
# Computer Networks & Internet

A/PROF. DUY NGO

# Learning Objectives

**1.1 what is the Internet?**

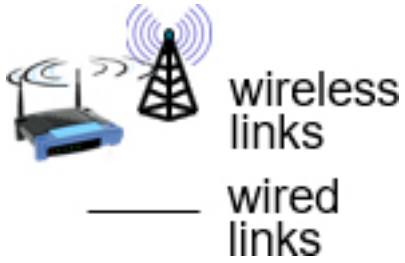
1.2 network edge

- end systems,
- access networks,
- Links
- delays

# What's the Internet: "Nuts and Bolts" View (1 of 2)


billions of connected computing devices:

- **hosts** = **end systems**
- running **network apps**



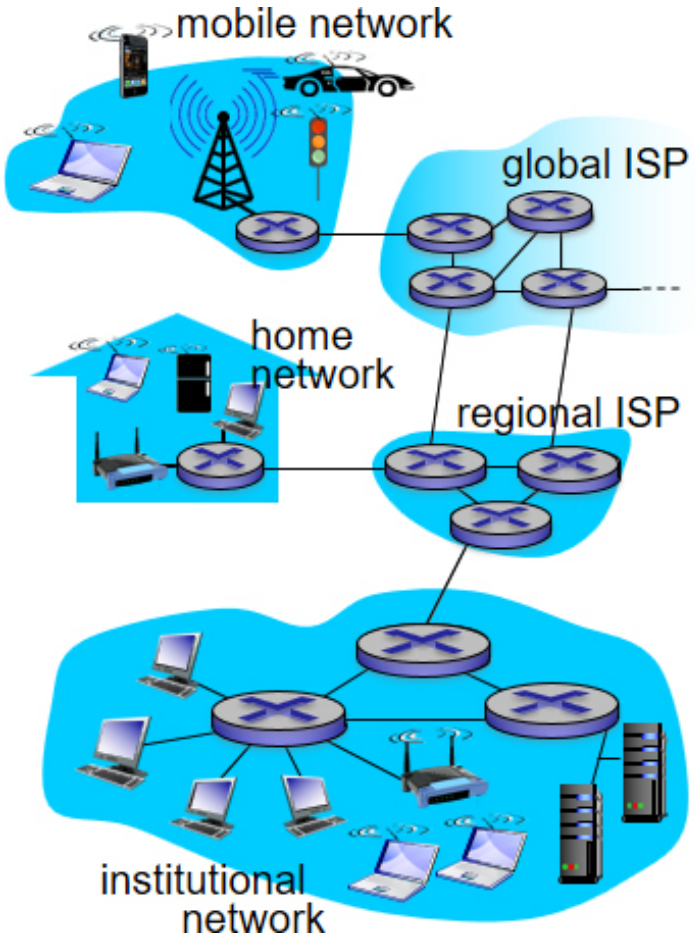

**communication links**

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


**packet switches:** forward packets (chunks of data)

- **routers** and **switches**

# What's the Internet: "Nuts and Bolts" View (2 of 2)



# “Fun” Internet-Connected Devices

IP picture frame
http://www.ceiva.com/

Web-enabled toaster + weather forecaster


Tweet-a-watt: monitor energy use

Slingbox: watch, control cable TV remotely

Internet refrigerator

sensorized, bed mattress

Internet phones

# What's the Internet: "Nuts and Bolts" View

**Internet: "network of networks"**

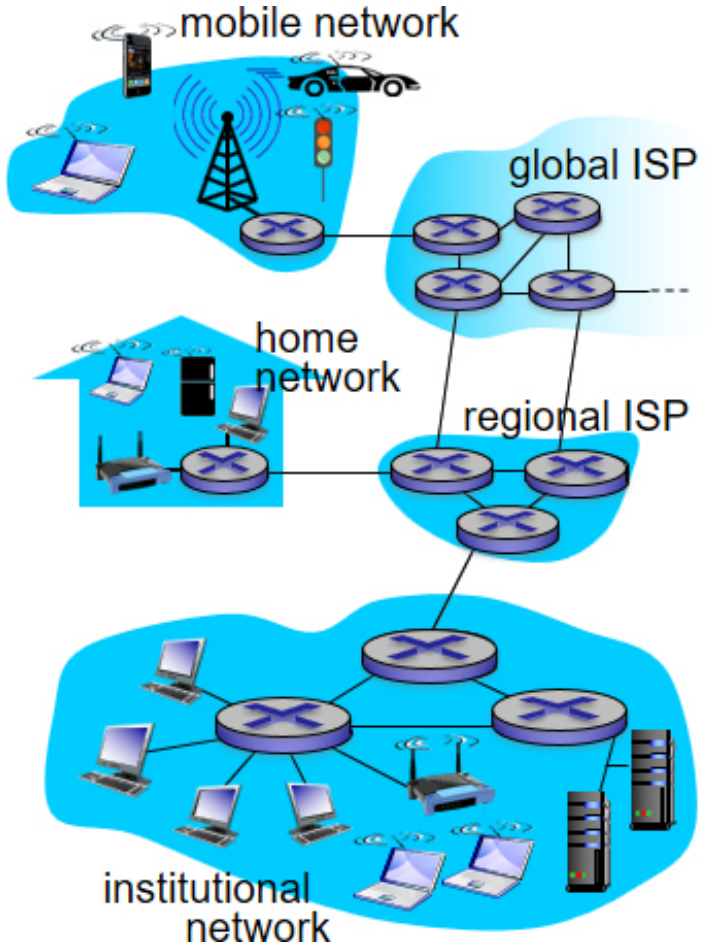
