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

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
8th 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

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 <u>computers connected together</u> to communicate, exchange data, and share resources in real time
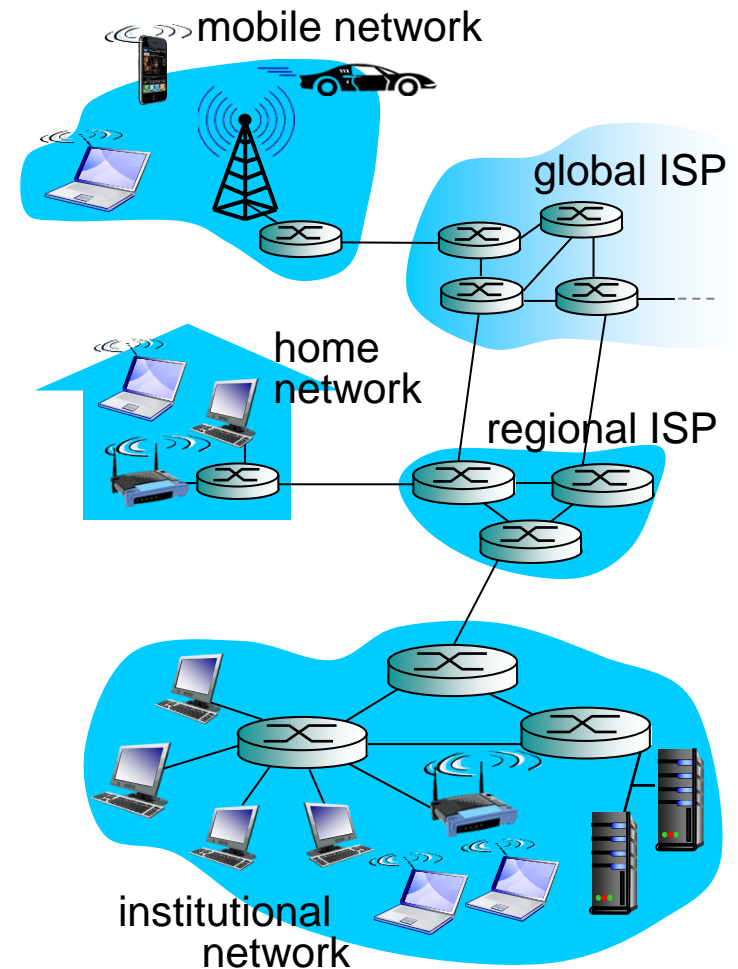

8

Network Enables...
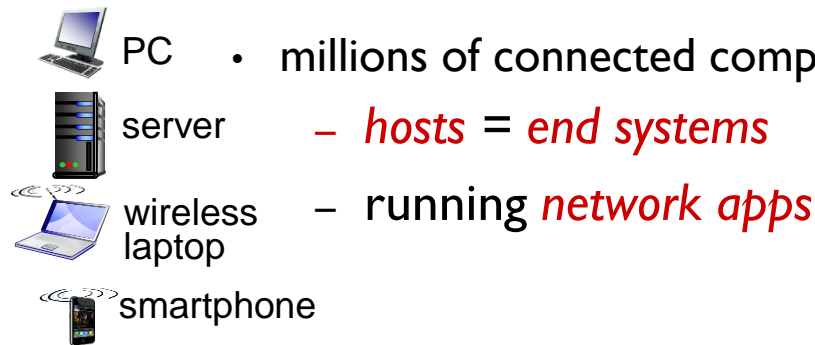
- Simultaneous access to data
    - Data files are shared
        - Data are stored in a centralized place
        - All users have access to identical, up-to-date information
    - Software can also be shared
        - Site licenses

- 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

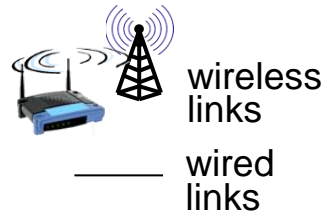- *Internet:* "network of networks"
  - Interconnected ISPs

mobile network

global ISP

home network

regional ISP

institutional network

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

PC

server

wireless laptop

smartphone

- millions of connected computing devices:
  - *hosts* = *end systems*
  - running *network apps*

