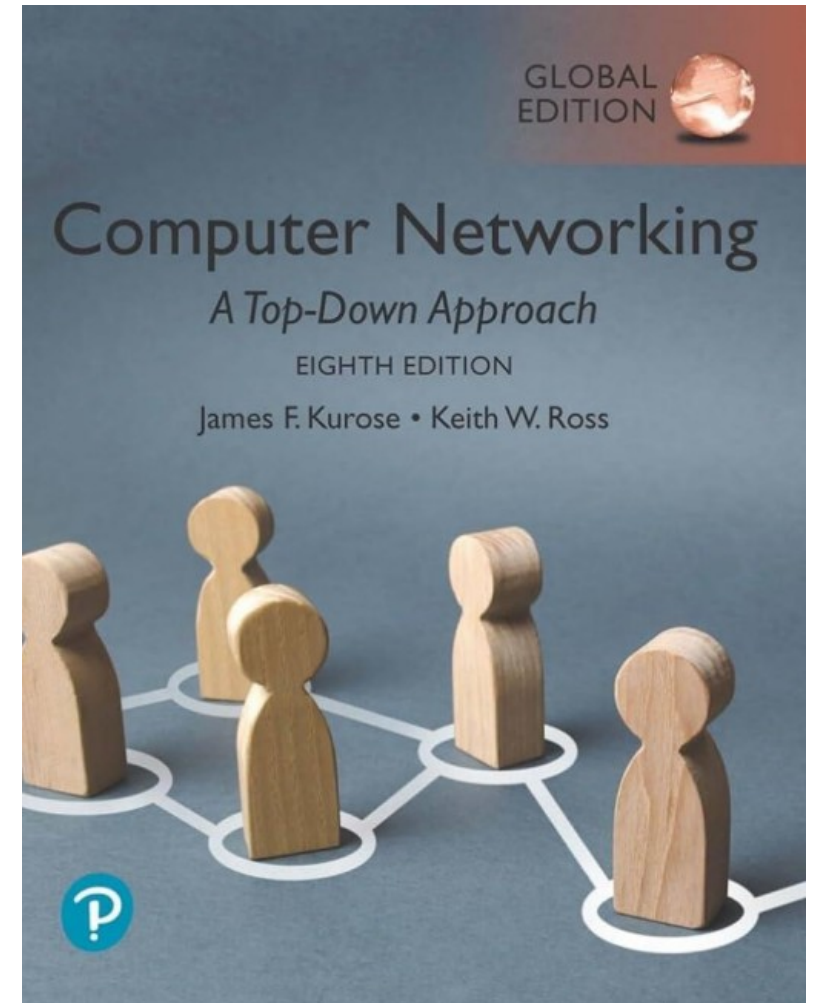- **Course Information**
- Introduction

Course Information

- Topics:
  - Number representation, integer arithmetic. von Neumann machine. Instruction set architecture. Addressing modes. Assembly programming. Arrays and records. Subroutines and macros. Interrupts. I/O interfacing and communication

- Prerequisites:
  - C or better in CS 130 or CS 1300 and CS 141 or CS 1400.

Course Information (Cont'd)

- Learning outcomes (at minimum):
  - Understand the network architecture design process
  - Understand the prominent protocols at various levels in layered protocol design
  - Become familiar with recent computer network technologies

Course Information (Cont'd)

- Textbook
  - Computer Networking A Top-Down Approach, 8th Edition, by James F Kurose & Keith W. Ross

Course Information (Cont'd)

- Technical Requirements
  - Computer with virtualization support
  - Virtual box, VMware, etc.
  - Python

Course Information (Cont'd)

- Course will roughly cover topics as ordered in the text book
- Likely won't take all semester to get through these topics
  - Extra topics added depending on pace of the class

Course Information (Cont'd)

- Canvas
  - Syllabus
  - Class Notes
    - Slides posted day of class
  - Assignments
    - Posted after class
    - Pay attention to due dates
  - Posting grades
  - Class emails

Course Information (Cont'd)

- Grading Policy:
  - Attendance/Participation: 10%
  - Homework/Labs: 50%
  - Exams: 40% (2 midterms, 1 final, lowest score dropped)
- Final letter grades will be based on your overall score as follows (subject to change):
  - A ≥ 90
  - 90 > B+ ≥ 86
  - 86 > B ≥ 80
  - 80 > C+ ≥ 76
  - 76 > C ≥ 70
  - 70 > D+ ≥ 66
  - 66 > D ≥ 60
  - 60 > F

Course Information (Cont'd)

- Late Assignment Policy
  - All assignments are expected to be submitted by the specified deadline, but they will (usually) remain open for a week after the deadline)
- Honor Code
  - All assignments, unless explicitly specified, are to be your own work
  - Collaboration is permitted, so long as it is properly documented
  - Evidence of cheating, plagiarism, or unauthorized collaboration will result in a 0 grade for quiz/assignment/exam

Asynchronous class

- Mondays
  - Mostly lectures
  - Occasional collected in-class activities (you will know ahead of time)
  - Exams
- Wednesdays
  - Asynchronous labs
  - Pre-recorded lectures

How to do Well in This Class

- Attendance
  - Try to attend every class
  - Ask questions
- Notes
  - Take notes and review notes after class
- Homework
  - Get started early
  - Contact me if you encounter problems

How to Get Help?

- Ask questions in class or after class

- Attend office hours

- Email me
  - Put "CS3800" in the subject line
  - Send it from your .cpp account

- Class Discord (preferred method)
  - https://discord.gg/avh2KB4N
  - Note: If you direct message me about something important (like missing a class or making up an assignment), include your name!

Exams

- 3 exams (lowest score dropped)
  - You can skip the final if you do well on both midterms
- To be completed during class time
- All exams open-notes

Introductions

- Tell us about yourself,
  - Name/Year/Major
  - Something interesting about yourself
  - Expectation in this class
  - Optional: Any questions for me?

Outline of Lecture

- Course Information
- **Introduction**

Internet of Connected Devices

Amazon Echo

Internet refrigerator

IP picture frame

Pacemaker & Monitor

Tweet-a-watt: monitor energy use

bikes

Web-enabled toaster + weather forecaster

cars

Security Camera

Slingbox: remote control cable TV

AR devices

scooters

Internet phones

Gaming devices

sensorized, bed mattress

Fitbit

Others?

The Internet: A "Nuts and Bolts" View

Billions of connected computing *devices*:

- *hosts = end systems*
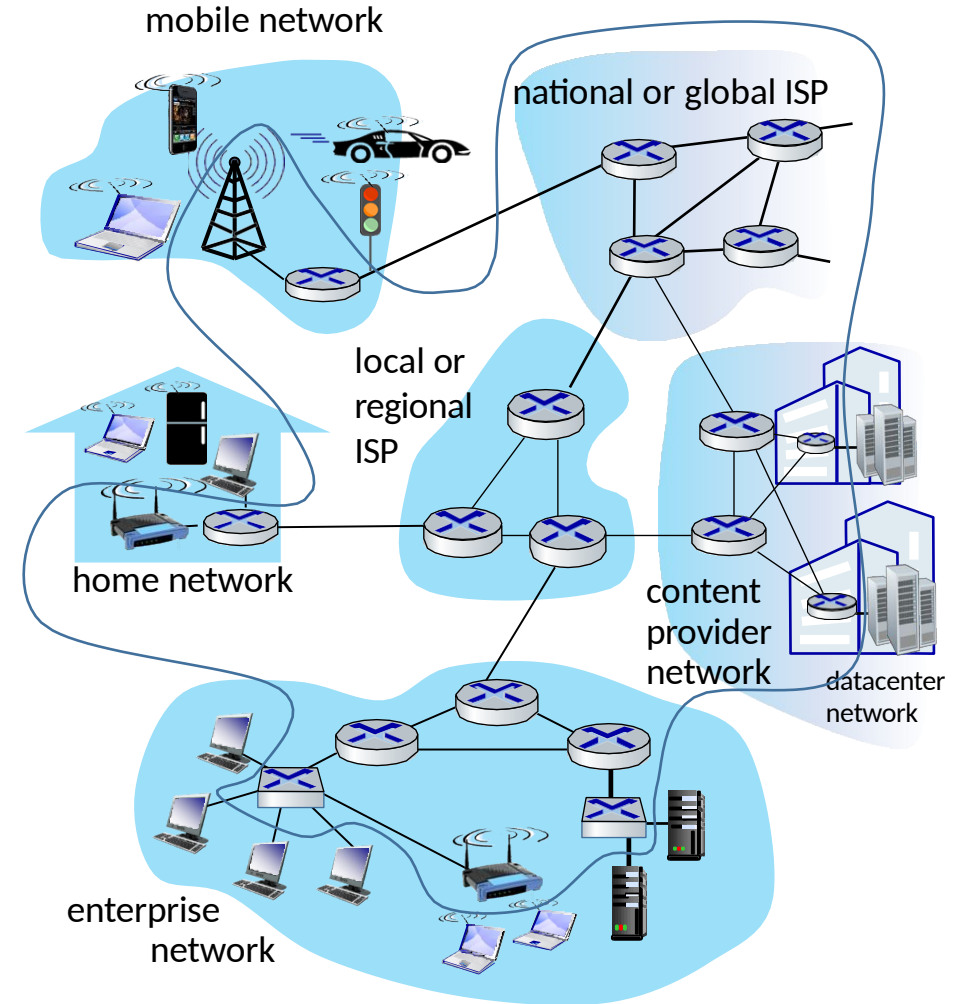- running *network apps* at Internet's "edge"

Communication links

- Optical fiber, copper wire, radio, satellite
- transmission rate: *bandwidth*

Packet switches: forward packets (chunks of data)

- *routers*, *link-layer switches*

mobile network

national or global ISP

local or regional ISP

home network

content provider network

datacenter network

enterprise network

The Internet: A "Nuts and Bolts" View

- ***Internet: "network of networks"***
  - Interconnected ISPs

- ***protocols*** are *everywhere*
  - control sending, receiving of messages
  - e.g., HTTP (Web), streaming video, Skype, TCP, IP, WiFi, 4/5G, Ethernet

- ***Internet   standards***
  - RFC: Request for Comments
  - IETF: Internet Engineering Task Force
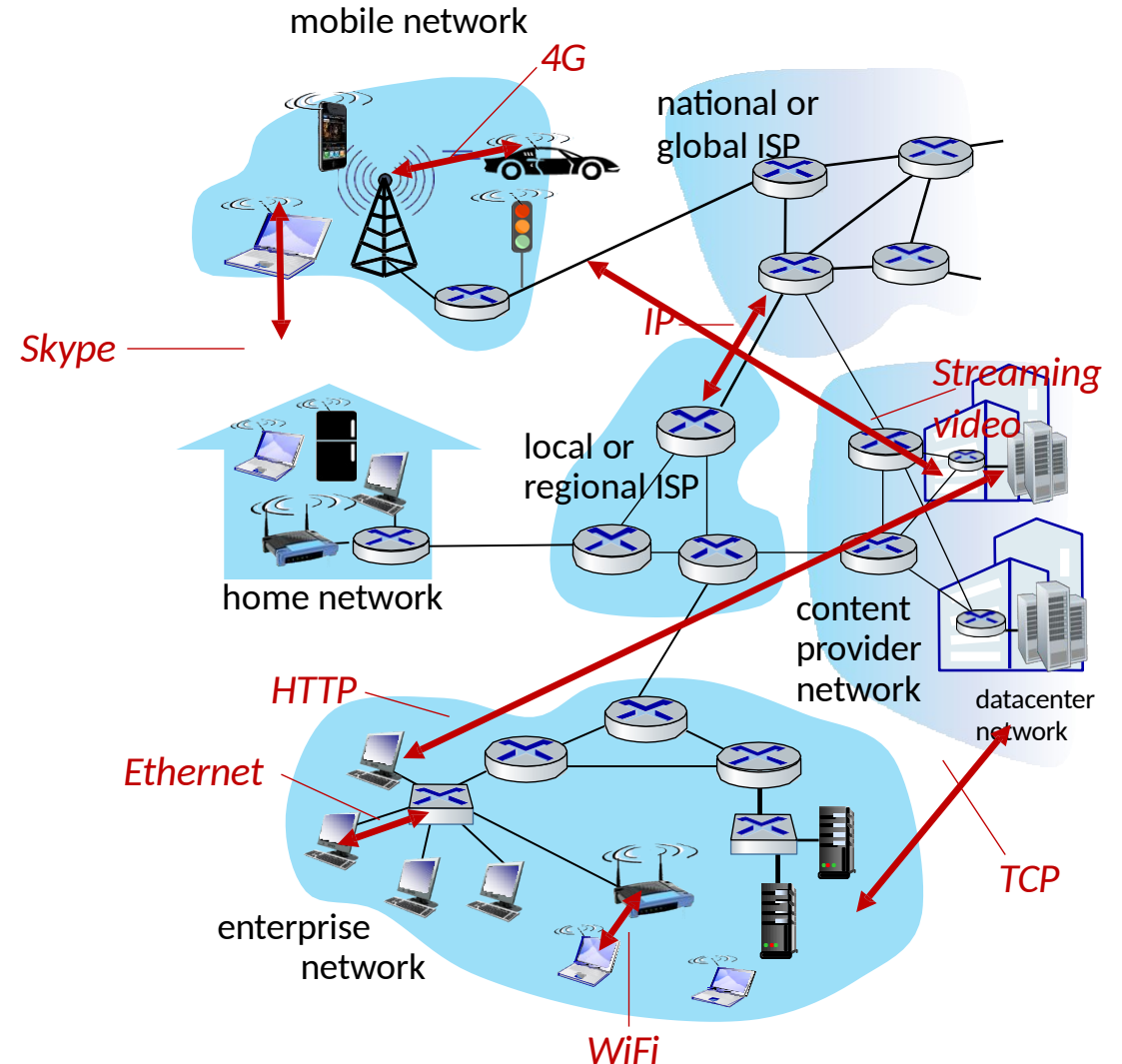
The Internet: A "Services" View

- *Infrastructure* that provides services to applications:
  - Web, streaming video, multimedia teleconferencing, email, games, e-commerce, social media, inter-connected appliances, …