- Interconnected ISPs

**protocols** control sending, receiving of messages

- e.g., TCP, IP, HTTP, Skype, 802.11

**Internet standards**

- RFC: Request for comments
- IETF: Internet Engineering Task Force



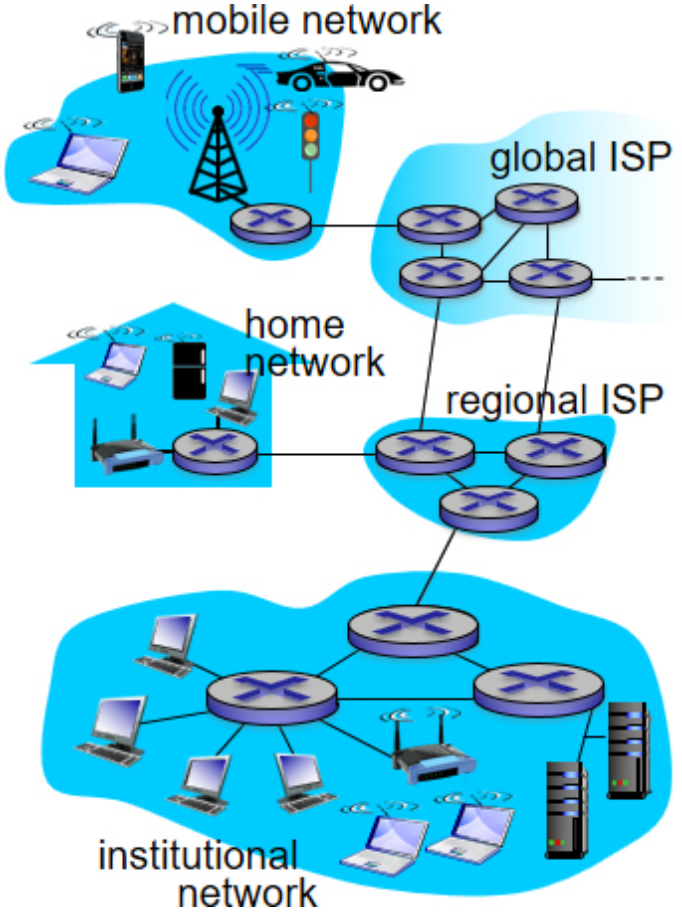
# What's the Internet: A Service View

**infrastructure that provides services to 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
- provides service options, analogous to postal service



# What's a Protocol? (1 of 2)

**human protocols:**

"what's the time?"

"I have a question"

introductions

… specific messages sent

… specific actions taken when messages received, or other events

**network protocols:**

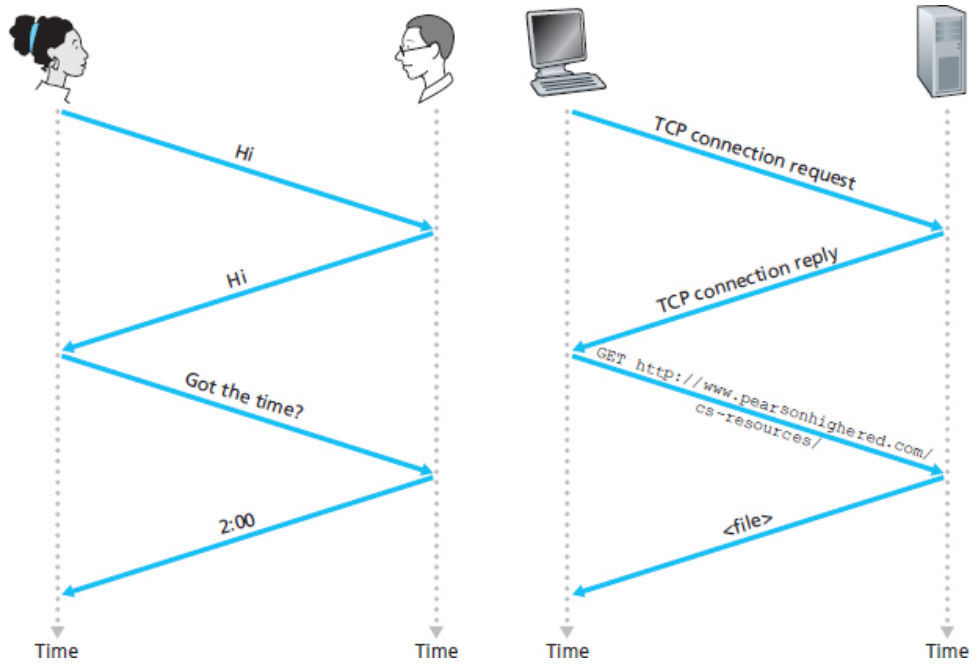
machines rather than humans

all communication activity in Internet governed by protocols

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

# What's a Protocol? (2 of 2)

A human protocol and a computer network protocol:




**Q:** other human protocols?

# A Closer Look at Network Structure:

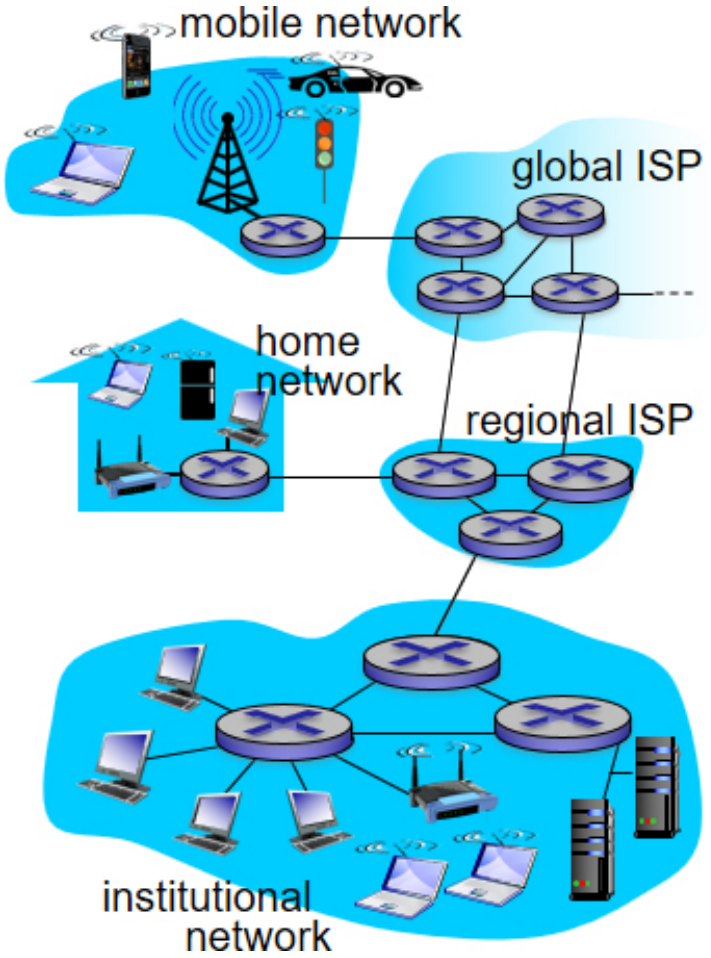
**network edge:**

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

**access networks, physical media**: wired, wireless communication links

**network core:**

- interconnected routers
- network of networks



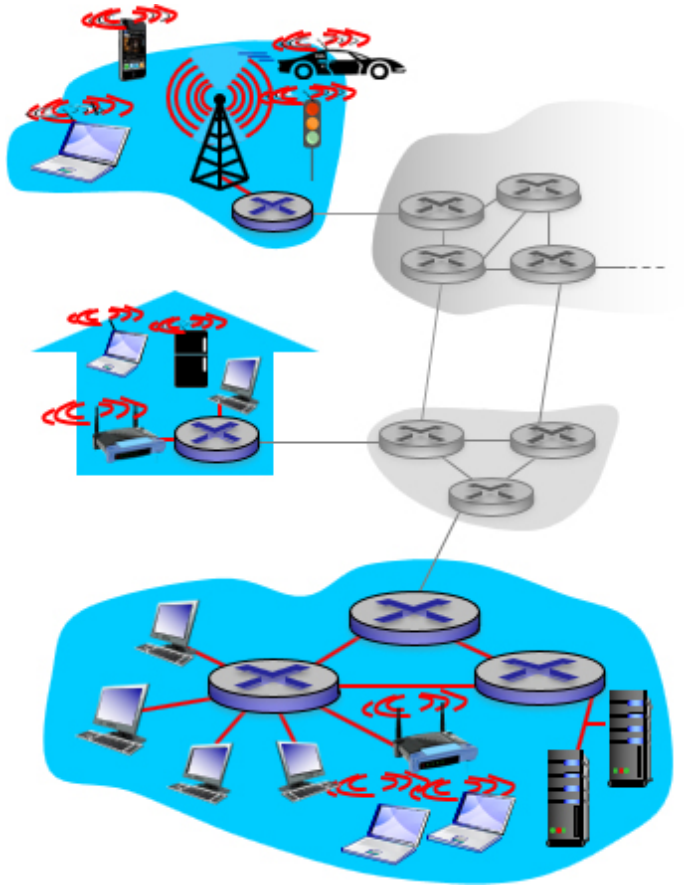
# Access Networks

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

- residential access nets
- institutional access networks (school, company)
- mobile access networks