mobile network

global ISP

home network

regional ISP

❖ *communication links*

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

wireless links

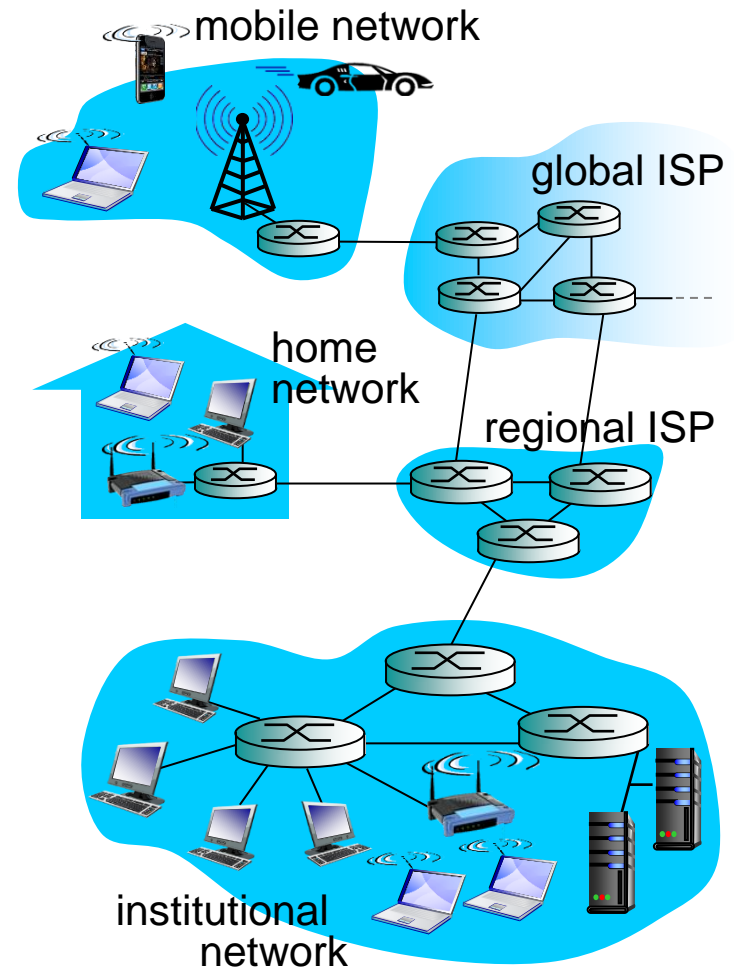wired links

router

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

- *routers* and *switches*

institutional network
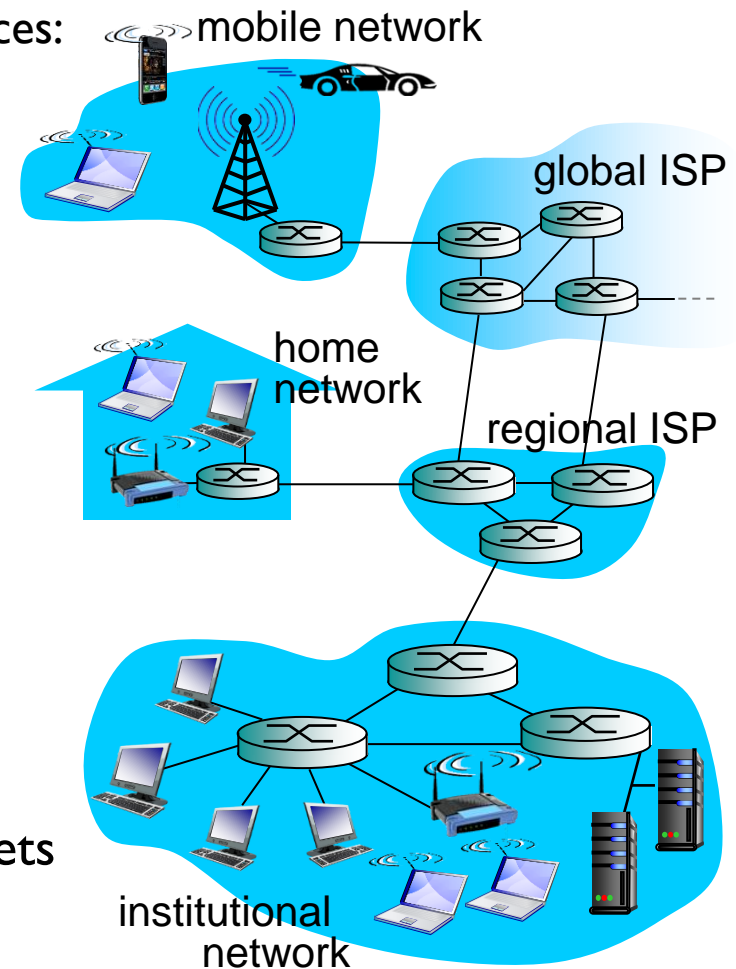
What's the Internet: a service view