- provides *programming interface* to distributed applications:
  - "hooks" allowing sending/receiving apps to "connect" to, use Internet transport service
  - provides service options, analogous to postal service
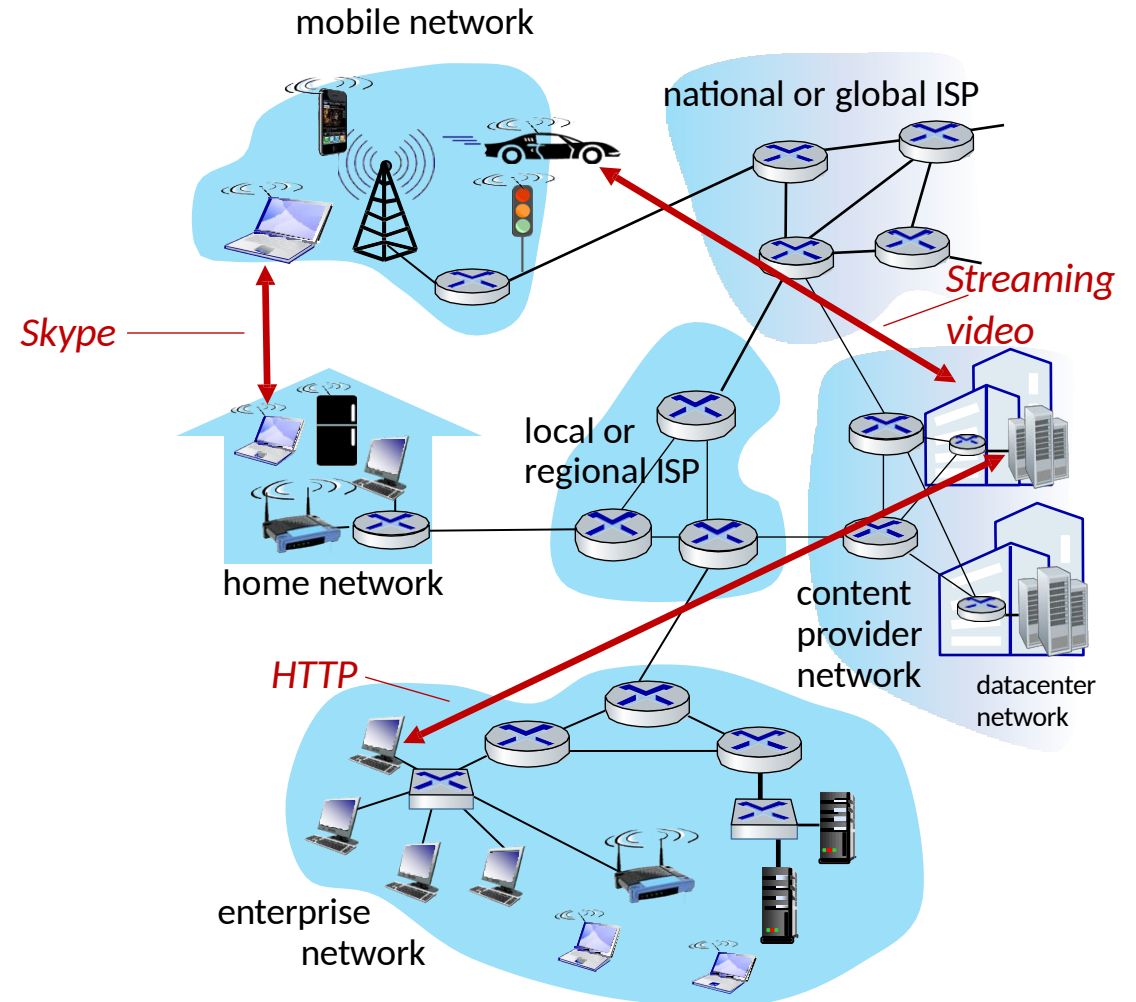
What is a Protocol?

Human protocols:

- "what's the time?"
- "I have a question"
- introductions

Rules for:
… specific messages sent
and
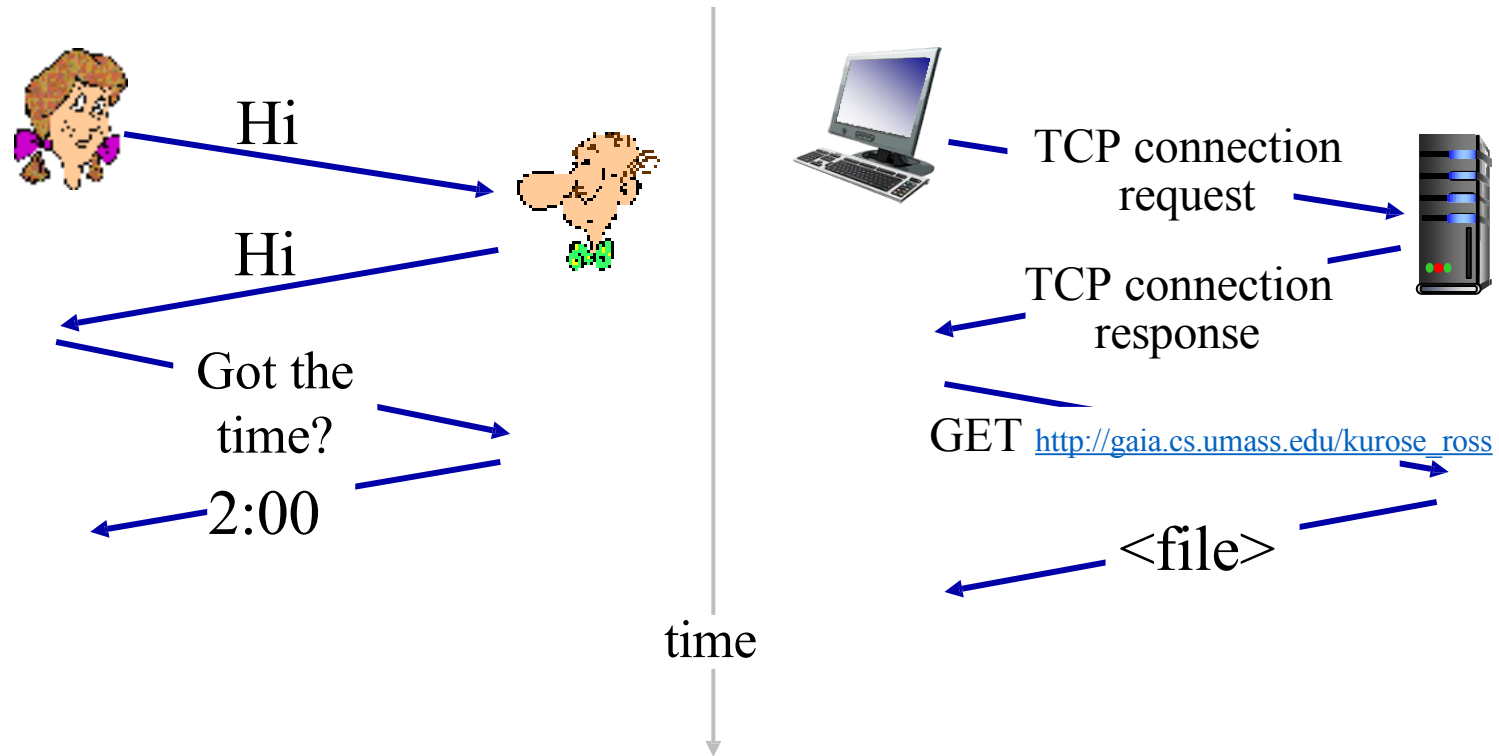… specific actions taken
when message received, or
other events

Network protocols:

- computers (devices) rather than humans
- all communication activity in Internet governed by protocols