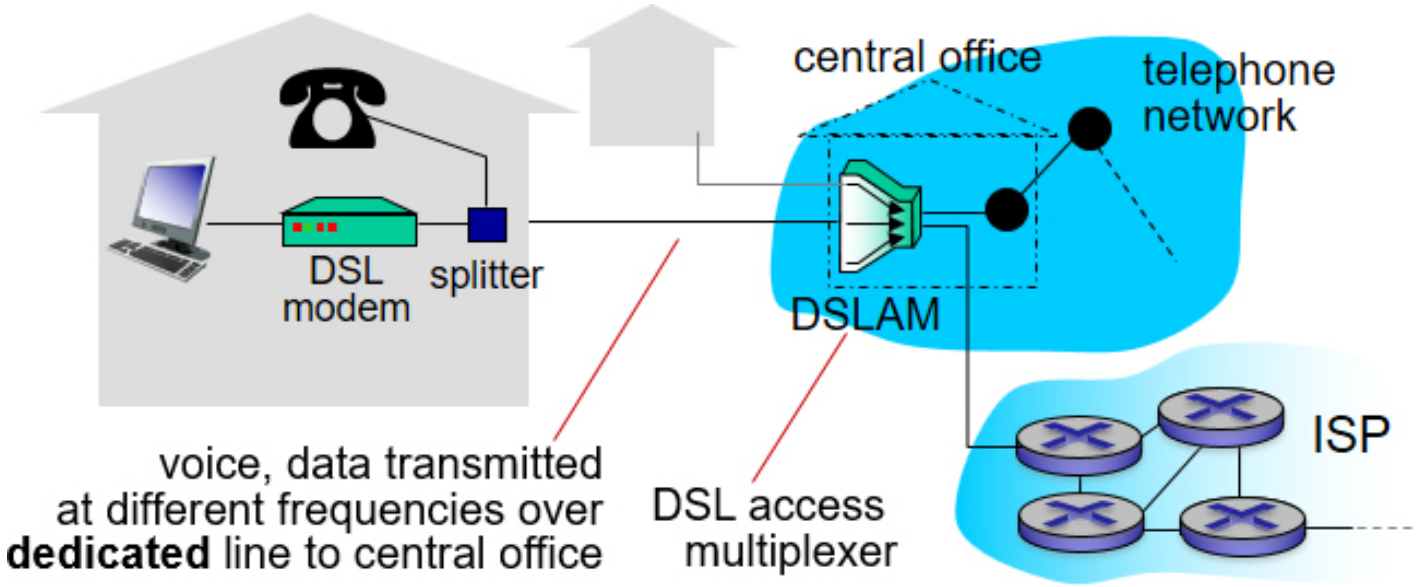
**keep in mind:**

- bandwidth (bits per second) of access network?
- shared or dedicated?



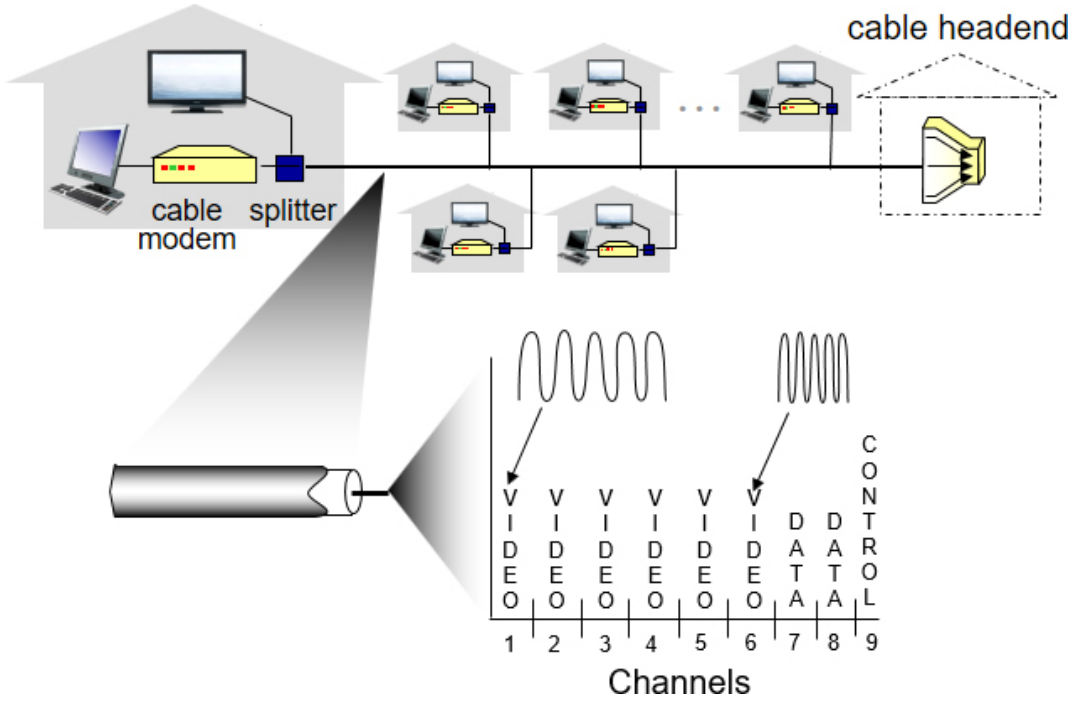
# Access Network: Digital Subscriber Line (DSL) (1 of 2)



