

# National University of Computer & Emerging Sciences

Computer Networks  
BS(CS)

Session: Fall 2024

Lecture 01

**Introduction**

# Dishonesty, Plagiarism

- Plagiarism in project or midterm/ final exam may result in F grade in the course.
- Plagiarism in an assignment may result in zero marks in the whole assignments category.
- Due Dates for Assignments and Quizzes will be fix any request to postpone deadlines will not be considered

# Tentative Evaluation Breakdown

Grading Policy	Absolute grading
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Assignments (3)	10
Mid 1	15
Mid 2	15
Project (Lab)	10
Final	40
Quizzes	10
Total	100

Note: The evaluation Breakdown plus course outline for all sections will be same

# Course Outline

- Introduction
- Internet & Protocols, Network Edge/Core, Delays
- Service Models and Security
- Application Layer and Transport Layer
- Network and Data Link Layer
- ...

Lectures will be uploaded to google classroom  
code:

# Text Book

*Computer Networking: A Top Down Approach*

8<sup>th</sup> edition

Jim Kurose, Keith Ross

Addison-Wesley

# Chapter 1: roadmap

- What is the Internet?
- What *is* a protocol?
- Network edge: hosts, access network, physical media
- Network core: packet/circuit switching, internet structure
- Performance: loss, delay, throughput
- Security
- Protocol layers, service models
- History



Introduction: 1-6

# Chapter 01: Introduction

*our goal:*

- get “feel” and terminology
- more depth, detail *later* in course
- approach:
  - use Internet as example

# Computer Network

- Computer *network* - a group of computers connected together to communicate, exchange data, and share resources in real time



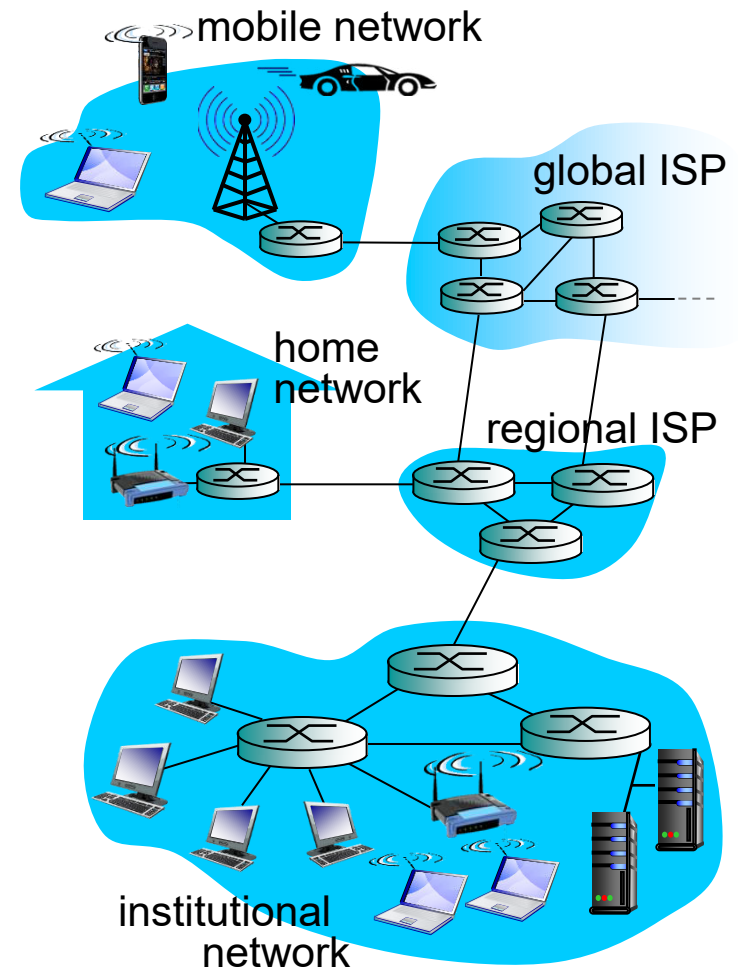


# Network Enables...

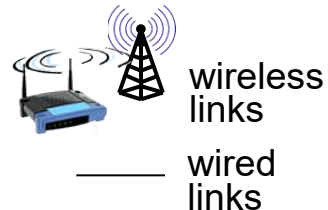
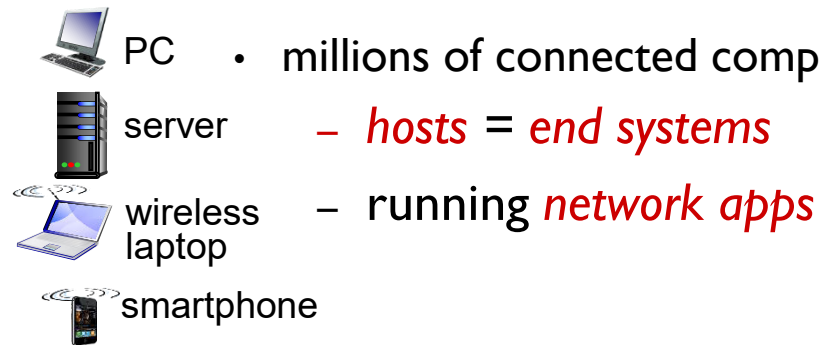
- Simultaneous access to data
  - Data files are shared
    - Data are stored in a centralized place
    - All users have access to identical, up-to-date information
  - Software can also be shared
    - Site licenses
- Sharing of hardware resources
  - Printers and faxes are commonly shared devices
  - Reduces the cost per user
- Collaborative work by multiple people
- Personal communication
  - Email
  - Instant messaging
  - Conferencing
    - Videoconferencing
  - Voice over IP
    - Phone communication over network wires
- Easier data backup
  - Usually in business corporations
    - Employers keep the data on a shared storage device
    - The network manager makes regular backups of the data