Protocols define the format, order of messages sent and received among network entities, and actions taken on message transmission, receipt
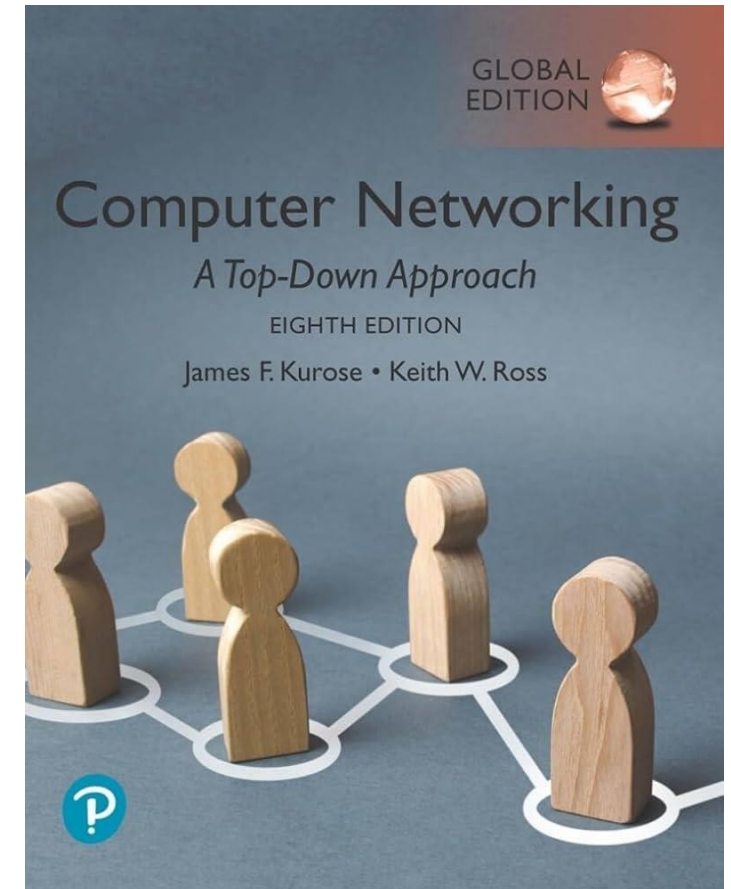
What is a Protocol?

A human protocol and a computer network protocol:

Hi

Hi

Got the time?

2:00

TCP connection request

TCP connection response

GET http://gaia.cs.umass.edu/kurose_ross

<file>
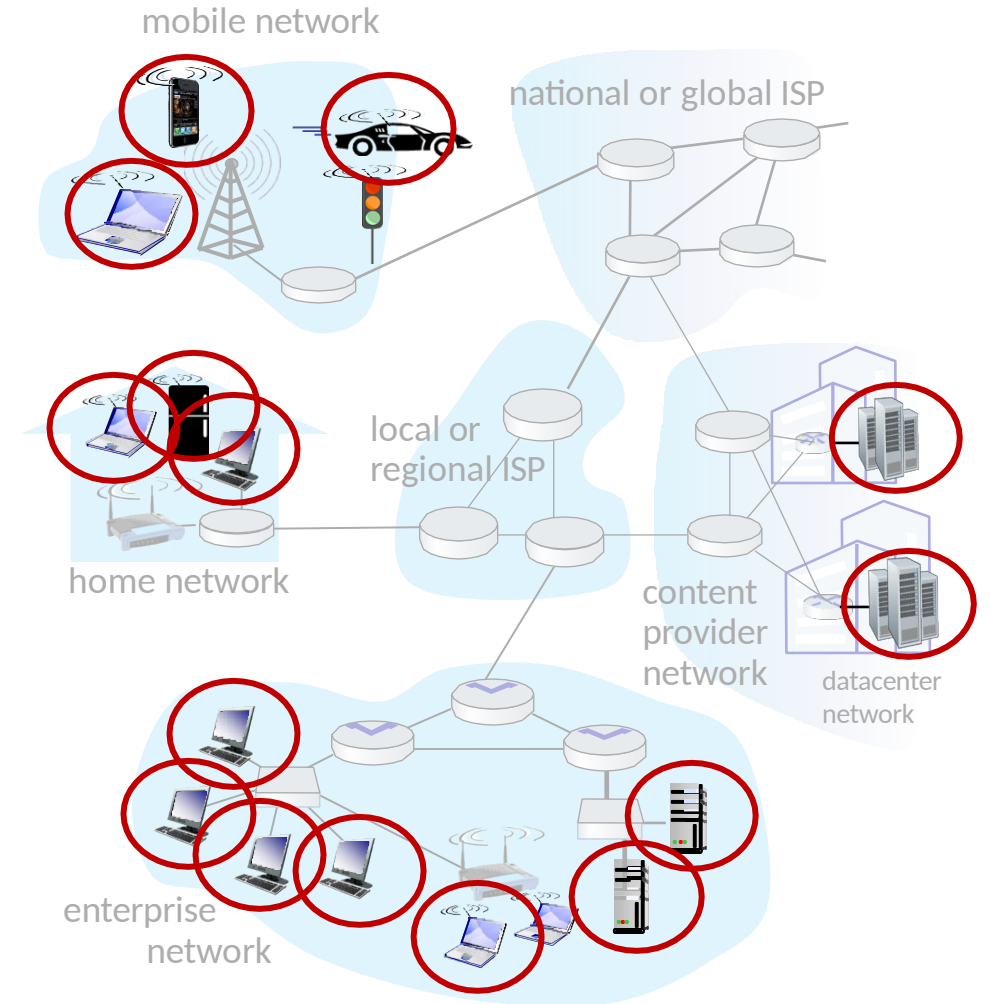
time

Next Session (also today):

- What *is* the Internet?
- What *is* a protocol?
- **Network edge:** hosts, access network, physical media
- **Network core:** packet/circuit switching, internet structure

A closer look at Internet Structure

Network edge:

- hosts: clients and servers
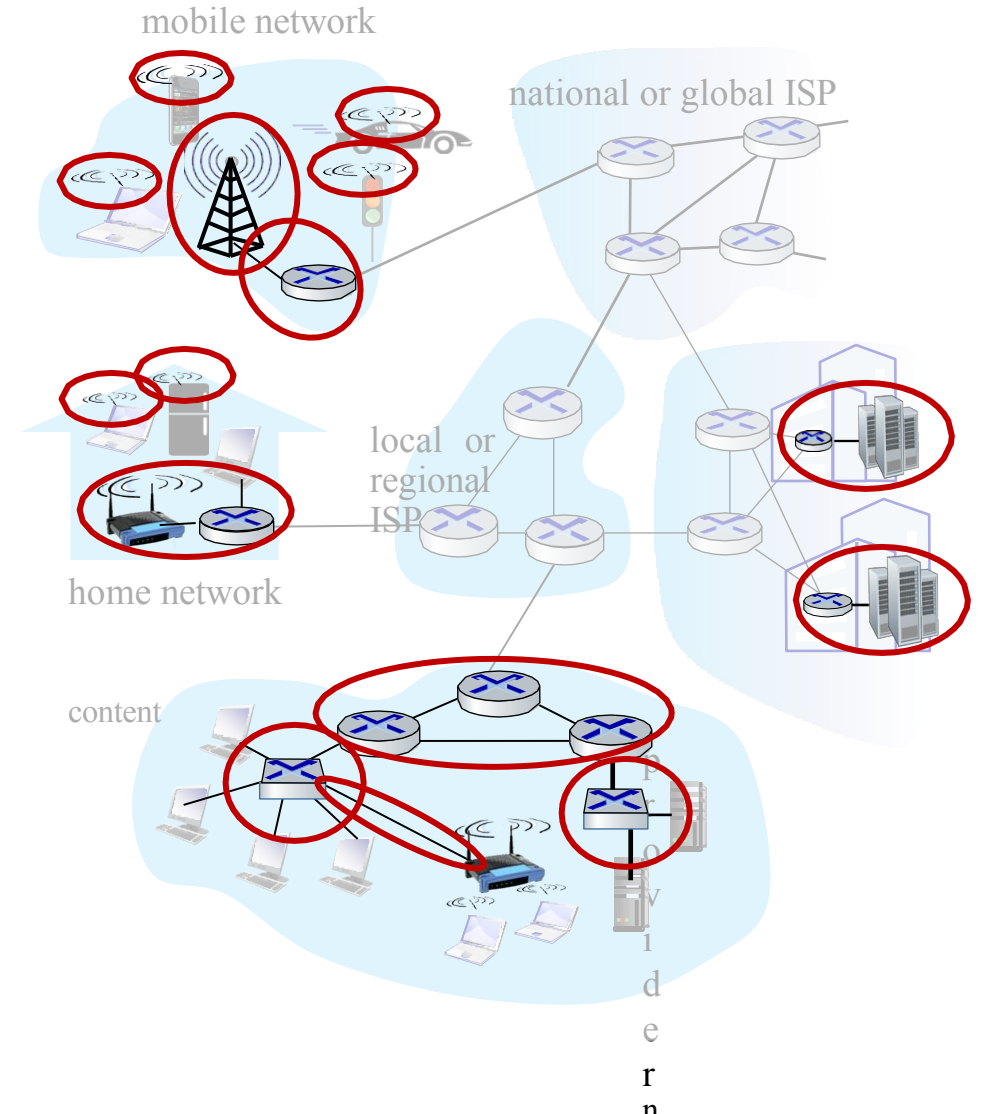- servers often in data centers

