CS 305
Computer Networks
Fall 2019

Jin Zhang
Department of Computer Science and Engineering

Course Information

Lecture:

- Instructor: Professor Jin Zhang, zhang.j4@sustech.edu.cn,
  Office: Room 904, Building A7, Nanshan Zhiyuan
- Lectures: Monday 10:20 am – 12:10 am
- Venue: Room 101, 2st building Liyuan,

Lab:

- TA: Wei Wang, wangw6@sustech.edu.cn
  Office: Room 913, Building A7, Nanshan Zhiyuan

- Lab Venue: Room 205, 2nd Teaching building
- Attention: Today's lab is in room 204, 2nd Teaching building

Course Information

Office Hour:

- Monday 16 : 00 – 18 : 00
- Jin Zhang: Room 904, Building A7, Nanshan Zhiyuan

- Tuesday 14:00 – 16:00
- Wei Wang: Room 913, Building A7, Nanshan Zhiyuan

What will we learn in this course?

- What is network? What is communication?
- What networks do we use in daily life? Any other network ever heard?
- What applications require network access?
- What network problems have you ever met in your real life?
- What do you expect to learn in this course?

What is this course about?

What is Data Communications?

- the transmission of digital data between two or more computers or other hosts
- vs. telegram and telephone communications

What is Computer networking?

- a telecommunications network that allows computers to exchange data
- a best known computer network is the Internet
- we use internet to introduce computer network

What is this course about?

introductory (first) course in computer networking

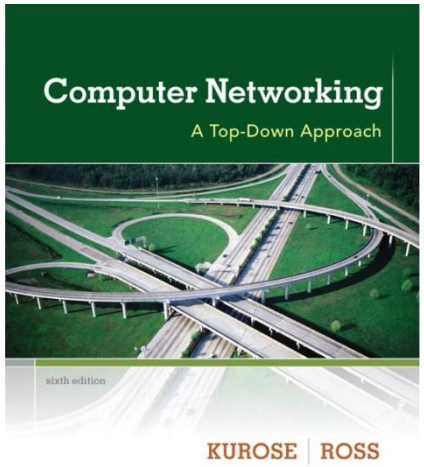
- learn principles of computer networking
- learn practice of computer networking
- Internet architecture/protocols as case study

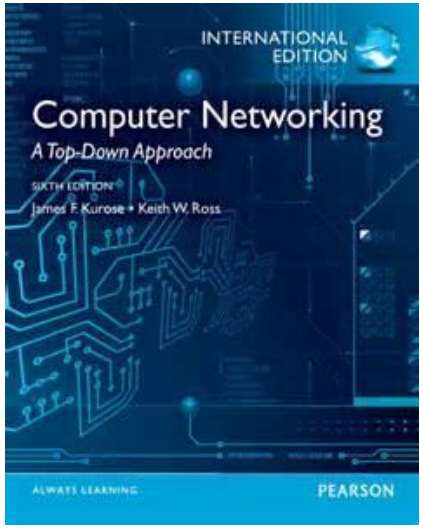
Goals:

- learn a lot (not just factoids, but principles and practice)
- have fun (well, it should be interesting, at least)

Textbook information

- course materials:
  - text: *Computer Networking: A Top Down Approach Featuring the Internet*, J. Kurose & K. Ross, Pearson, 7th ed., 2017
  - slides
- online resources:
  - http://sakai.sustc.edu.cn
  - Textbook in pdf
  - Slides
  - Homework
  - Projects





How to use the textbook?

For each lecture:

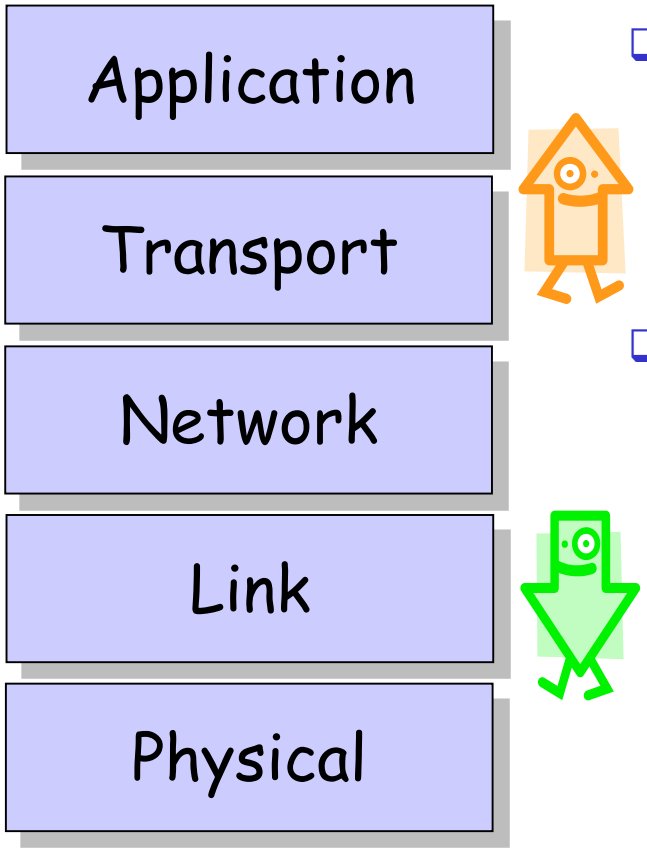
- Read corresponding content after class
- Go through the review questions
- Write homework

After each chapter

- read summary and interview if interested

Textbook information

Computer Networking: A Top-Down Approach, James Kurose and Keith Ross, Pearson (7th Ed.)