# What's the Internet: "nuts and bolts" view

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



# What's the Internet: "nuts and bolts" view

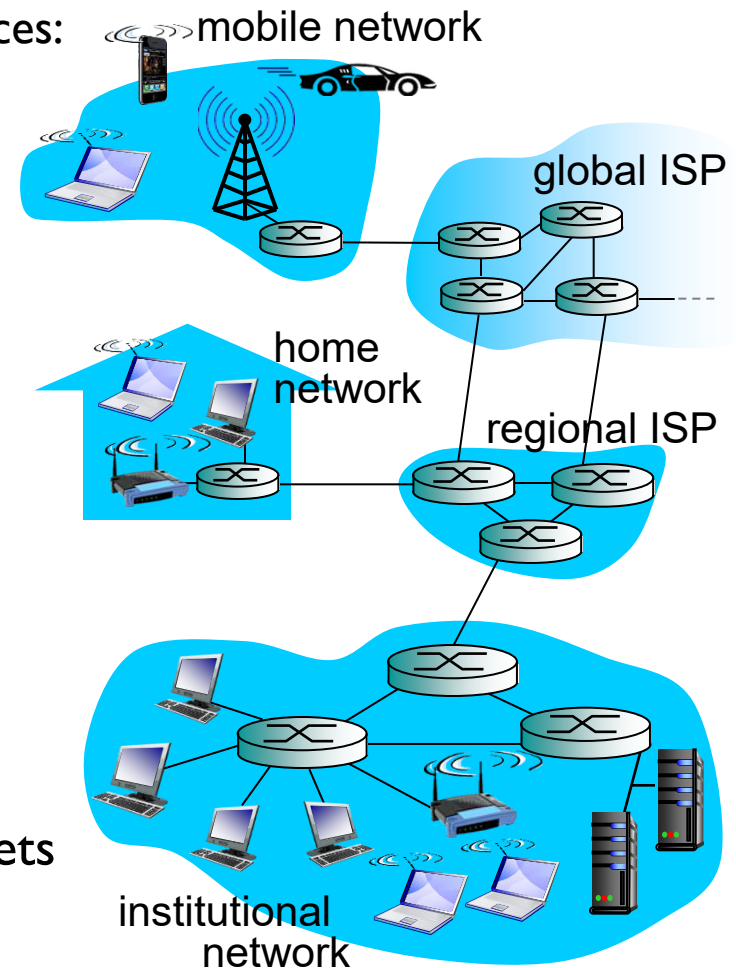


## ❖ *communication links*

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

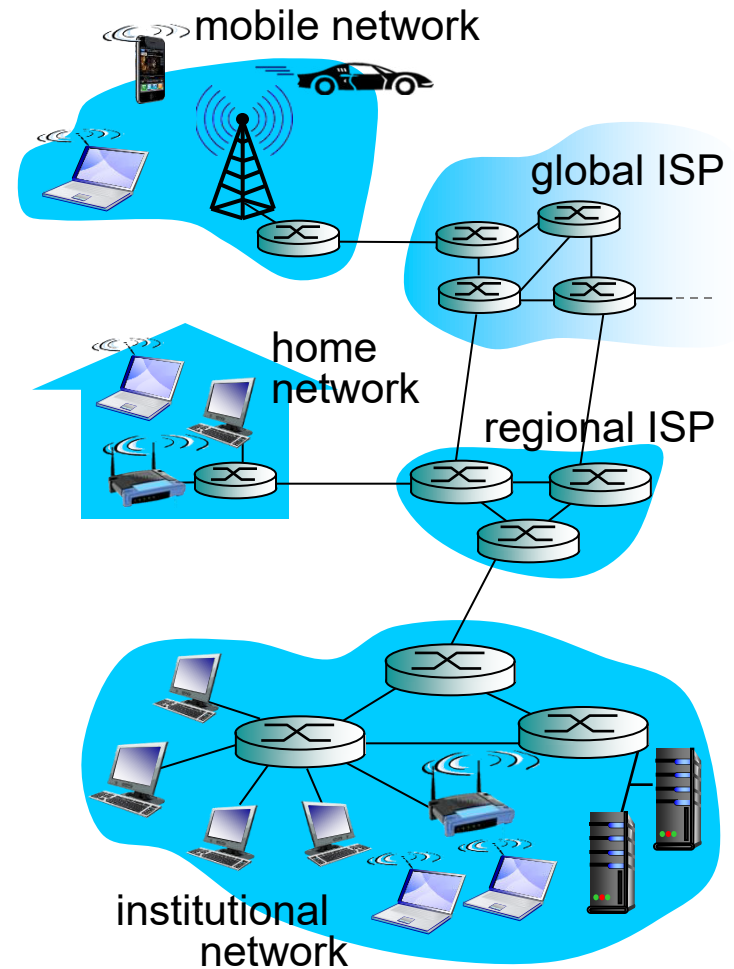
## ❖ *Packet switches*: forward packets (chunks of data)

- *routers* and *switches*



# What's the Internet: a service view

- *Infrastructure that provides services to distributed applications:*
  - Web, VoIP, email, games, e-commerce, social nets, ...
- *provides programming interface to apps*
  - hooks that allow sending and receiving app programs to “connect” to Internet



But how these systems and network apps communicate with each other?