- *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

mobile network

global ISP

home network

regional ISP

institutional network

1-12

Introduction

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

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

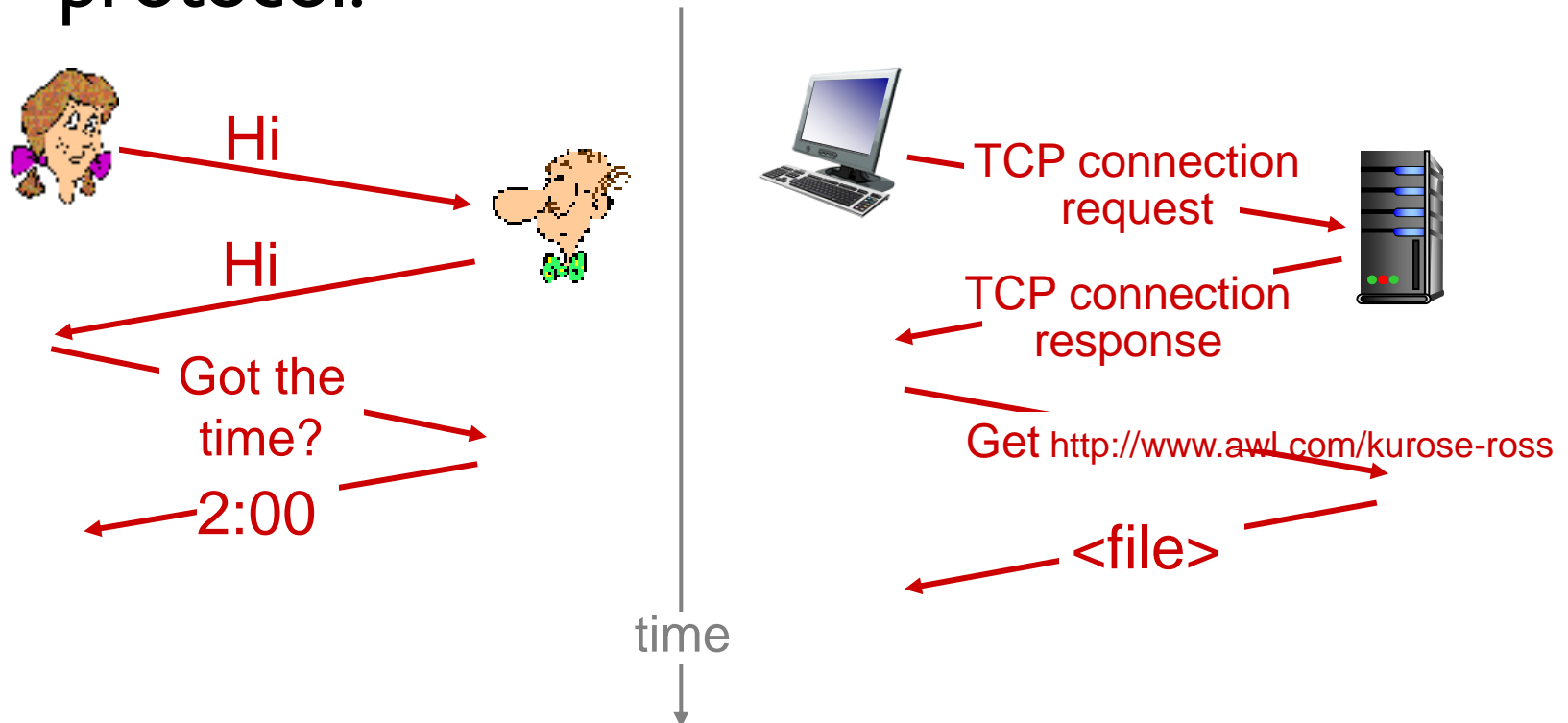- Security

- Protocol layers, service models

- History

Introduction: 1-14

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:

Hi

Hi

Got the time?

2:00

TCP connection request

TCP connection response

Get http://www.awl.com/kurose-ross

<file>

time

Q: other human protocols?

Introduction

1-16

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

Tweet-a-watt:
monitor energy use

Pacemaker & Monitor

bikes

Amazon Echo

IP picture frame

Web-enabled toaster +
weather forecaster

Internet
refrigerator

cars

Slingbox: remote
control cable TV

Security Camera

AR devices

scooters

sensorized,
bed
mattress

Gaming devices

Others?