A closer look at Internet Structure

Network edge:

- hosts: clients and servers
- servers often in data centers

Access networks, physical media:

- wired, wireless communication links

mobile network

national or global ISP

local or regional ISP

home network

content

provider

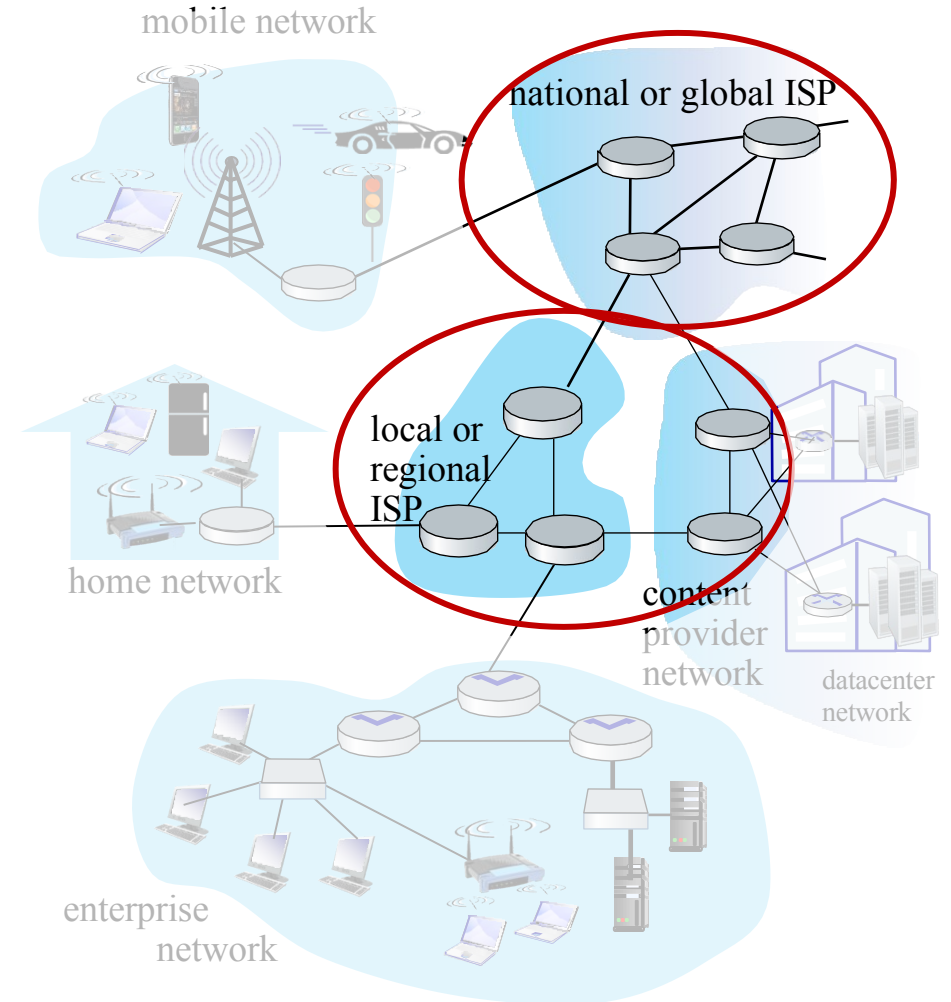# A closer look at Internet Structure

Network edge:
- hosts: clients and servers
- servers often in data centers

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

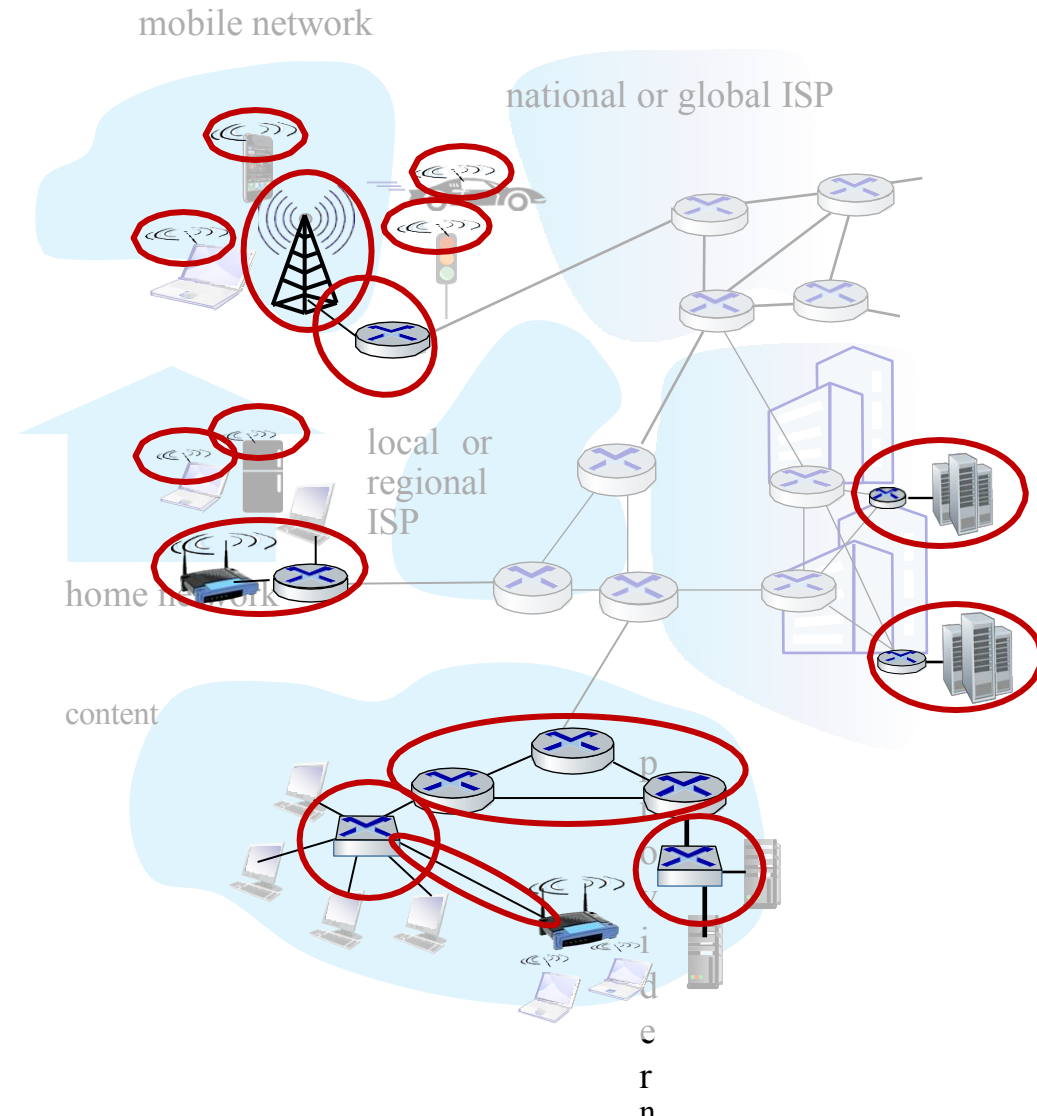**Network core:**
- interconnected routers
- network of networks
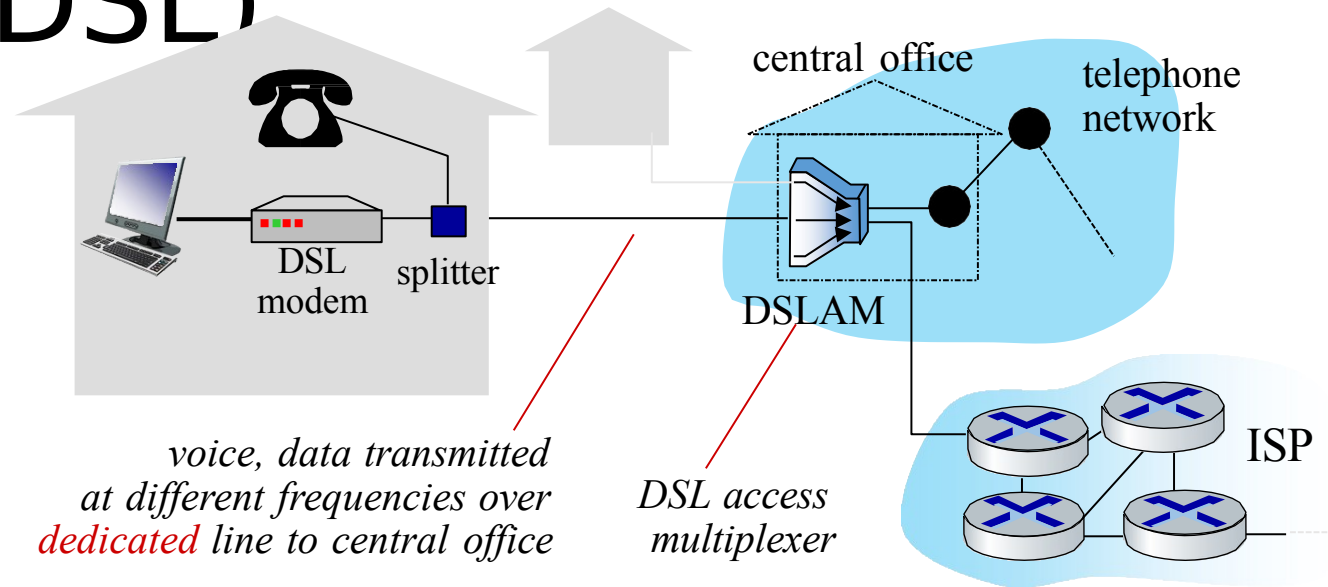
Access Networks and Physical Media