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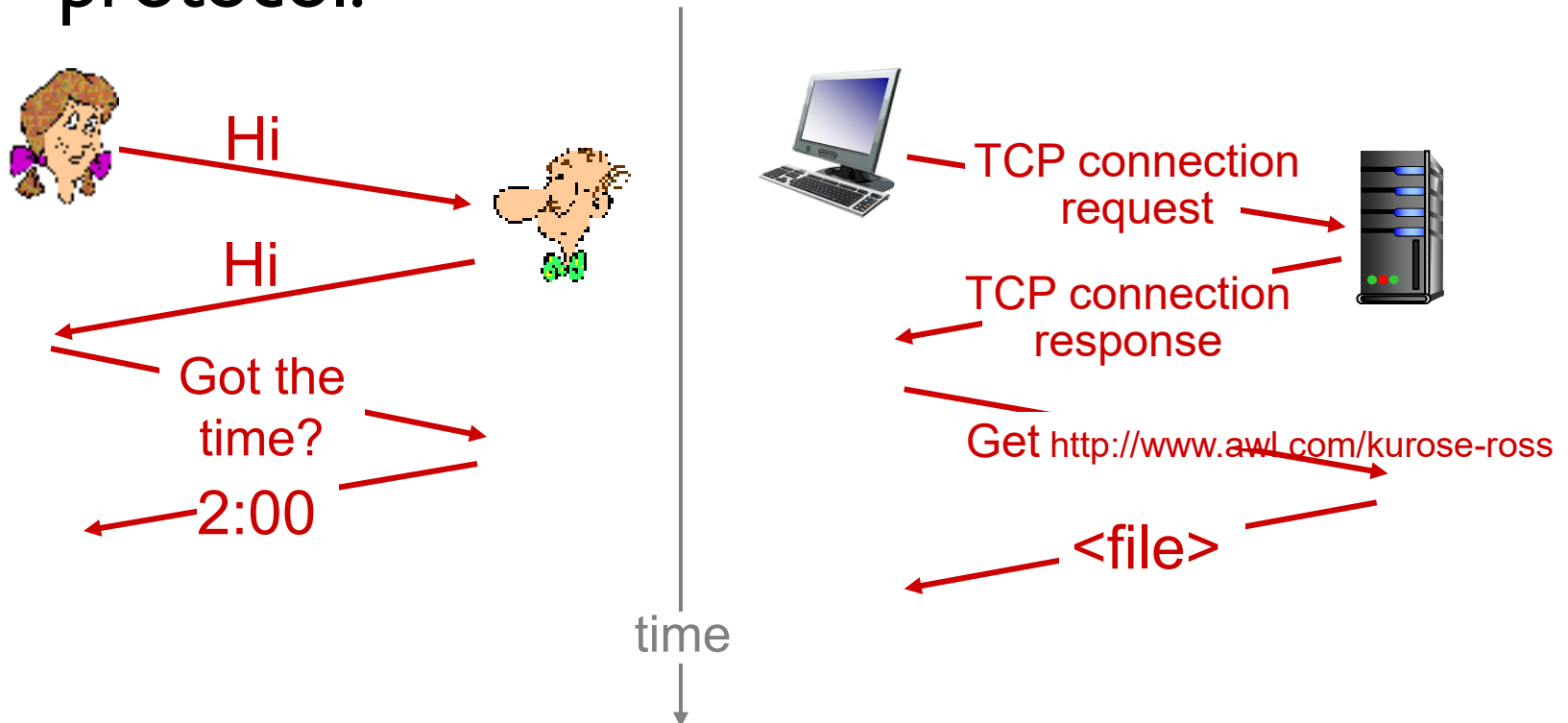
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# Protocols

- For proper communication, entities in different systems **must speak the same language**
  - there must be mutually acceptable conventions and rules about the content, timing and underlying mechanisms
- Those conventions and associated rules are referred as “PROTOCOLS”

# What's a protocol?

a human protocol and a computer network protocol:



**Q:** other human protocols?

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# What's a protocol?

## *human protocols:*

- “what's the time?”
  - “I have a question”
  - introductions
- ... specific msgs sent
- ... specific actions taken when msgs received, or other events

## *network protocols:*

- machines rather than humans
- all communication activity in Internet governed by protocols

*protocols define format, order of msgs sent and received among network entities, and actions taken on msg transmission, receipt*