Internet phones

Fitbit

Introduction: 1-18

# 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
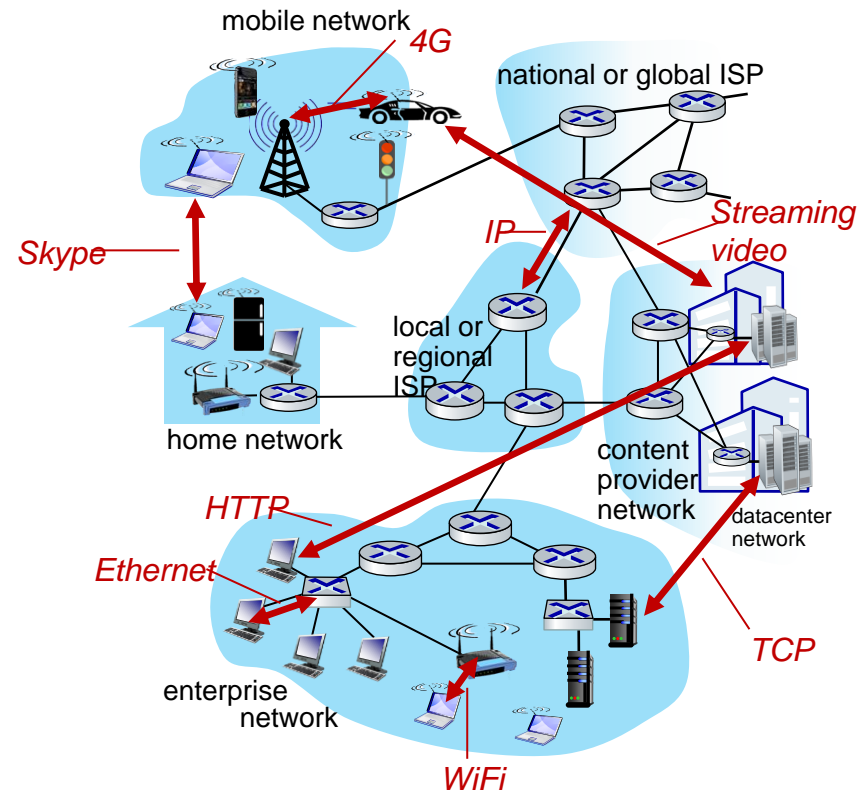
Introduction: 1-19

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
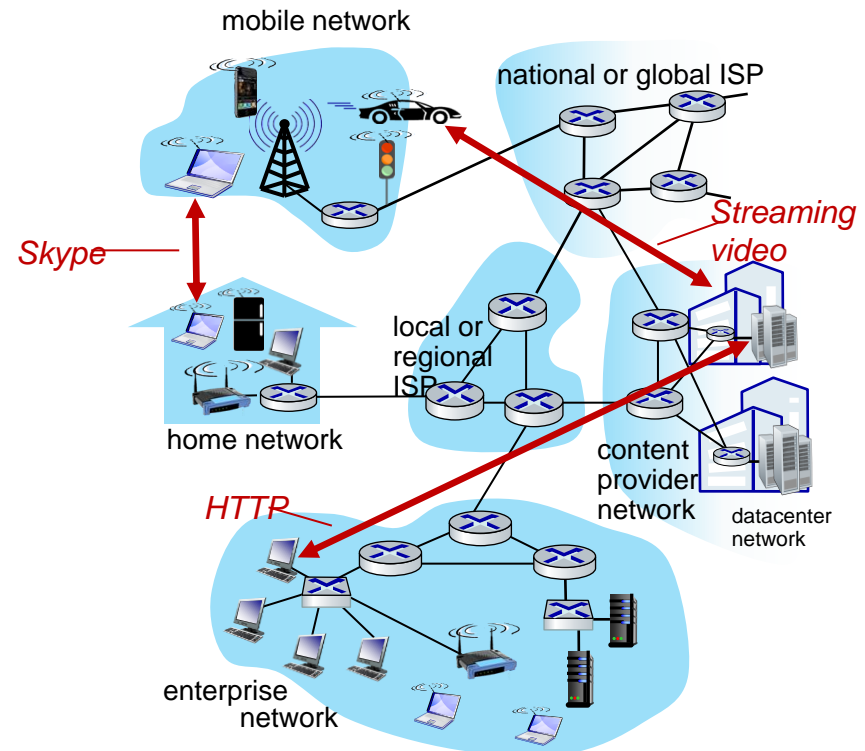


Introduction: 1-20

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

A closer look at Internet structure

Network edge:

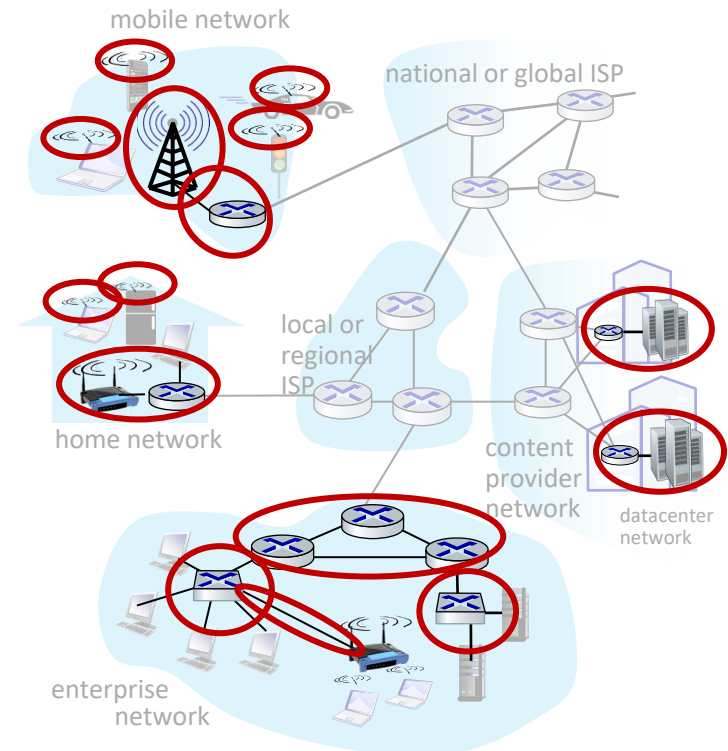- hosts: clients and servers

- servers often in data centers
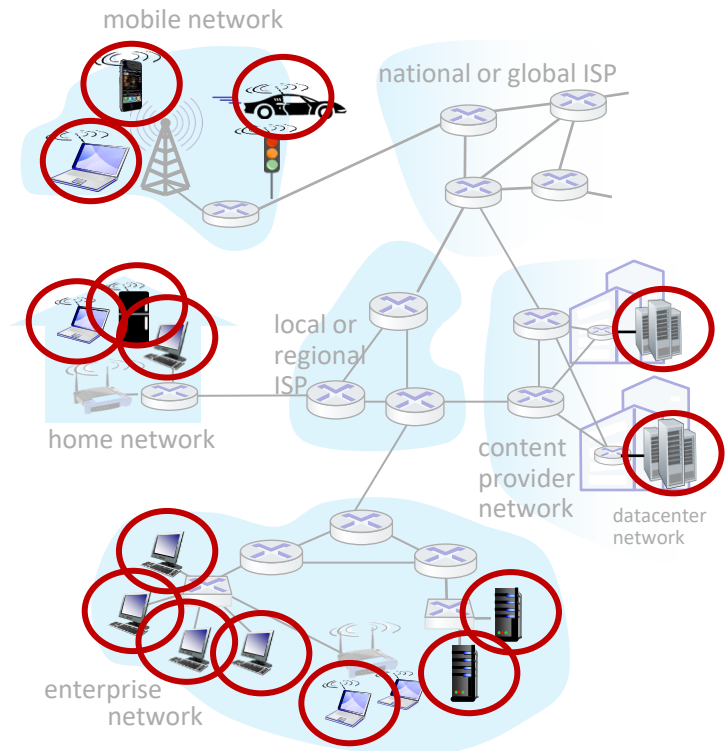
A closer look at Internet structure