*Q: How to connect **end systems** to edge routers?*

A: Access Networks

- Residential Access Nets
- Institutional Access Networks (school, company)
- Mobile Access Networks (WiFi, 4G/5G)

Access Network: Digital Subscriber Line (DSL)

central office

telephone network

DSL modem

splitter

DSLAM

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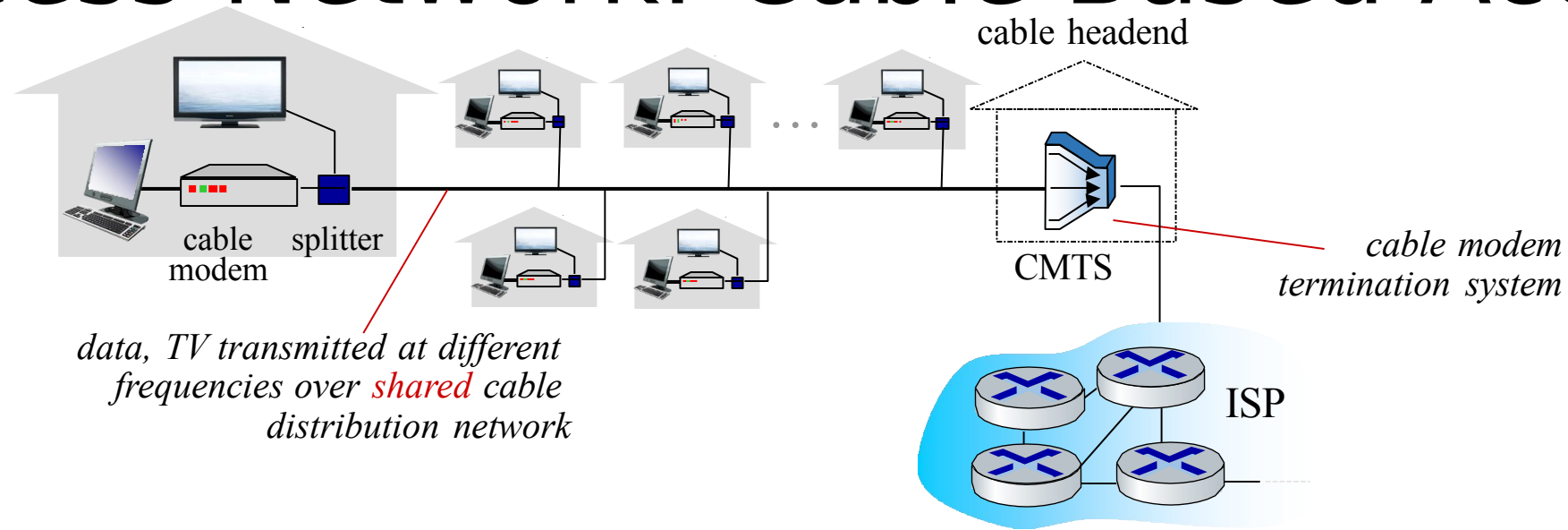
DSL access multiplexer

ISP

- 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
- 24-52 Mbps dedicated downstream transmission rate
- 3.5-16 Mbps dedicated upstream transmission rate