# “Fun” Internet-connected devices



Amazon Echo



Internet refrigerator



IP picture frame



Pacemaker & Monitor



Tweet-a-watt:  
monitor energy use



bikes



Web-enabled toaster +  
weather forecaster



cars



Slingbox: remote  
control cable TV



AR devices



scooters



Security Camera



sensorized,  
bed  
mattress



Fitbit



Gaming devices

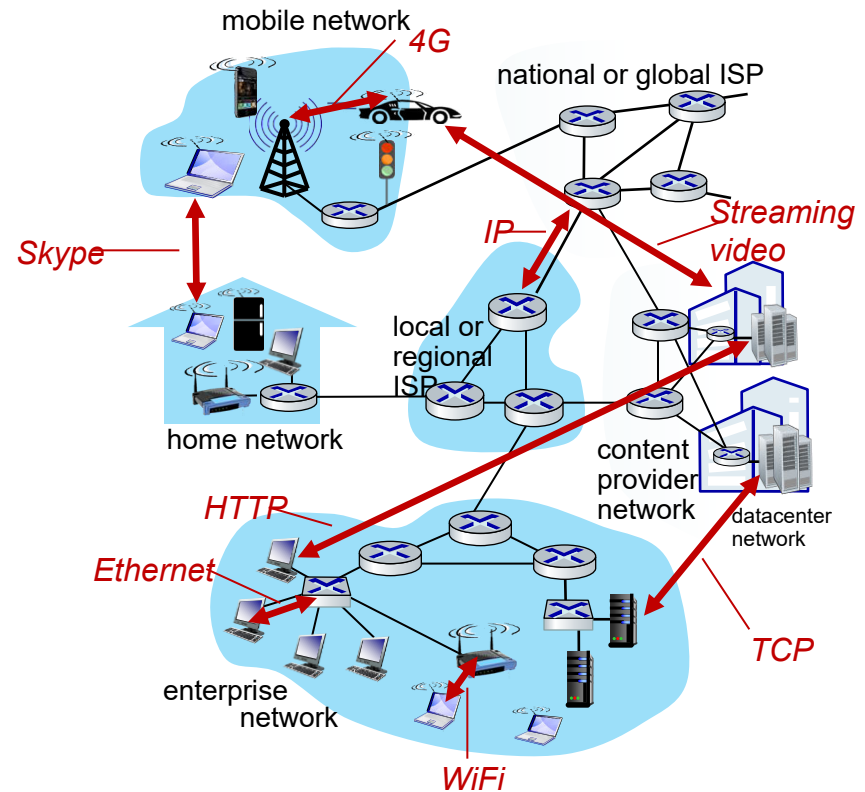


Internet phones

*Others?*

## The Internet: a “nuts and bolts” view

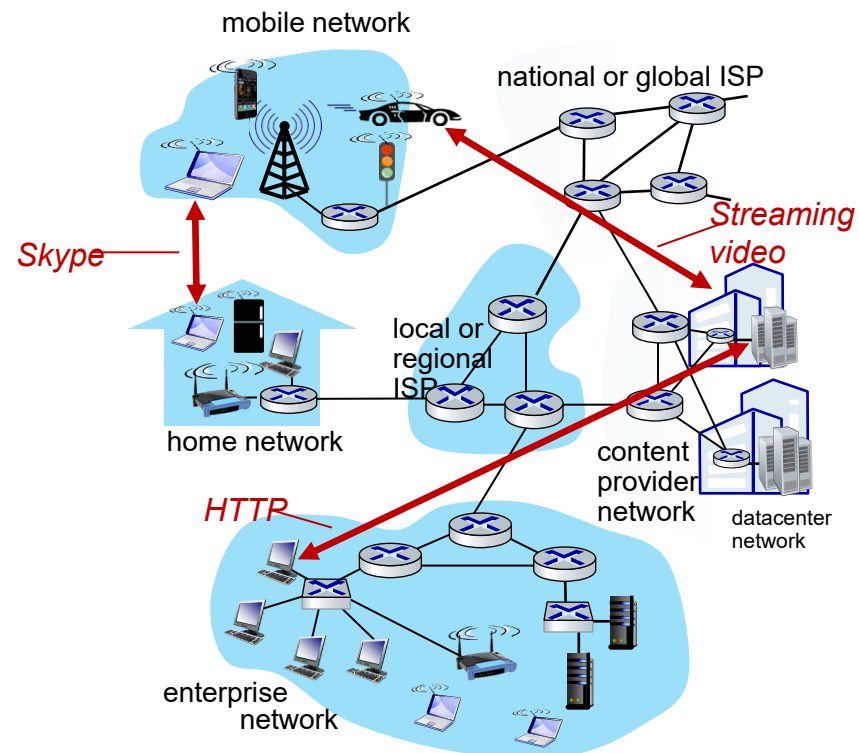
- *Internet: “network of networks”*
  - Interconnected ISPs
- *protocols* are everywhere
  - control sending, receiving of messages
  - e.g., HTTP (Web), streaming video, Skype, TCP, IP, WiFi, 4G, Ethernet
- *Internet standards*
  - RFC: Request for Comments
  - IETF: Internet Engineering Task Force



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# 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



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# Chapter 1: roadmap

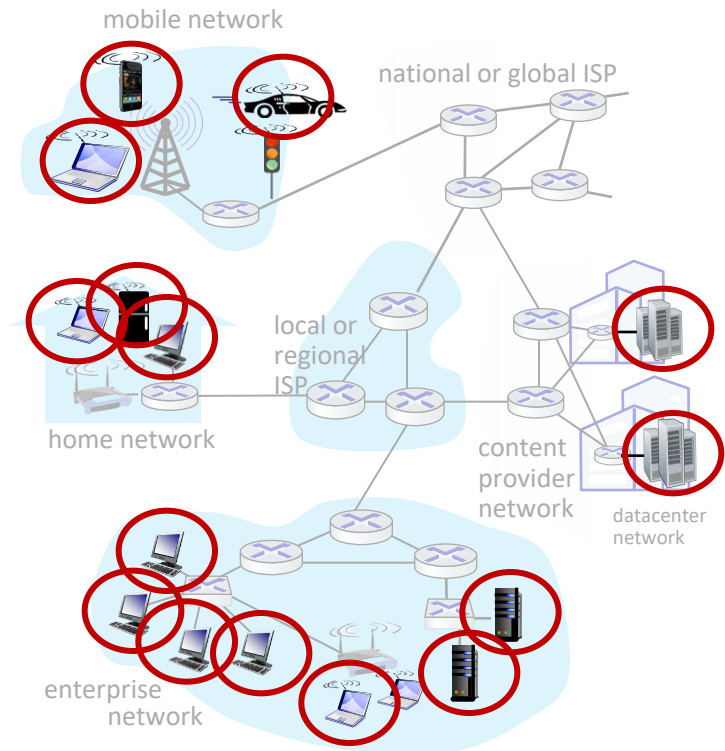
- What *is* the Internet?
- What *is* a protocol?
- **Network edge:** hosts, access network, physical media
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# A closer look at Internet structure