# Access Network: Digital Subscriber Line (DSL) (2 of 2)

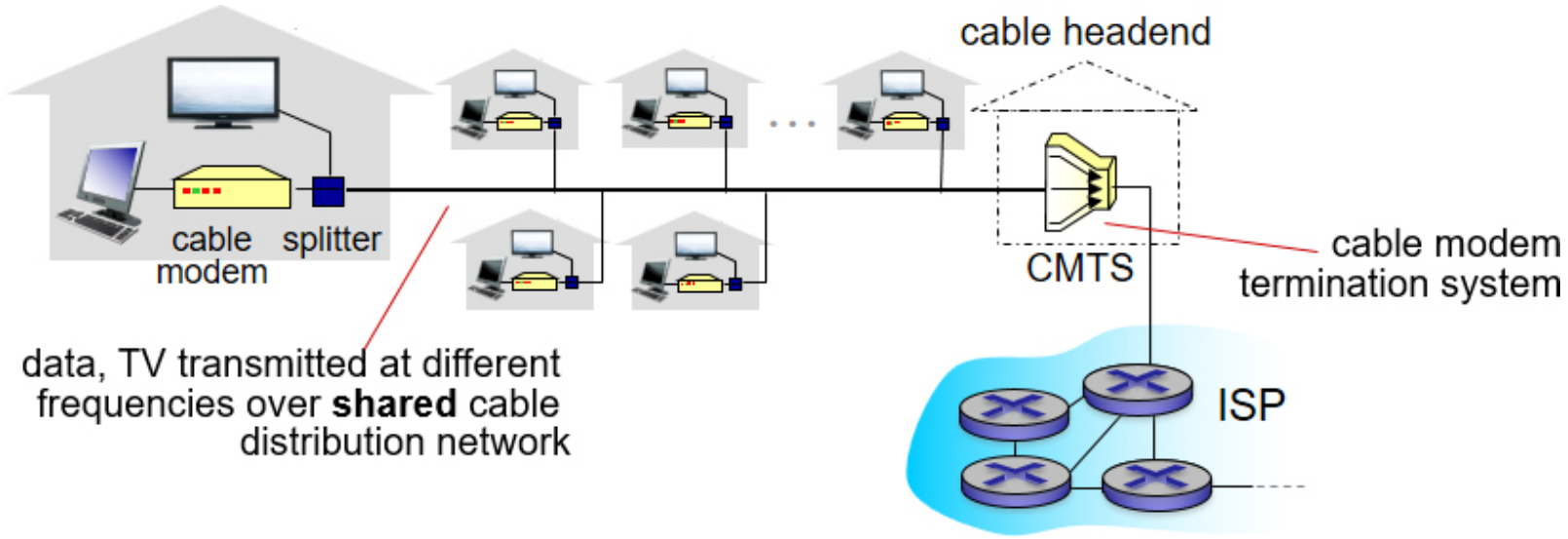
- use **existing** telephone line to central office DSLAM
  - data over DSL phone line goes to Internet
  - voice over DSL phone line goes to telephone net
- < 2.5 Mbps upstream transmission rate (typically < 1 Mbps)
- < 24 Mbps downstream transmission rate (typically < 10 Mbps)

# Access Network: Cable Network (1 of 3)




**frequency division multiplexing:** different channels transmitted in different frequency bands

# Access Network: Cable Network (2 of 3)



# Access Network: Cable Network (3 of 3)

**HFC: hybrid fiber coax**

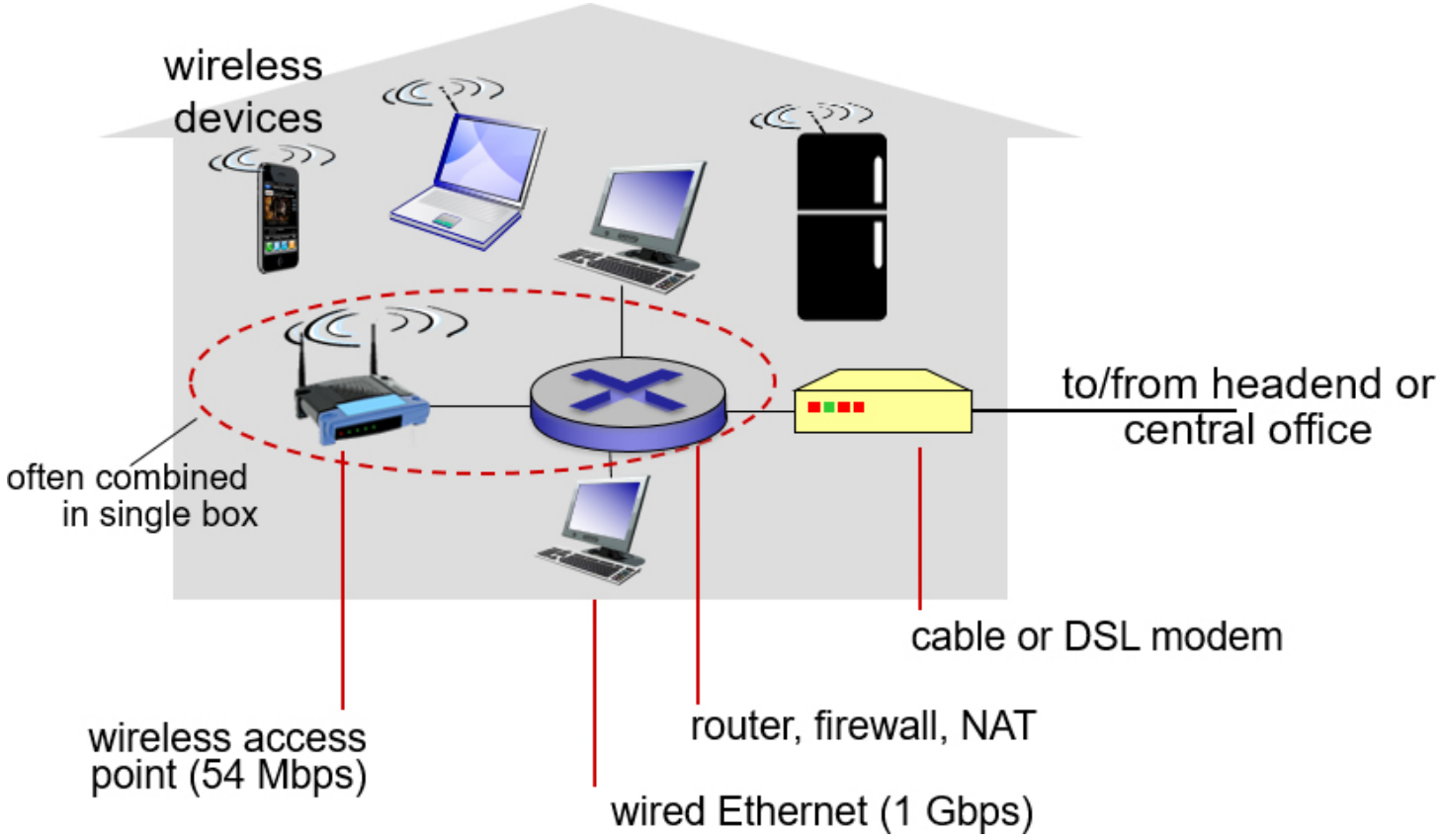
- asymmetric: up to 30Mbps downstream transmission rate, 2 Mbps upstream transmission rate