- **Bottom Up**: Start with physical (e.g., wires) layer and move up to applications (e.g., mail, web browsers) layer explaining how functions are implemented
- **Top Down** : Start with Application layer and move down to Physical layer, explaining what expectations from applications, and how such services are implemented

Course overview:

Introduction *(2 classes, text: Chapter 1)*

- what is the Internet, what is a protocol?
- network edge, network core, network access
- physical media
- delay, loss, throughput in packet-switched networks
- protocol layers, service models
- Internet backbones, ISPs, IXPs
- brief history of networking, Internet

Course overview:

Application layer *(3 classes, text: Ch. 2)*

- principles of application-layer protocols
- World Wide Web: HTTP
- ~~file transfer: FTP~~ video streaming and content distribution networks
- electronic mail in the Internet
- the Internet's directory service: DNS
- P2P: Skype
- socket programming

Course overview:

Transport layer *(4 classes, text Ch. 3)*

- transport-layer services and principles
- multiplexing and demultiplexing applications
- connectionless transport: UDP
- principles of reliable of data transfer
- TCP case study
- PROGRAMMING ASSIGNMENT 2
- principles of congestion control
- TCP congestion control
- ~~ATM~~ ECN

MIDTERM EXAM (approx)

Course overview:

Network layer *(3 classes, text: Ch. 4)*

- introduction and network service model
- what's inside a router?
- routing principles (algorithms)
- hierarchical routing
- IP: the Internet Protocol
- Internet routing: RIP, OSPF, BGP

In Textbook 7th edition:

Network layer – Data Plane

Network layer – Control Plane

- Software defined network (SDN)

Course overview:

Link layer, LANs *(3 classes, text: Ch. 5)*

- introduction, services
- error detection, correction
- multiple access protocols, LANs
- LAN addresses, ARP
- Ethernet
- network as a link layer: MPLS
- a day in the life of a web request (synthesis)

We will add more physical layer content in this chapter

Course overview:

Wireless and mobile networks (1 classes, Ch 6)

- wireless link characteristics
- the wireless link:
  - 802.11
  - cellular Internet access
  - mobility principles
- mobility in practice:
  - mobile IP
  - mobility in cellular networks

Other Readings

- 《浪潮之巅 》《硅谷之谜》吴军
- 《数学之美 》《文明之光（第三册）》吴军
- 《激荡十年 水大鱼大》吴晓波
- 纪录片《互联网时代》
- KK三部曲 《失控》《科技想要什么》 《必然》

Online Resources:

- Lecture Video of this course in SUSTech：
  http://mooc1.chaoxing.com/course/95497722.html
- http://wps.pearsoned.com/ecs_kurose_compnetw_6/216/55463/14198700.cw/index.html

Lab

Basic content:

- Basic network command
- Packet capture using Wireshark
- Protocol analysis
- Socket programming

Make your hands dirty!

- Setup switch and router
- Setup wireless networks
- Analyze network performance

Grading scheme

Grading is based on

- Written Assignments – 10%
- Lab attendance and reports – 15%
- Programming Project – 15%
  - Submit on time: all the assignments and reports should be submitted in the Sakai system, late submission will not be accepted in the system.
- Midterm Examination - 30%
- Final Examination - 30%

Rules about Plagiarism

No Plagiarism is allowed

- If plagiarism on homework or project is found for the first time, the plagiaristic part is graded as 0 and warning is given to the students
- If plagiarism is found for the second time, the course is graded as 0
- For project report, any sentence that is copied from other paper or article should cite the original source as the reference, otherwise, the report is considered as plagiarism

Submit the commitment letter on Sakai system before homework #1

Tips for attending lecture

- Having 150+ students in one room is horrible
- To get the best use of lecture
  - interactive
  - ask whenever you have question, interrupt whenever you want
  - Ask immediately after the class if you are shy
  - Give me suggestions and feedback frequently
- Get the main idea in class, read the details after class

Tips for this course

- Computer network is a human-invented object
  - No strict right or wrong, science vs. technology
  - limited by many factors → trade-off
- We can meet almost all the content in our daily life
  - Think about: where do we use it when we learn a new application or protocol? What's your own experience?
- Take yourself as the designer of the internet.
  - Think how to design the protocol before learn it.
  - Try every idea out.
- Computer network always mimics social network
  - Computer vs. people
  - Protocol vs. people communication

Tips for this course

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- Computer
  - Computer vs. people
  - Protocol vs. people communication

Be active!
You can change the world!

Chapter 1: introduction

our goal:

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

overview:

- what's the Internet?
- what's a protocol?
- network edge; hosts, access net, physical media
- network core: packet/circuit switching, Internet structure
- performance: loss, delay, throughput
- security
- protocol layers, service models
- history

Chapter 1: roadmap

1.1 what *is* the Internet?