Network edge:

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

Access networks, physical media:

- wired, wireless communication links
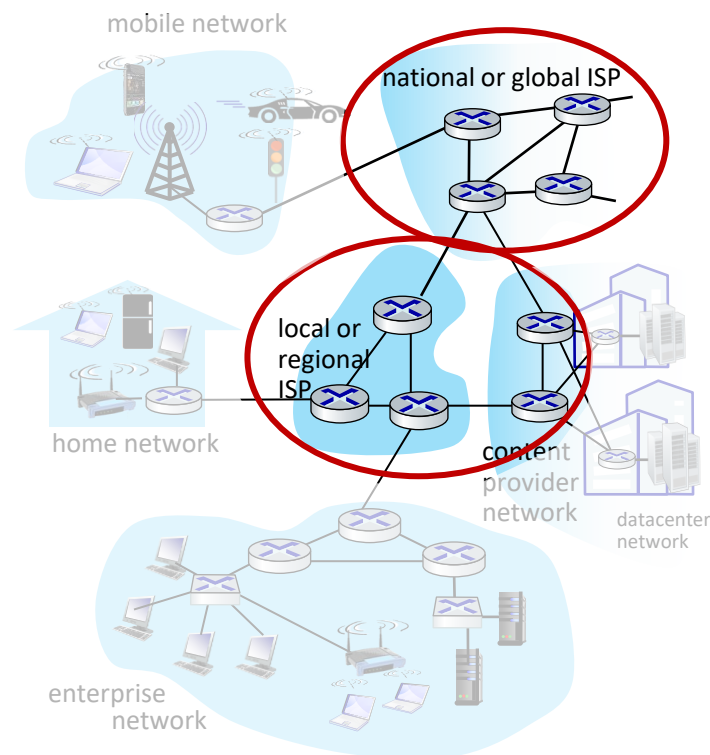
A closer look at Internet structure

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

mobile network

national or global ISP

local or regional ISP

home network

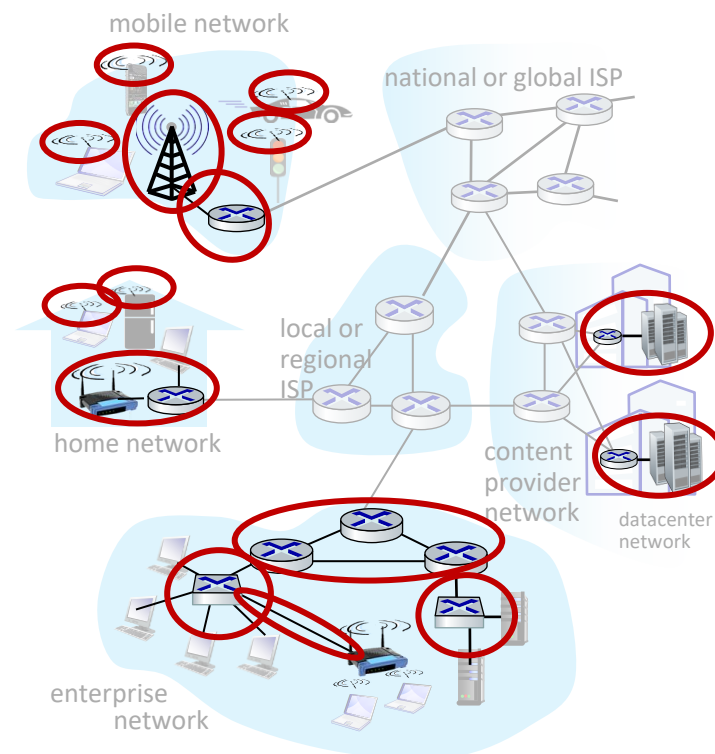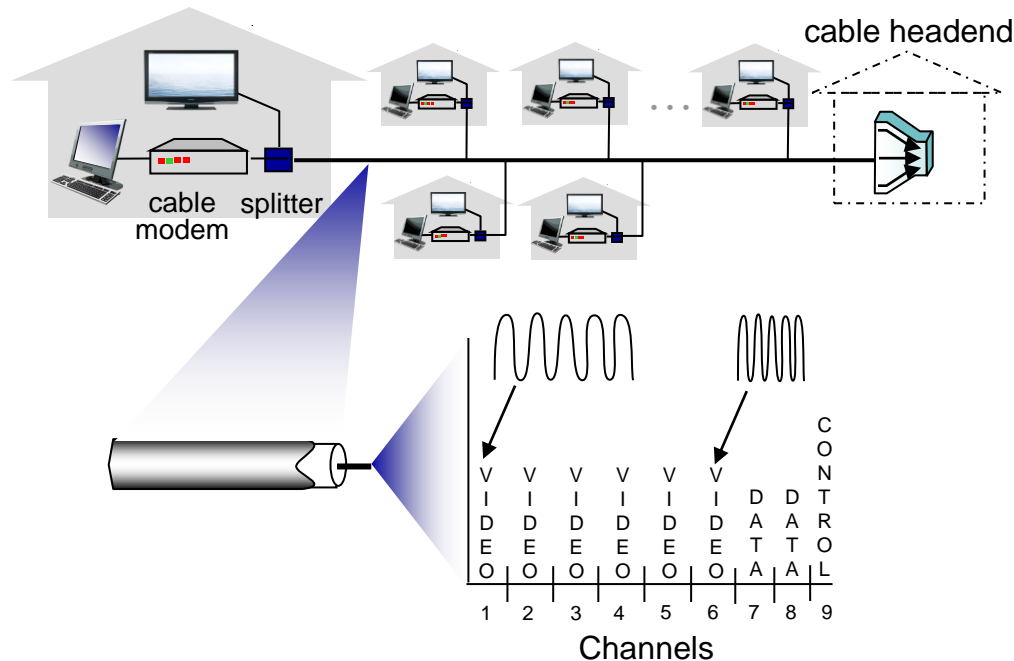content provider network