**network** of cable, fiber attaches homes to ISP router

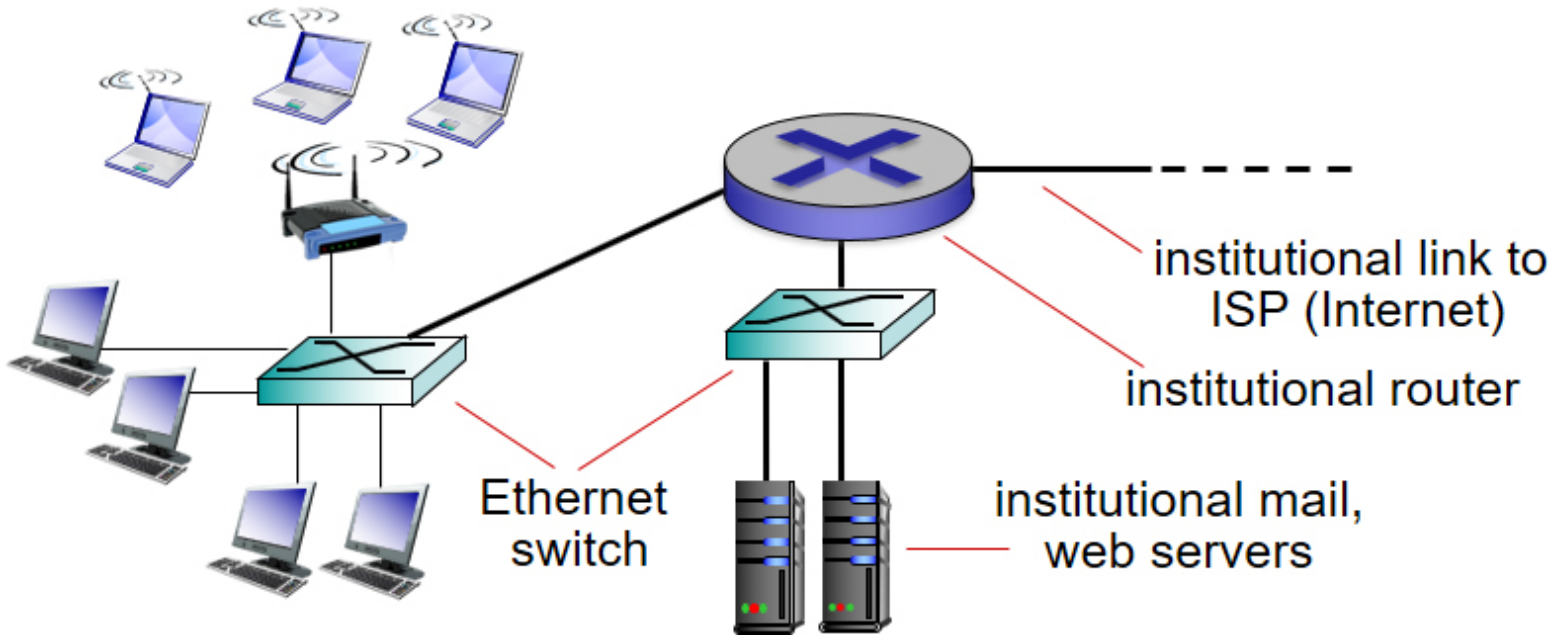
- homes **share access network** to cable headend
- unlike DSL, which has dedicated access to central office

# Access Network: Home Network



# Enterprise Access Networks (Ethernet)




typically used in companies, universities, etc.