1.2 network edge

- end systems, access networks, links

1.3 network core

- packet switching, circuit switching, network structure

1.4 delay, loss, throughput in networks

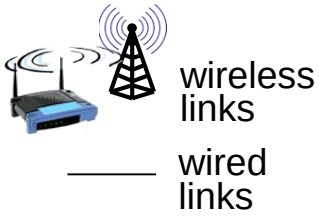
1.5 protocol layers, service models

1.6 networks under attack: security

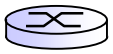
1.7 history

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

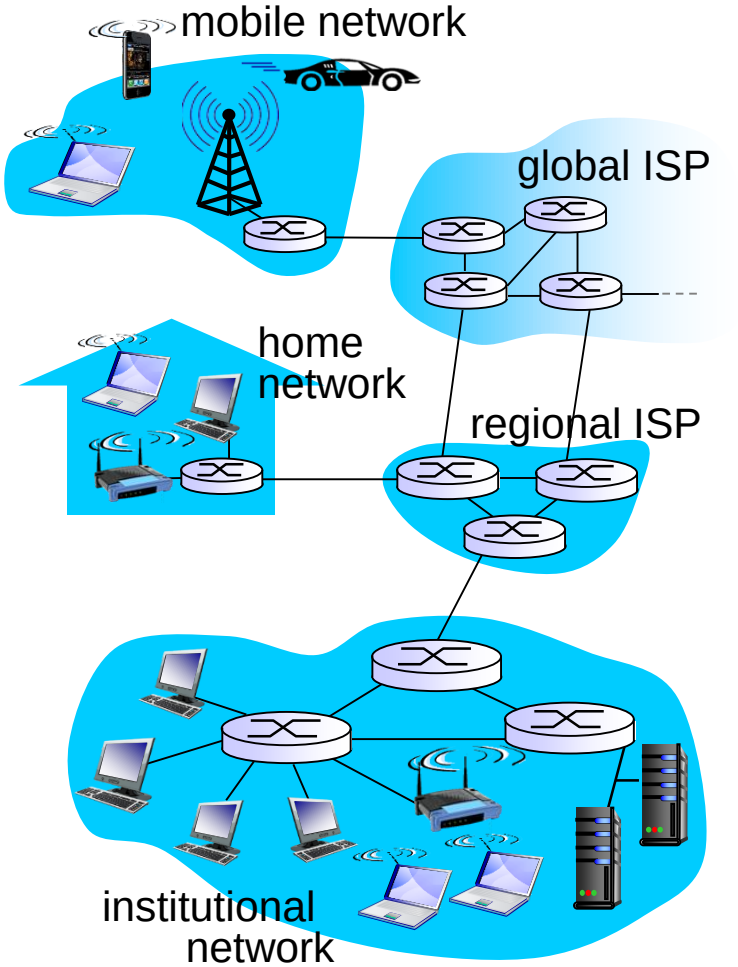
- millions of connected computing devices:
  - *hosts* = *end systems*
  - running *network apps*



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

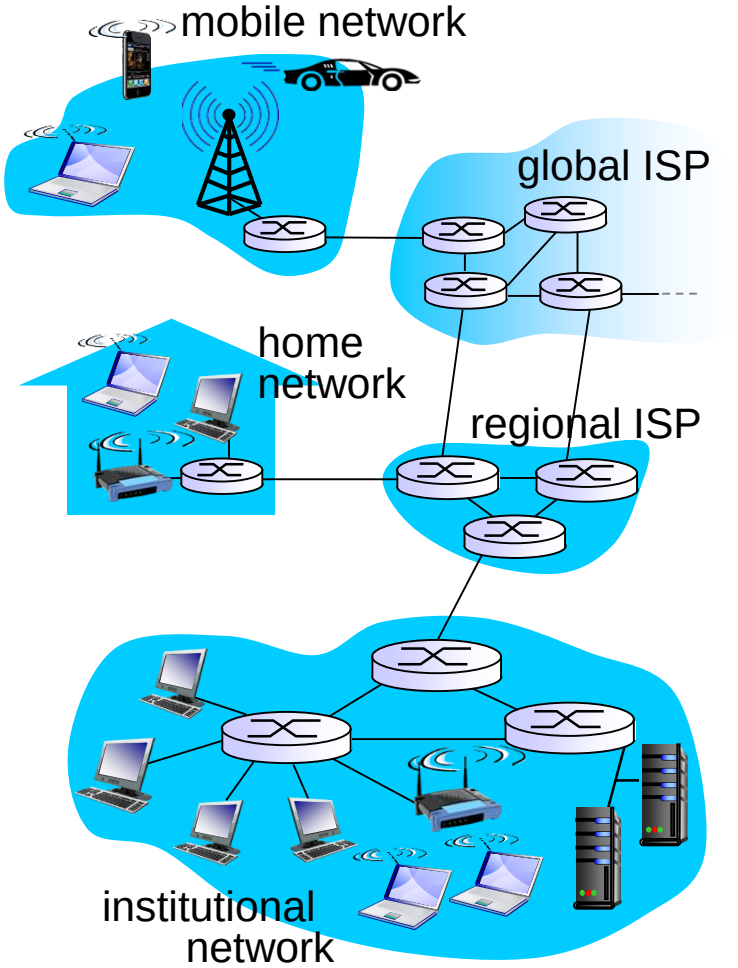


- *Packet switches:* forward packets (chunks of data)
  - *routers* and *switches*