### Network edge:

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



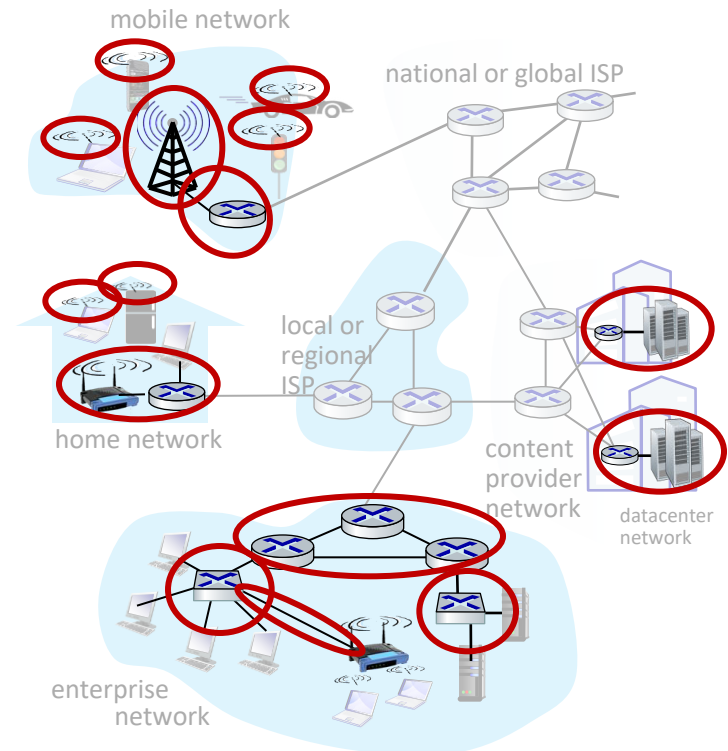
# A closer look at Internet structure

## Network edge:

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

## Access networks, physical media:

- wired, wireless communication links



# A closer look at Internet structure

## Network edge:

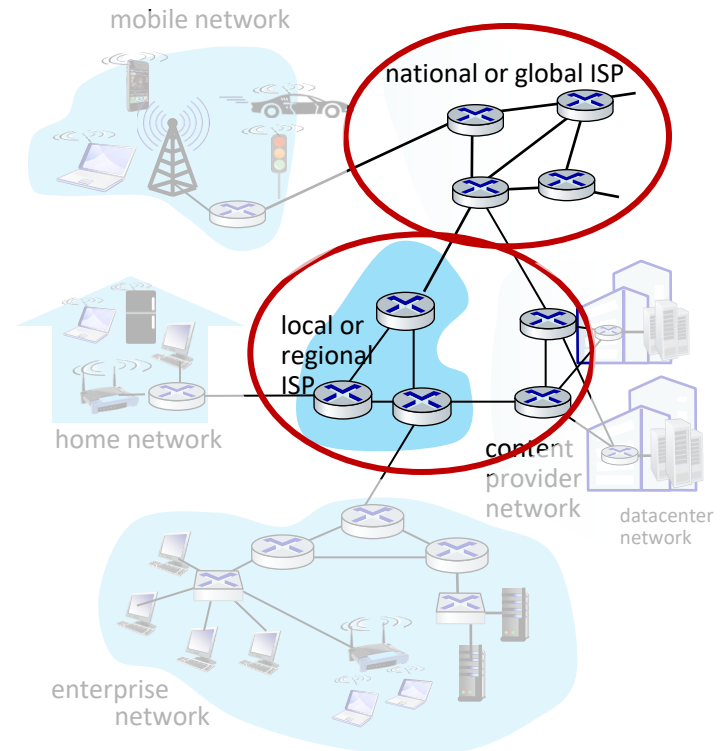
- hosts: clients and servers
- servers often in data centers