10 Mbps, 100Mbps, 1Gbps, 10Gbps transmission rates

today, end systems typically connect into Ethernet switch

# Wireless Access Networks (1 of 2)

- shared **wireless** access network connects end system to router
  - via base station aka “access point”

**wireless LANs:**

- within building (100 meters.)
- 802.11b/g/n/ac (WiFi): 11, 54, 450, 700 Mbps transmission rate

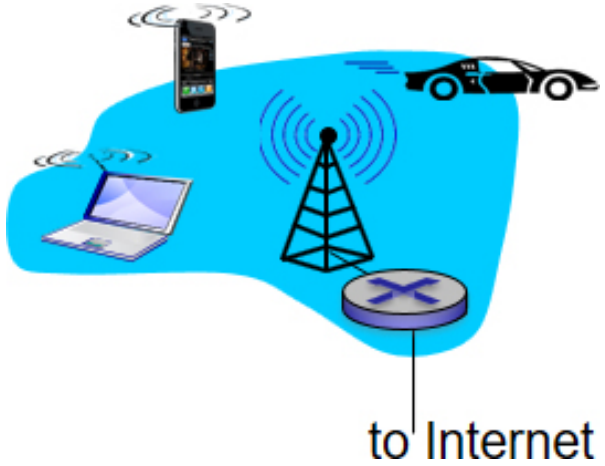
# Wireless Access Networks (2 of 2)

**wide-area wireless access**

provided by telco (cellular) operator, 10's km

between 1 and 100 Mbps

3G, 4G: LTE (Long Term Evolution)



# Host: Sends Packets of Data

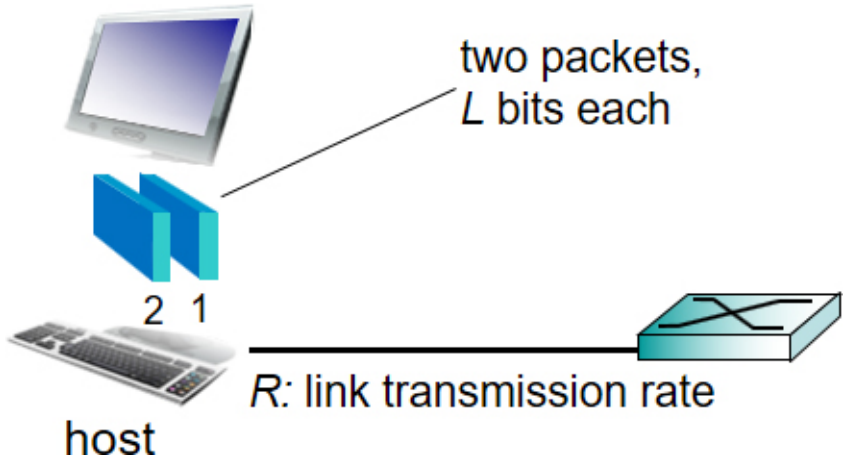
host sending function:

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**



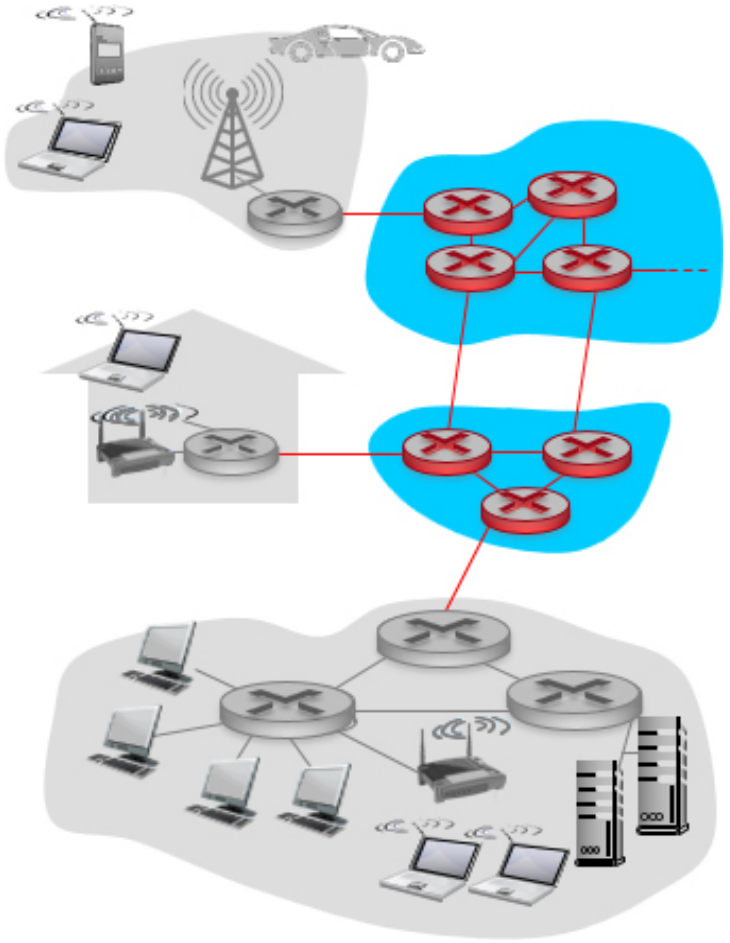

$$\text{packet transmission delay} = \text{time needed to transmit } L\text{-bit packet into link} = \frac{L(\text{bits})}{R\left(\frac{\text{bits}}{\text{sec}}\right)}$$