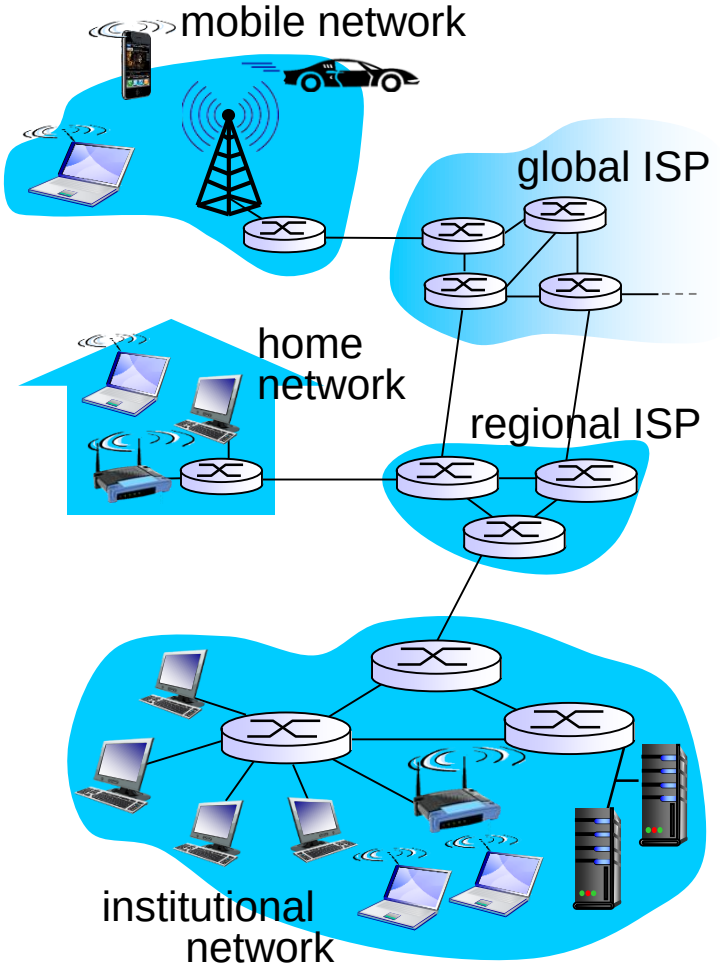
What's the Internet: "nuts and bolts" view

- *Internet:* "network of networks"
  - Interconnected Internet service providers (ISPs)
- *protocols* control sending, receiving of msgs
  - 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?

human protocols:

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

… specific msgs sent

… specific actions taken when msgs received, or other events

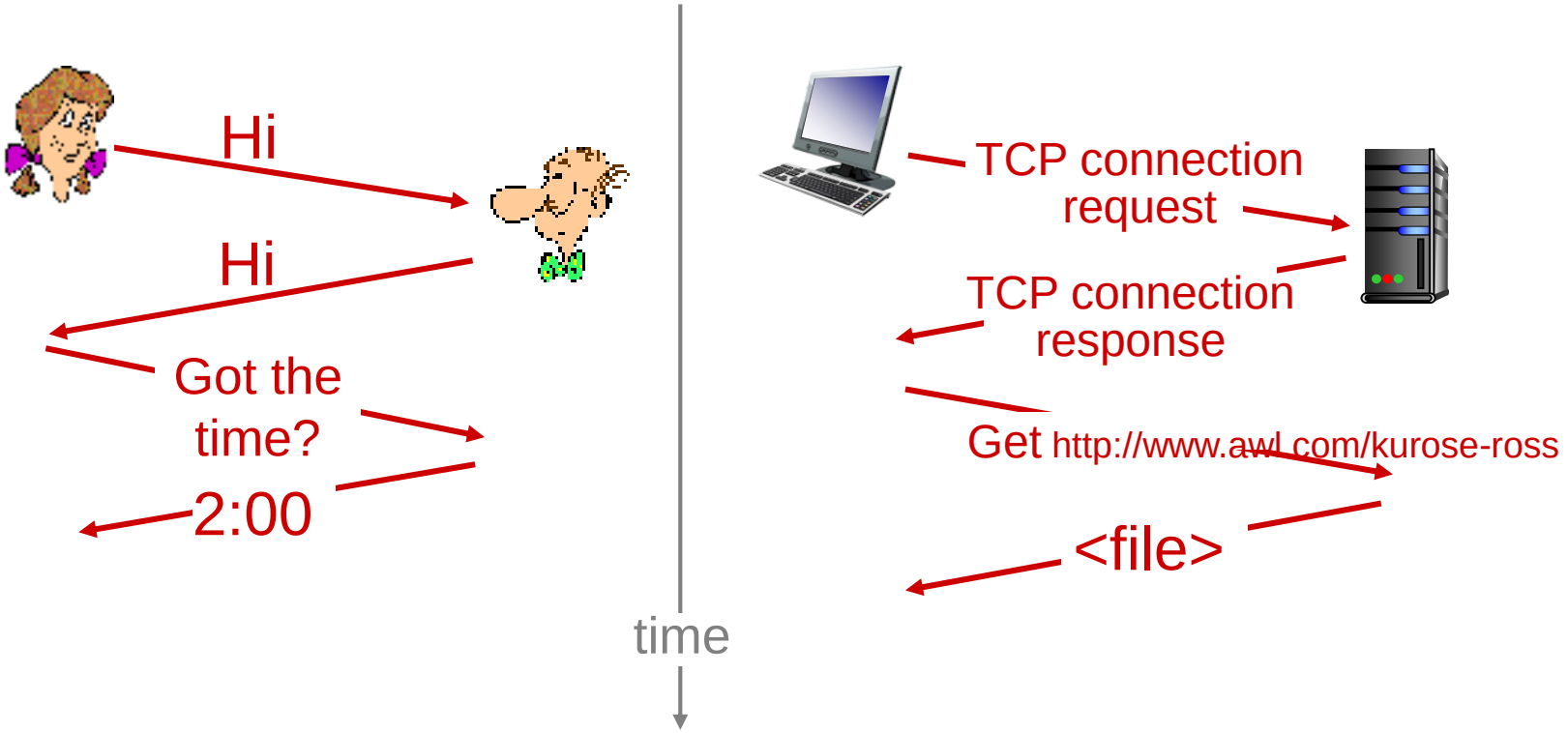
network protocols:

- 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

What's a protocol?

a human protocol and a computer network protocol:



Q: other human protocols?