## Access networks, physical media:

- wired, wireless communication links

## Network core:

- interconnected routers
- network of networks

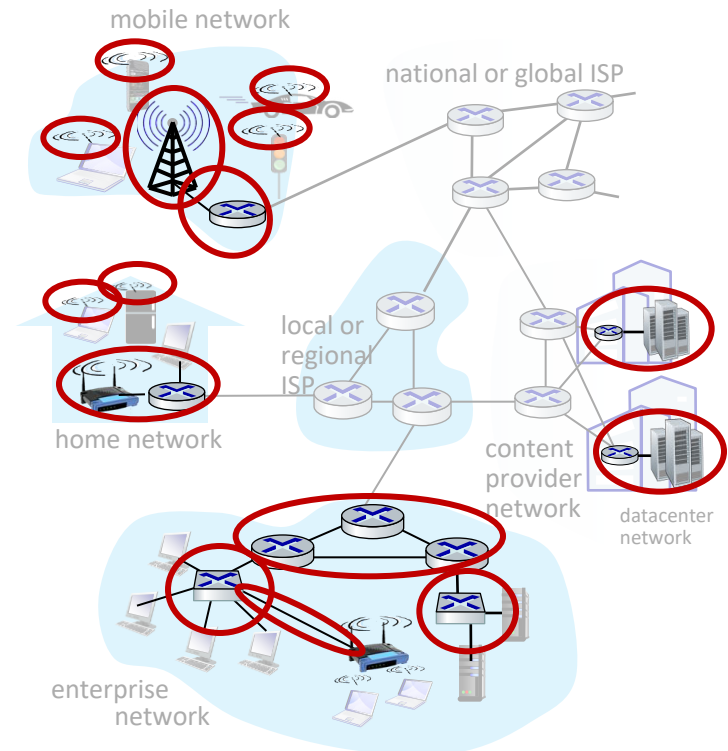




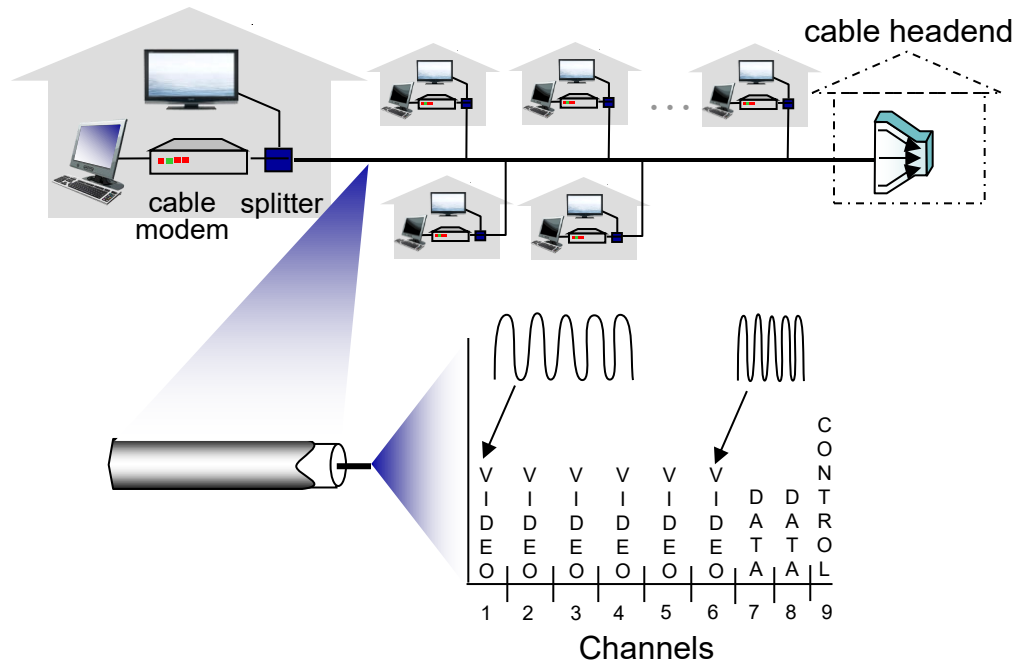
# Access networks and physical media

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

- residential access nets
- institutional access networks (school, company)
- mobile access networks (WiFi, 4G/5G)