datacenter network

enterprise network

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)

mobile network

national or global ISP

local or regional ISP

home network

content provider network

datacenter network
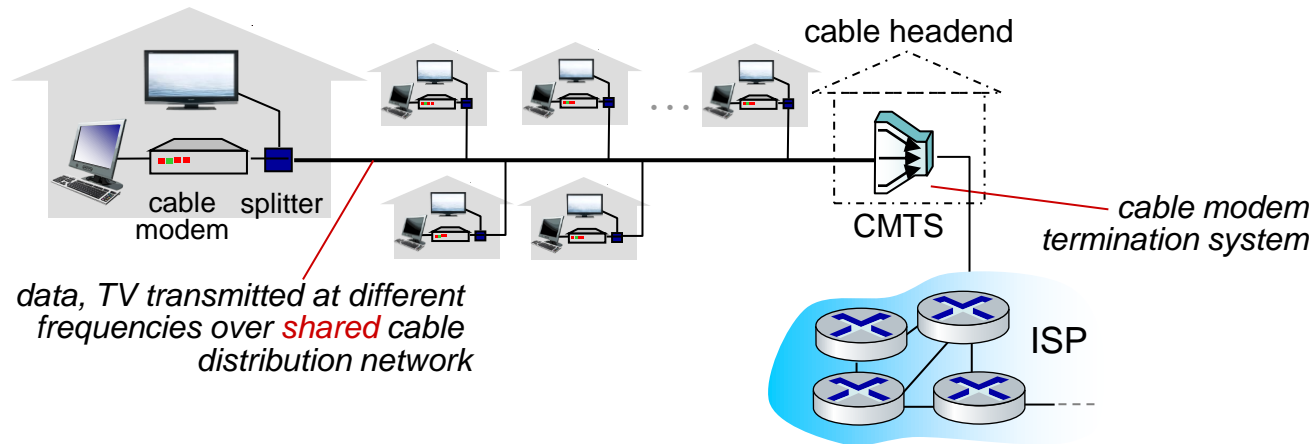
enterprise network

Access networks: cable-based access

frequency division multiplexing (FDM): different channels transmitted in different frequency bands
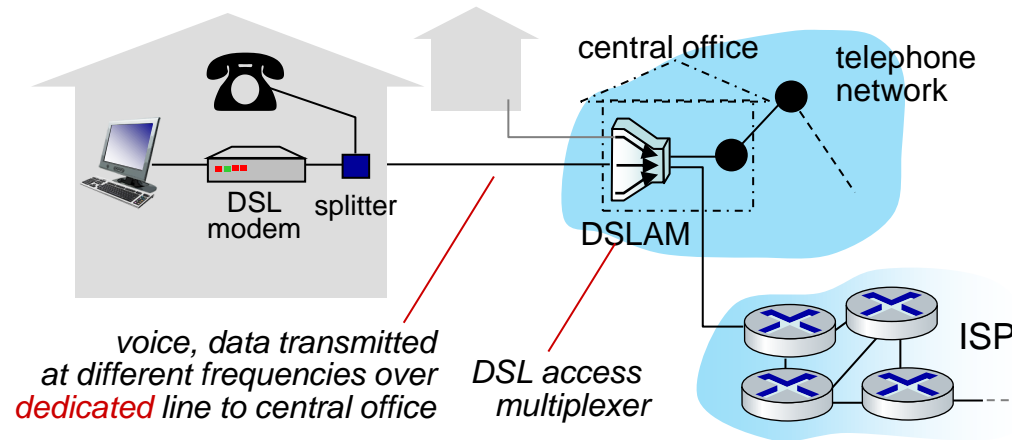
Access networks: cable-based access

- cable headend
- cable modem
- splitter
- *data, TV transmitted at different frequencies over shared cable distribution network*
- CMTS
- *cable modem termination system*
- ISP