Access Network: Cable-Based Access
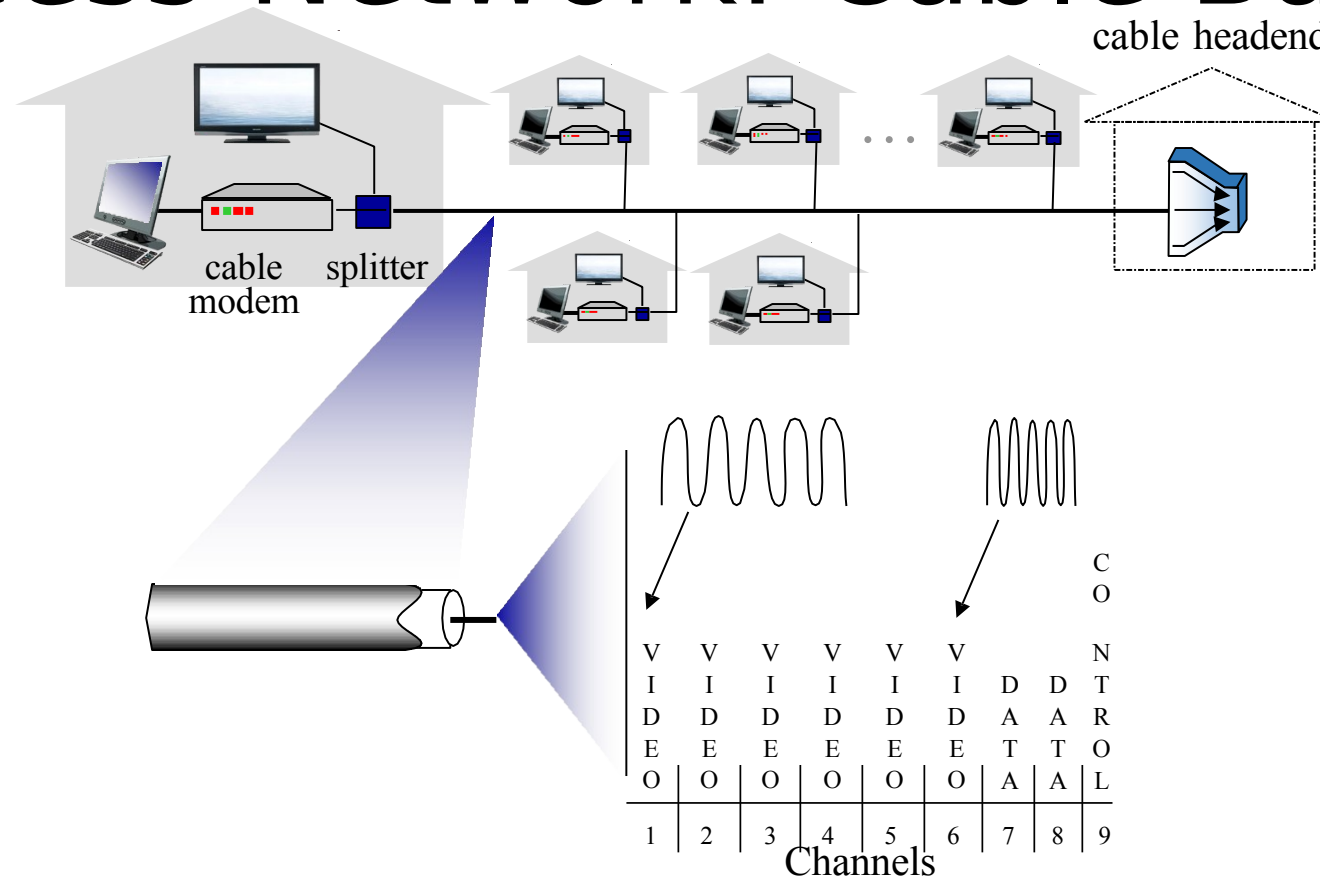
frequency division multiplexing (FDM): different channels transmitted in different frequency bands

Access Network: Cable-Based Access

cable headend

cable modem
termination system

CMTS

ISP

cable modem splitter

*data, TV transmitted at different
frequencies over shared cable
distribution network*

- **HFC: hybrid fiber coax**
  - asymmetric: up to 40 Mbps – 1.2 Gbps downstream transmission rate, 30-100 Mbps upstream transmission rate
- **network** of cable, fiber attaches homes to ISP router
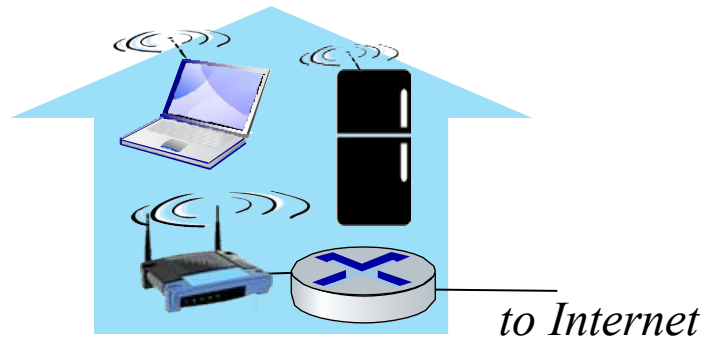 - homes *share access network* to cable headend

Wireless Access Networks

Shared *wireless* access network connects end system to router
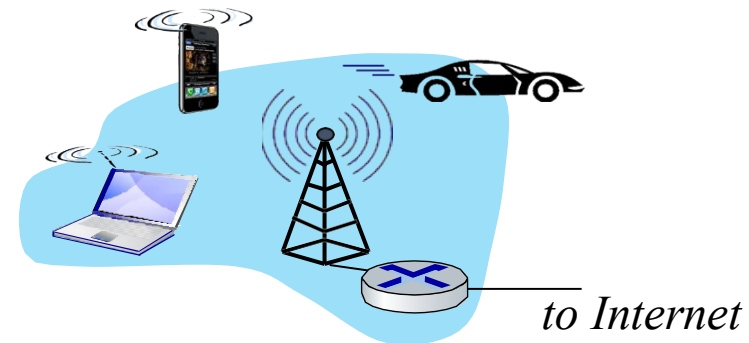
- via base station aka "access point"

Wireless local area networks (WLANs)

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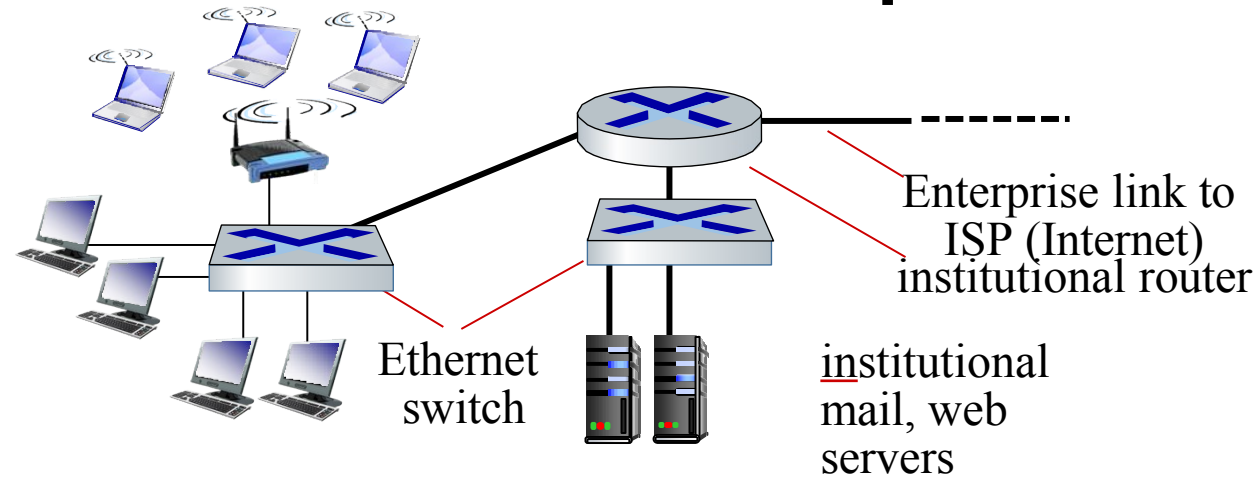- 802.11b/g/n (WiFi): 11, 54, 450 Mbps transmission rate