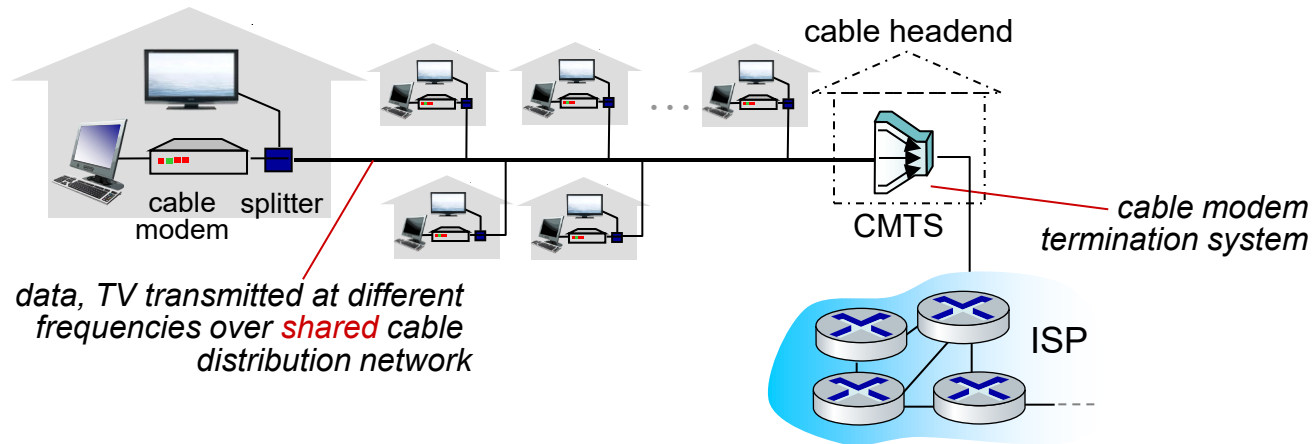


# Access networks: cable-based access



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

# Access networks: cable-based access



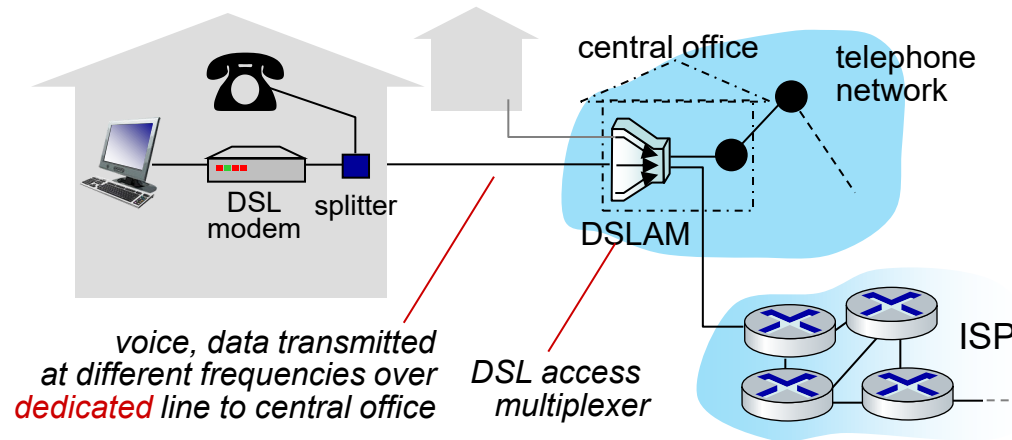
### ■ HFC: hybrid fiber coax

- 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

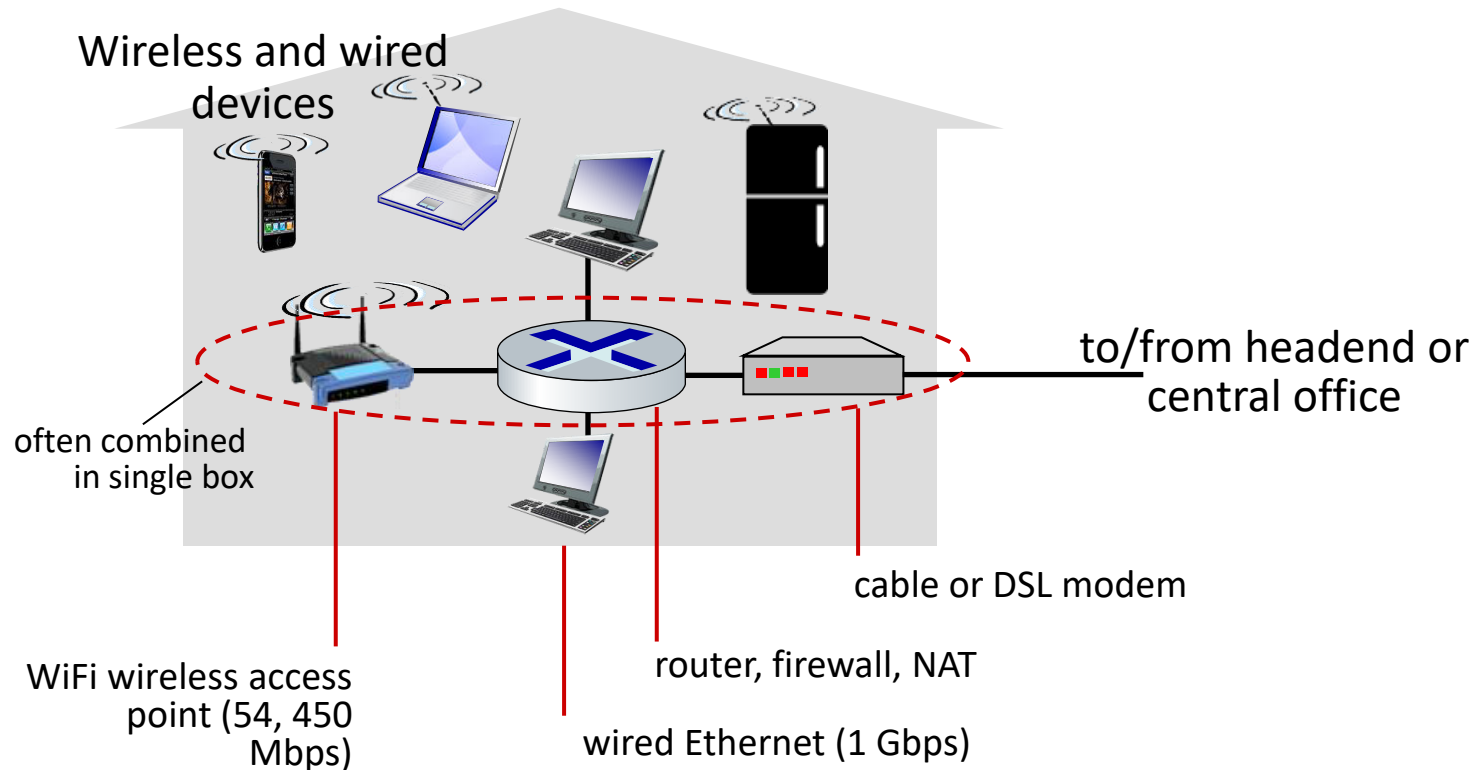
- homes *share access network* to cable headend

# Access networks: digital subscriber line (DSL)



- 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 networks: home networks



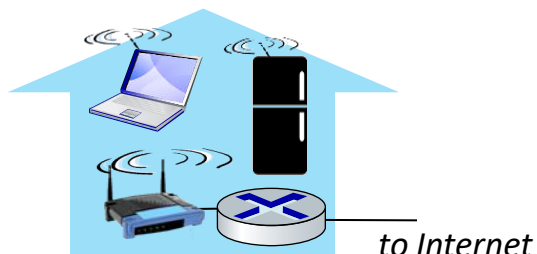
# Wireless access networks

Shared *wireless* access network connects end system to router

- via base station aka “access point”

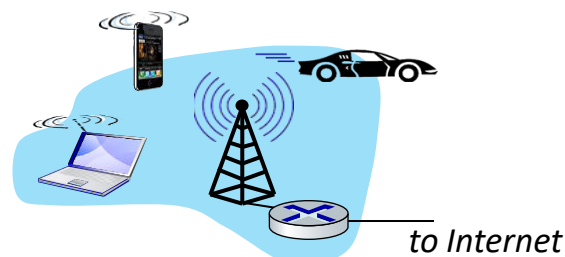
## Wireless local area networks (WLANs)