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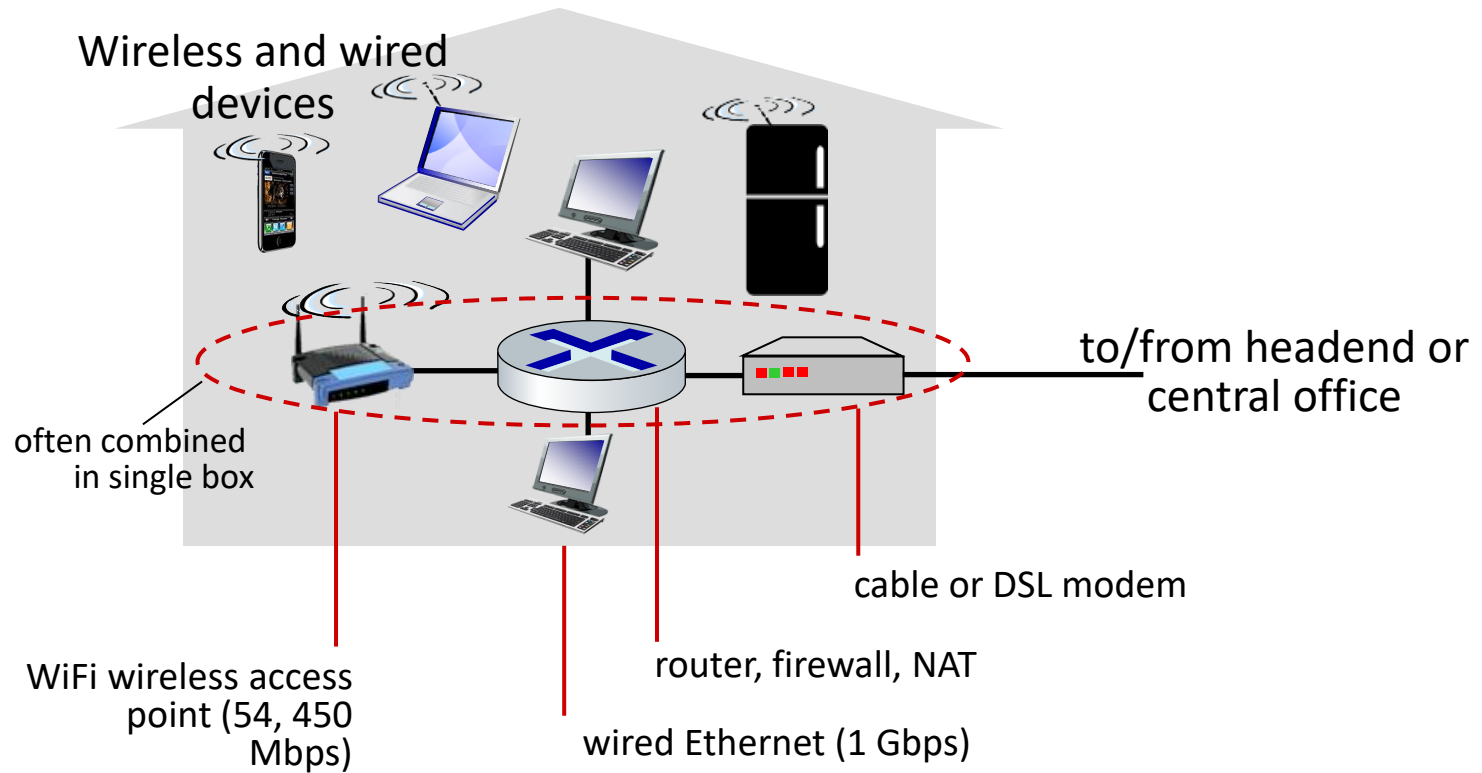- ■ network of cable, fiber attaches homes to ISP router
  - • homes *share access network* to cable headend

Access networks: digital subscriber line (DSL)

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
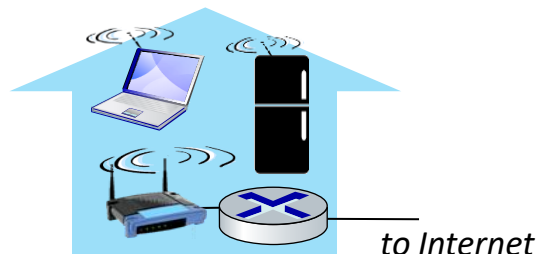
Access networks: home networks

Wireless and wired 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)

Wireless access networks

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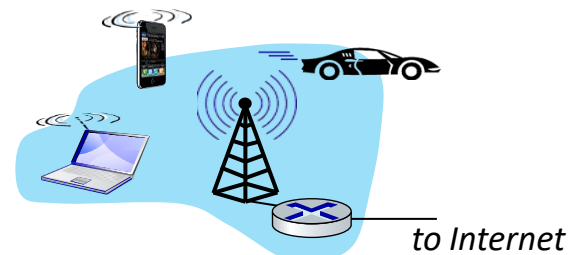
- via base station aka "access point"

Wireless local area networks (WLANs)