Chapter 1: roadmap

1.1 what *is* the Internet?

1.2 network edge

- end systems, access networks, links

1.3 network core

- packet switching, circuit switching, network structure

1.4 delay, loss, throughput in networks

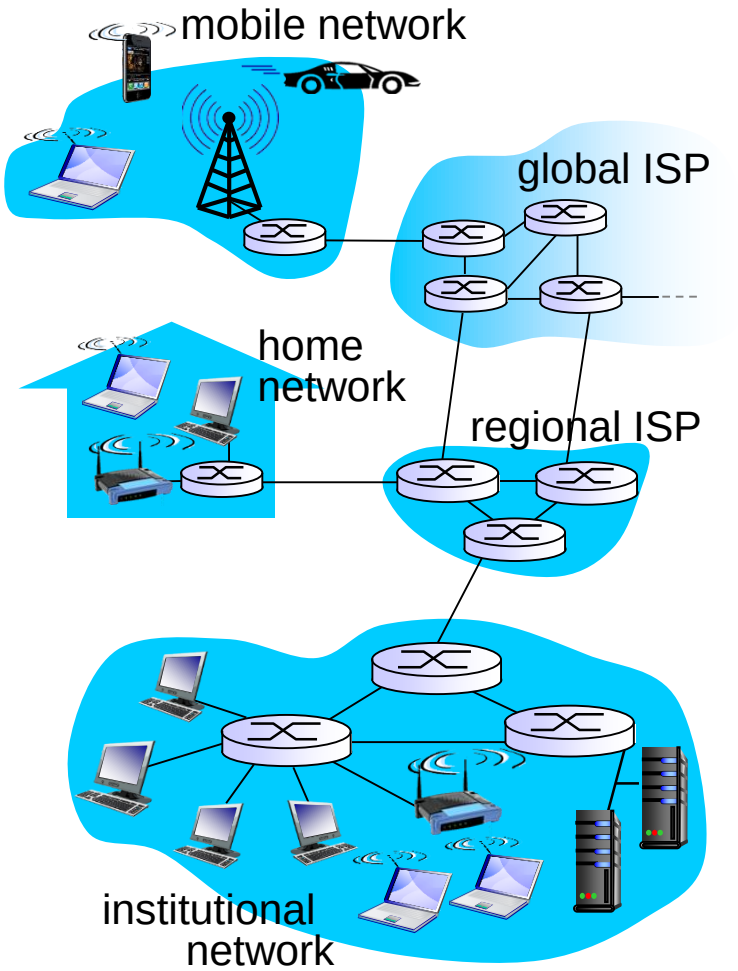
1.5 protocol layers, service models

1.6 networks under attack: security

1.7 history

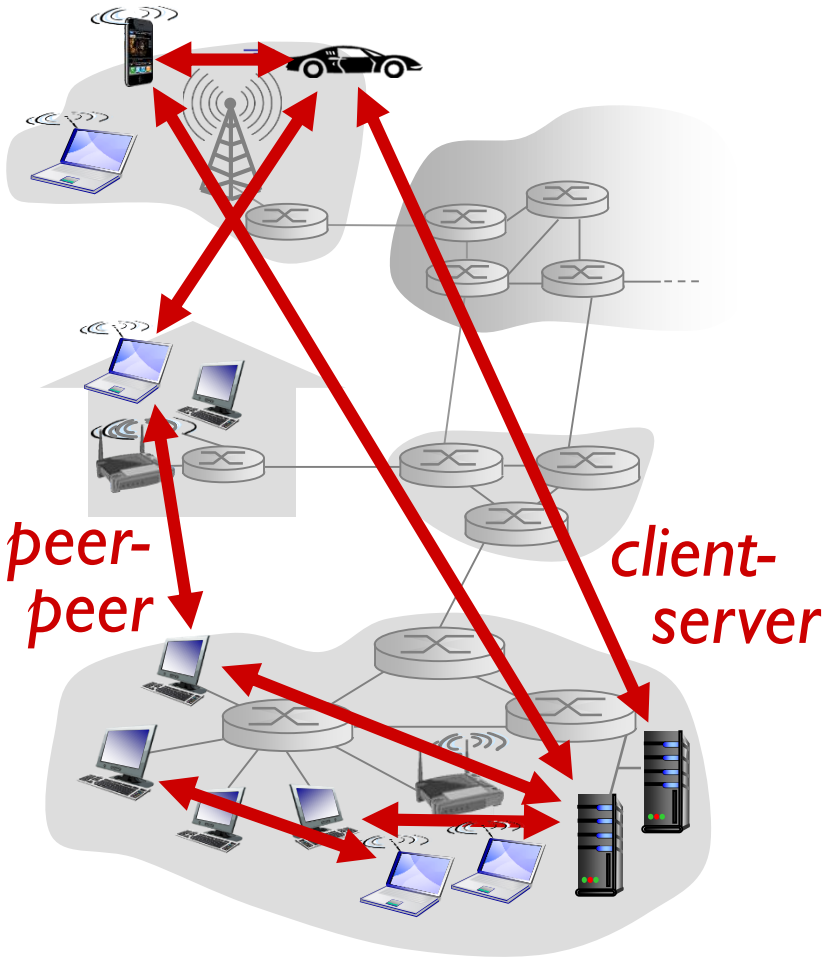
A closer look at network structure:

- *network edge:*
  - hosts: clients and servers
    - servers often in data centers
  - access networks: mobile network, home network, institutional network
  - physical media: wired, wireless communication links
- *network core:*
  - interconnected routers
  - network of networks



The network edge

- *end systems (hosts):*
  - run application programs
  - e.g. Web, email
  - at "edge of network"
- *client/server model*
  - client host requests, receives service from always-on server
  - e.g., Web browser/server; email client/server
- *peer-peer model:*
  - minimal (or no) use of dedicated servers
  - e.g. Skype, BitTorrent



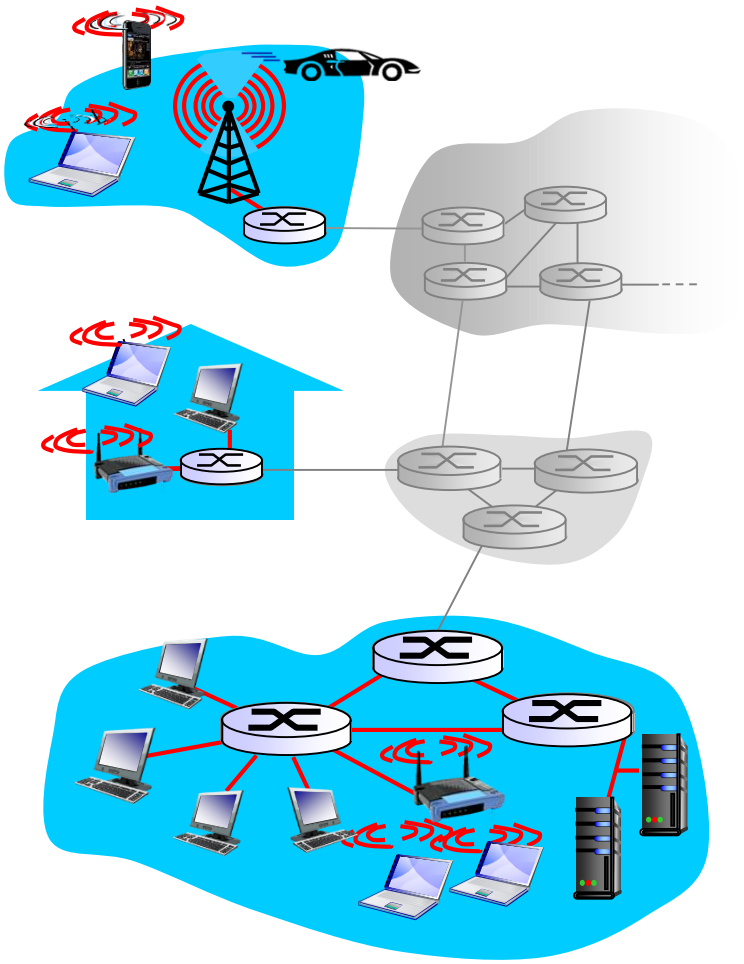
Access networks and physical media

Q: How to connect end systems to edge router?

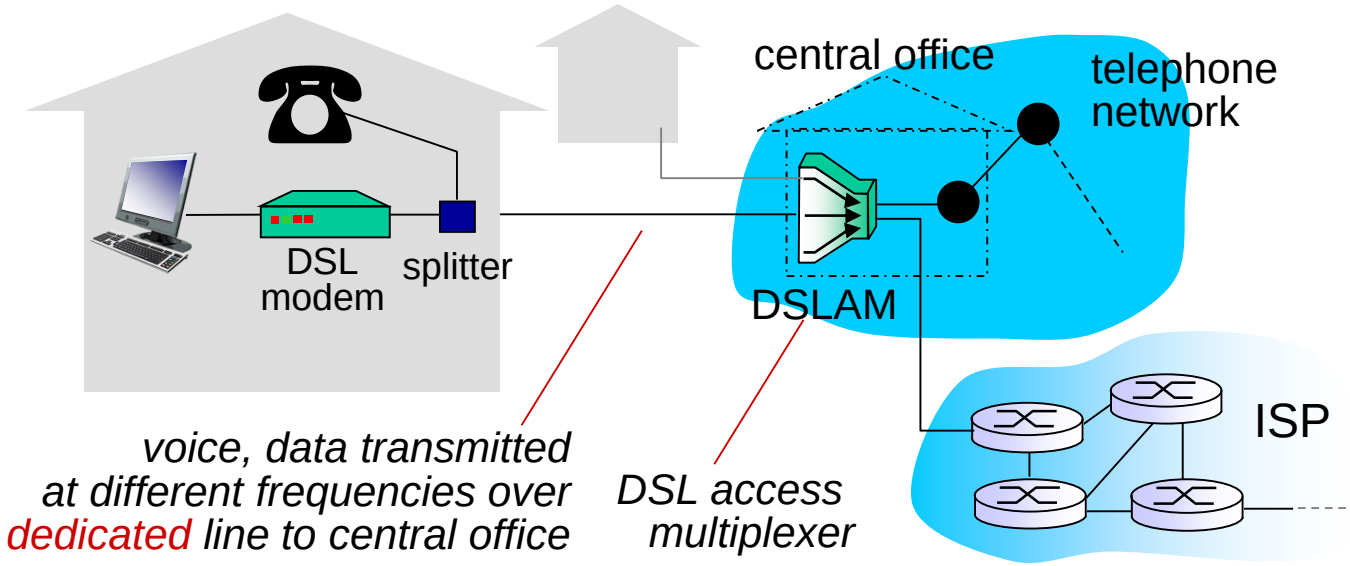
- residential access nets
- institutional access networks (school, company)
- mobile access networks

keep in mind:

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

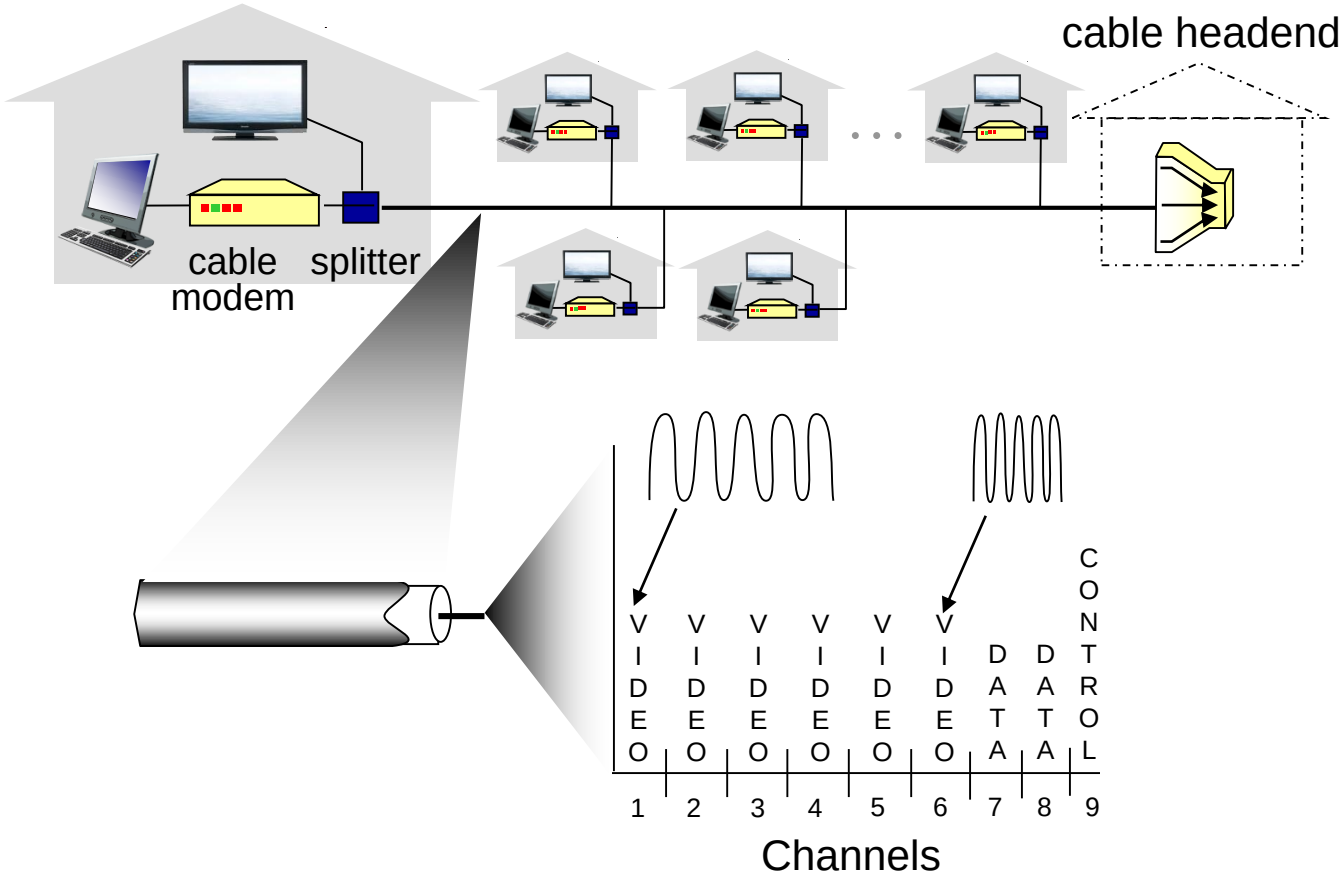


Access net: digital subscriber line (DSL)



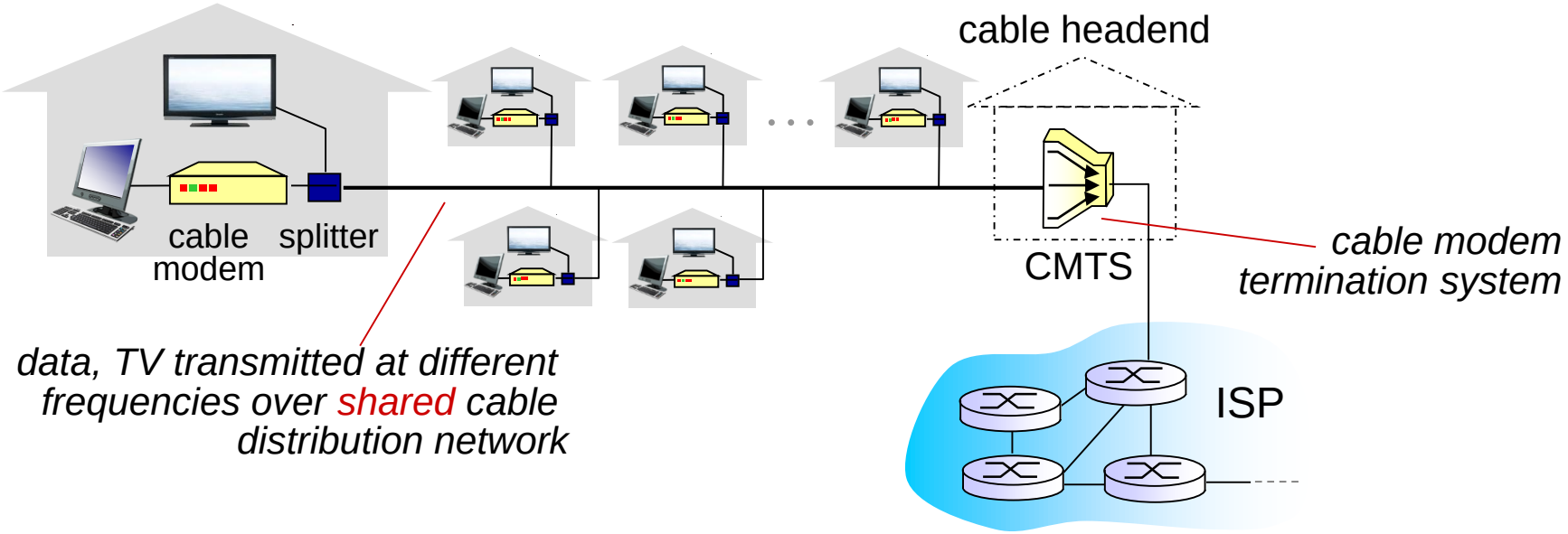
- use *existing* telephone line to central office DSLAM
  - data over DSL phone line goes to Internet
  - voice over DSL phone line goes to telephone net
- < 2.5 Mbps upstream transmission rate (typically < 1 Mbps)
- < 24 Mbps downstream transmission rate (typically < 10 Mbps)