to Internet

Wide-area cellular access networks

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

to Internet
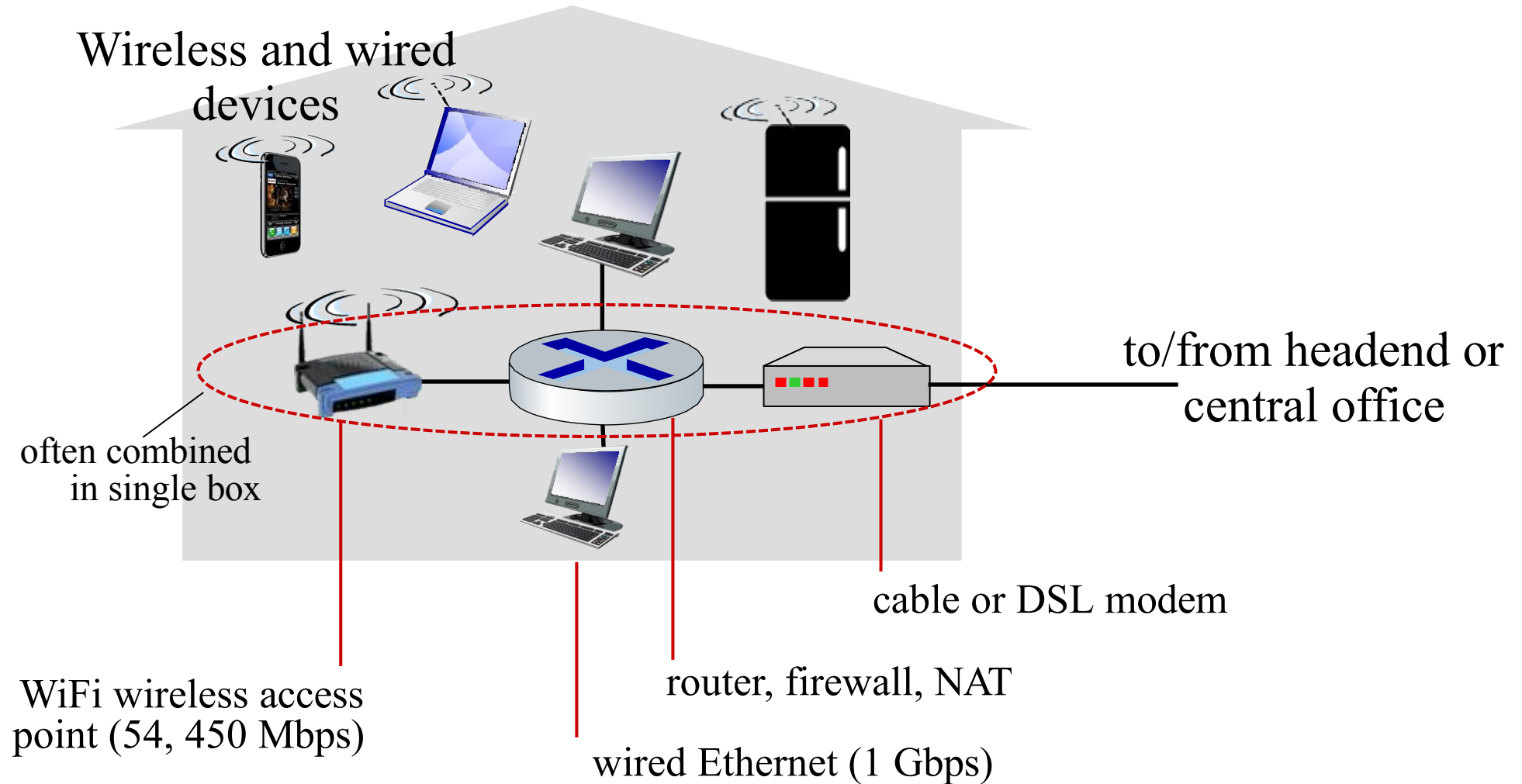
Access Network: Enterprise Networks

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 to create a Local Area Network (LAN)
  - Ethernet: wired access at 100Mbps, 1Gbps, 10Gbps
  - WiFi: wireless access points at 11, 54, 450 Mbps

Access Network: Home Networks

Wireless and wired devices

often combined in single box

to/from headend or central office

cable or DSL modem

router, firewall, NAT

wired Ethernet (1 Gbps)

WiFi wireless access point (54, 450 Mbps)

Links: 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
  - Category 5: 100 Mbps, 1 Gbps Ethernet
  - Category 6: 10Gbps Ethernet
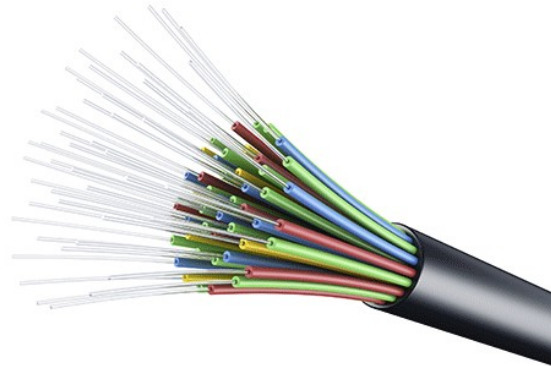
Links: Physical Media

Coaxial cable:

- two concentric copper conductors

- bidirectional

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

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

Links: Physical Media

Wireless radio

- signal carried in various "bands" in electromagnetic spectrum
- no physical "wire"
- broadcast, "half-duplex" (sender to receiver)
- propagation environment effects:
  - reflection
  - obstruction by objects
  - Interference/noise

Radio link types:

- Wireless LAN (WiFi)
  - 10-100's Mbps; 10's of meters
- wide-area (e.g., 4G/5G cellular)
  - 10's Mbps (4G) over ~10 Km
- Bluetooth: cable replacement
  - short distances, limited rates
- terrestrial microwave
  - point-to-point; 45 Mbps channels
- satellite
  - up to < 100 Mbps (Starlink) downlink
  - 270 msec end-end delay (geostationary)

Next Session:

- Network edge: hosts, access network, physical media
- Network core: packet/circuit switching, internet structure
- **Performance:** loss, delay, throughput
- Layering, Service models
- Security
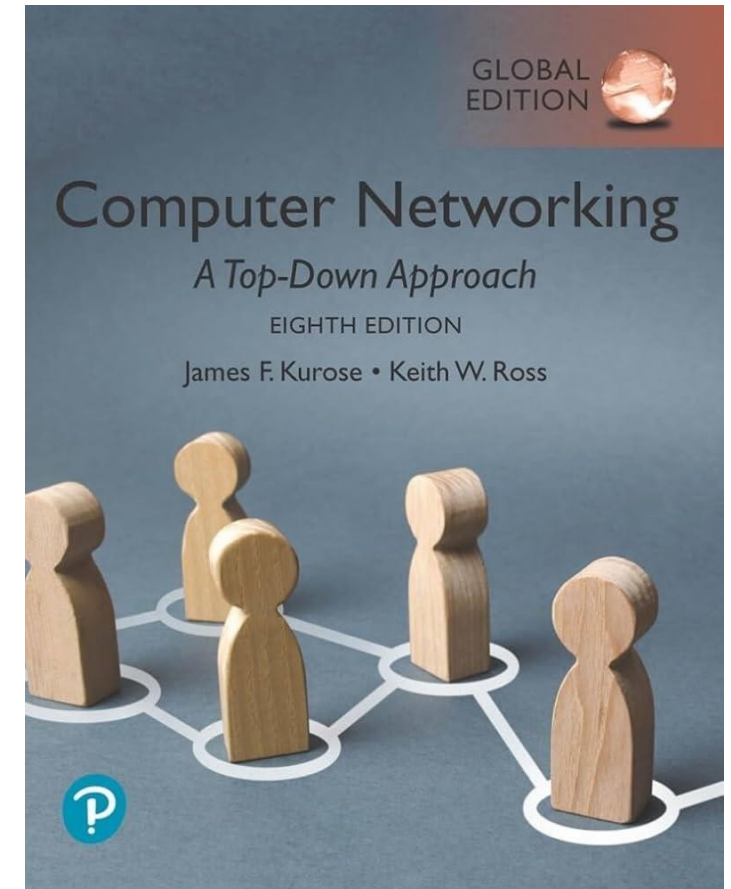
Lab 1: Virtual Box Setup & Wireshark Intro

- Due: Sunday February 2

- Assignment remains open a week after deadline

- Talk to me if you need more time

- Rest of class today: Get virtual box running