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

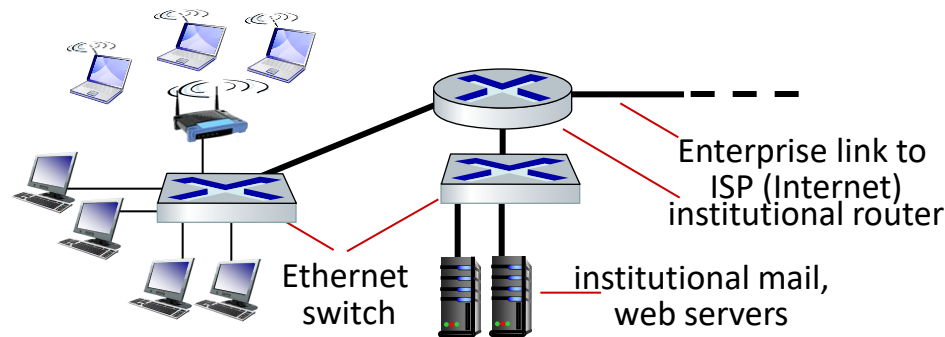


## Wide-area cellular access networks

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



# Access networks: enterprise networks



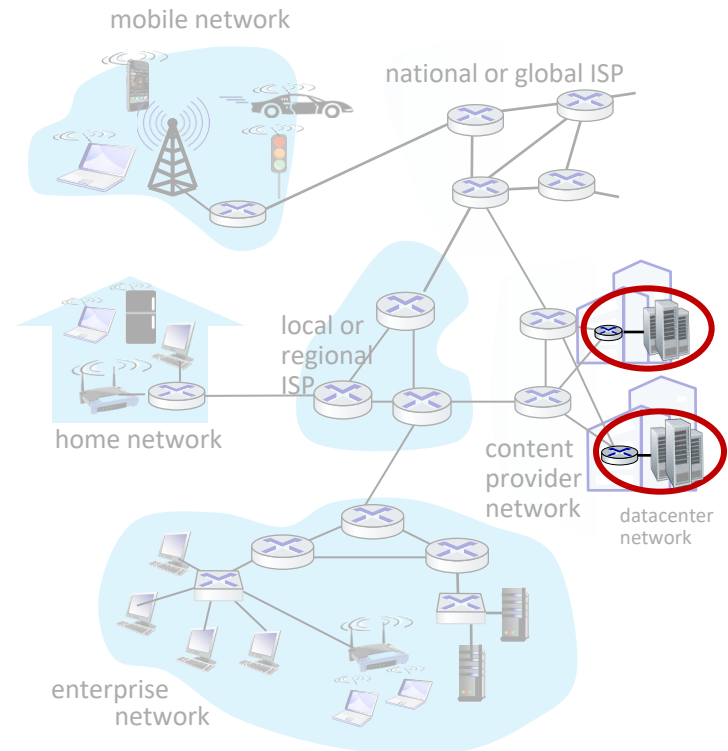
- companies, universities, etc.
- mix of wired, wireless link technologies, connecting a mix of switches and routers (we'll cover differences shortly)
  - Ethernet: wired access at 100Mbps, 1Gbps, 10Gbps
  - WiFi: wireless access points at 11, 54, 450 Mbps

# Access networks: data center networks

- high-bandwidth links (10s to 100s Gbps) connect hundreds to thousands of servers together, and to Internet



*Courtesy: Massachusetts Green High Performance Computing Center (mghpcc.org)*

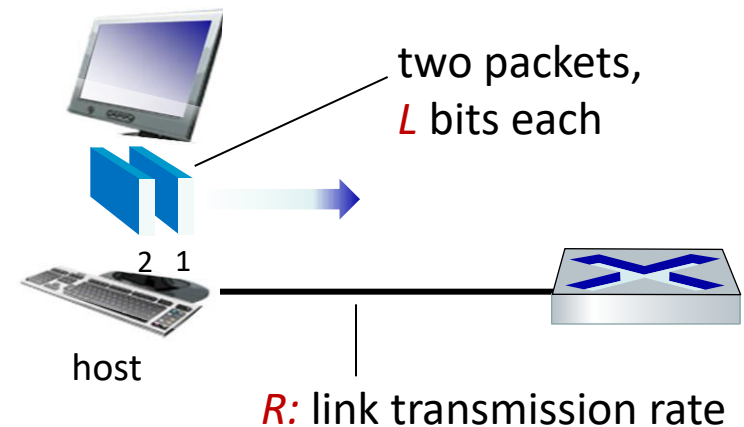




# Host: sends *packets* of data

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*



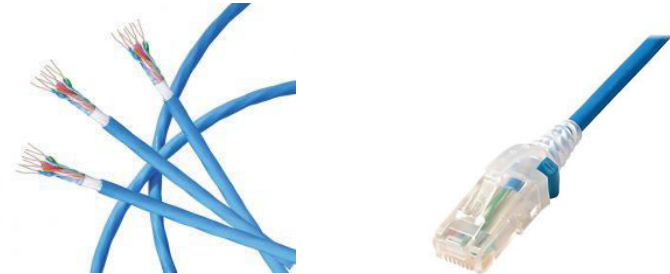
$$\text{packet transmission delay} = \text{time needed to transmit } L\text{-bit packet into link} = \frac{L \text{ (bits)}}{R \text{ (bits/sec)}}$$

# 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

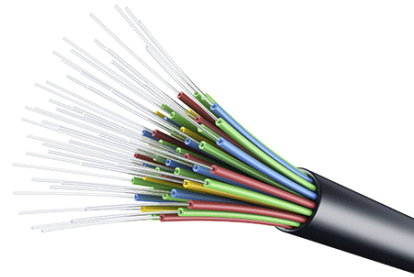
## Coaxial cable:

- 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 cellular)
  - 10's Mbps over ~10 Km
- **Bluetooth:** cable replacement
  - short distances, limited rates
- **terrestrial microwave**
  - point-to-point; 45 Mbps channels
- **satellite**
  - up to 45 Mbps per channel
  - 270 msec end-end delay

## *Computer Networking: A Top Down Approach*

8<sup>th</sup> edition

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A note on the origin of these ppt slides:

These slides are freely provided by the book authors and it represents a *lot* of work on their part.  
We would like to thank J.F Kurose and K.W. Ross.