# The Network Core

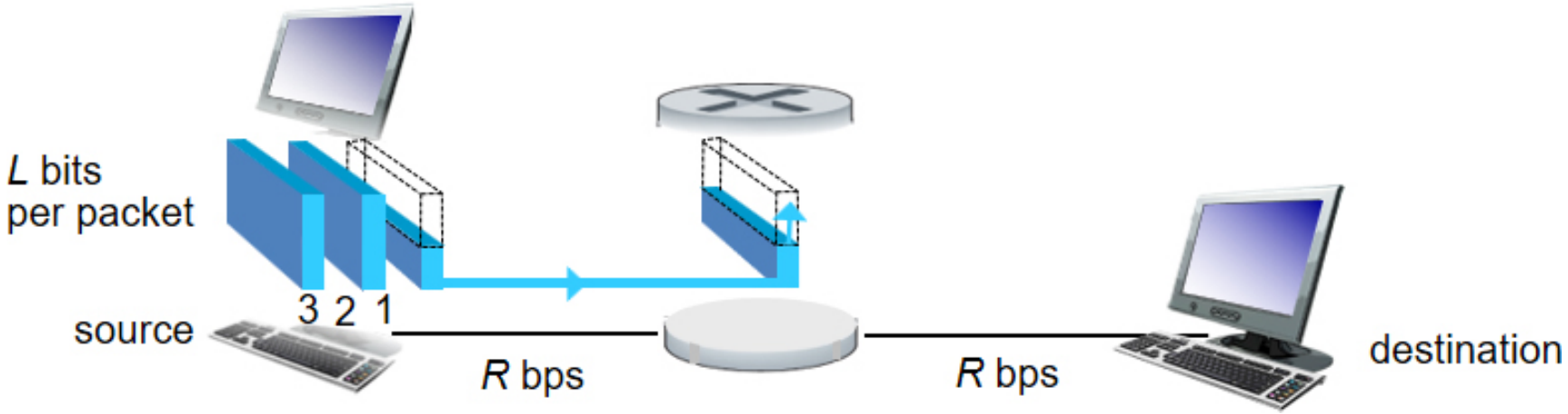
mesh of interconnected routers

packet-switching: hosts break application-layer messages into packets

- forward packets from one router to the next, across links on path from source to destination
- each packet transmitted at full link capacity



# Packet-Switching: Store-and-Forward (1 of 3)



# Packet-Switching: Store-and-Forward (2 of 3)

takes $\frac{L}{R}$ seconds to transmit (push out) *L*-bit packet into link at *R* bps

**store and forward:** entire packet must arrive at router before it can be transmitted on next link

$$\text{end-end delay} = \frac{2L}{R} \left\{ \begin{array}{l} (\text{assuming} \\ \text{zero propagation delay}) \end{array} \right.$$

more on delay shortly …

# Packet-Switching: Store-and-Forward (3 of 3)

**one-hop numerical example:**

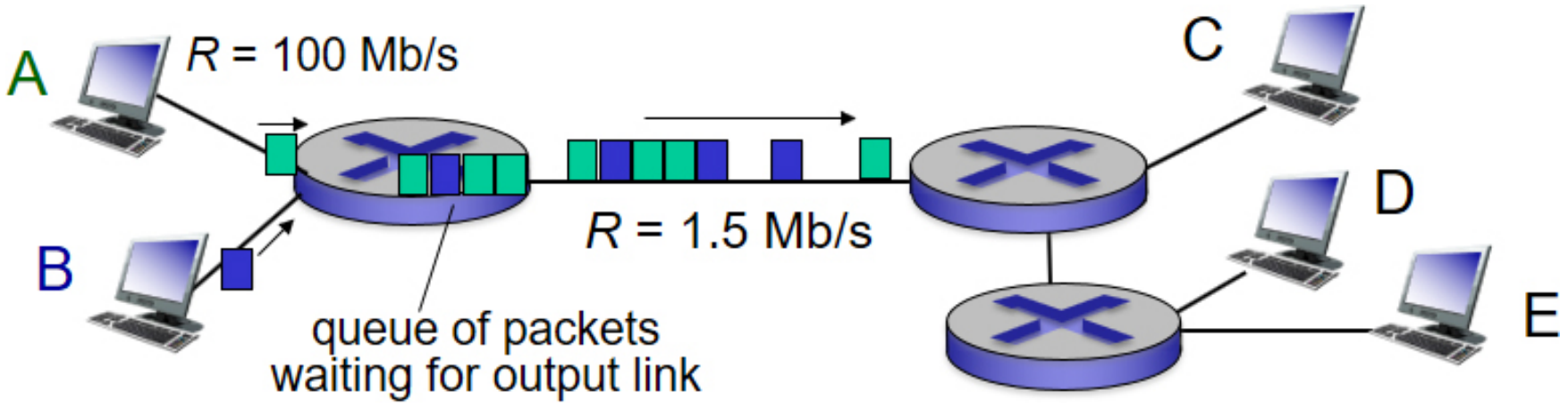
$L$ = 7.5 Mbits

$R$ = 1.5 Mbps

one-hop transmission delay = L/R= 7.5 Mbits/1.5 Mbps = 5 sec

# Packet Switching: Queueing Delay, Loss




**queuing and loss:**

if arrival rate (in bits) to link exceeds transmission rate of link for a period of time:

- packets will queue, wait to be transmitted on link
- packets can be dropped (lost) if memory (buffer) fills up