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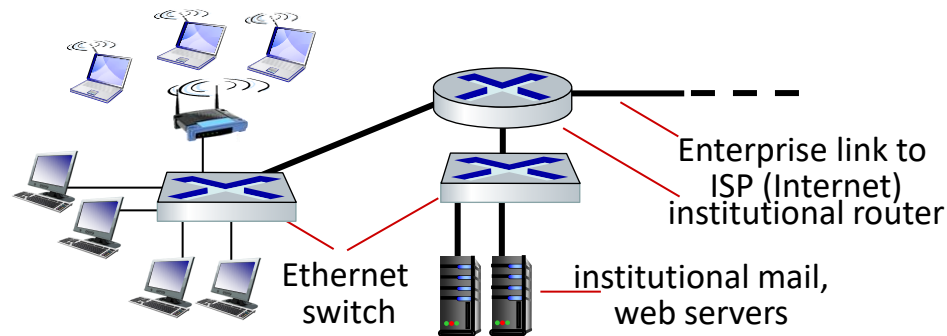- 802.11b/g/n (WiFi): 11, 54, 450 Mbps transmission rate

to Internet

Wide-area cellular access networks

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

to Internet

Access networks: enterprise networks

Enterprise link to
ISP (Internet)
institutional router

Ethernet
switch
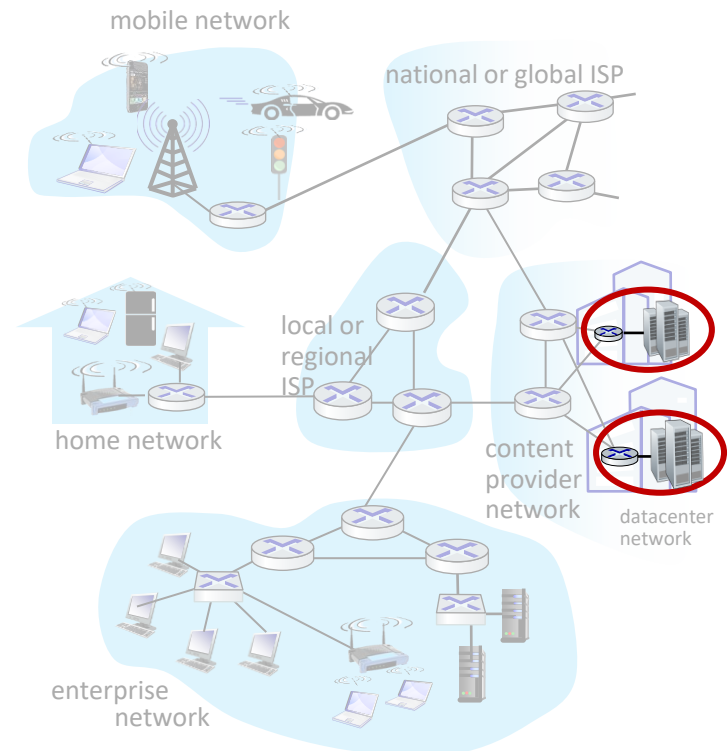
institutional mail,
web servers

- 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

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)


mobile network

national or global ISP

local or regional ISP

home network

content provider network

datacenter network

enterprise network

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*

two packets, *L* bits each

2 1

host

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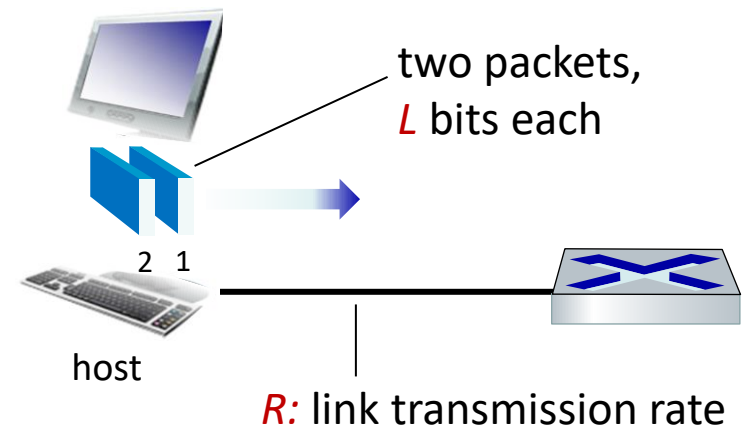
$$\text{packet transmission delay} = \text{time needed to transmit } L\text{-bit packet into link} = \frac{L \text{ (bits)}}{R \text{ (bits/sec)}}$$

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
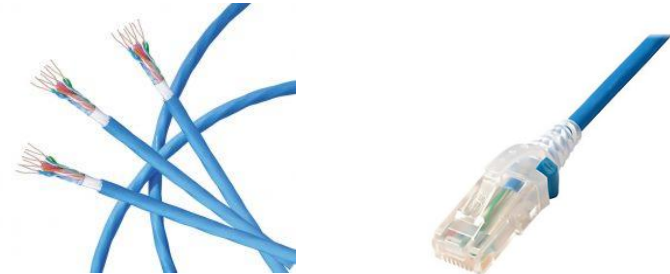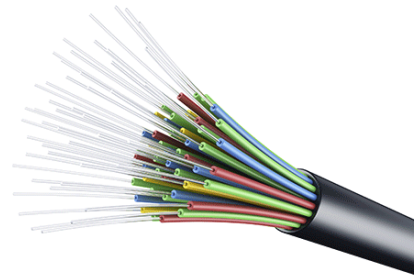
Links: physical media

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
8th edition
Jim Kurose, Keith Ross
Addison-Wesley

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.