Access net: cable network



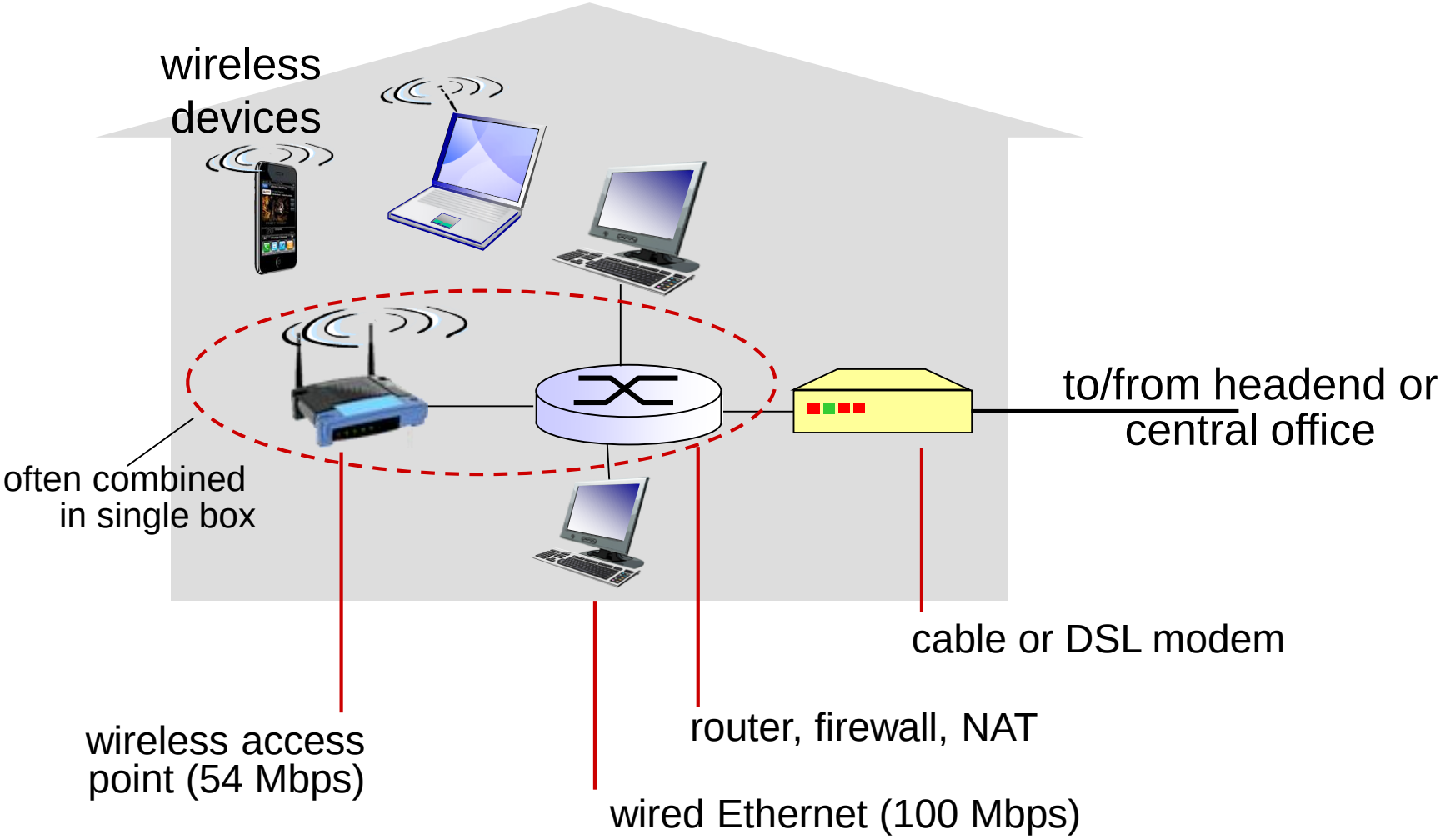
frequency division multiplexing: different channels transmitted in different frequency bands

Access net: cable network

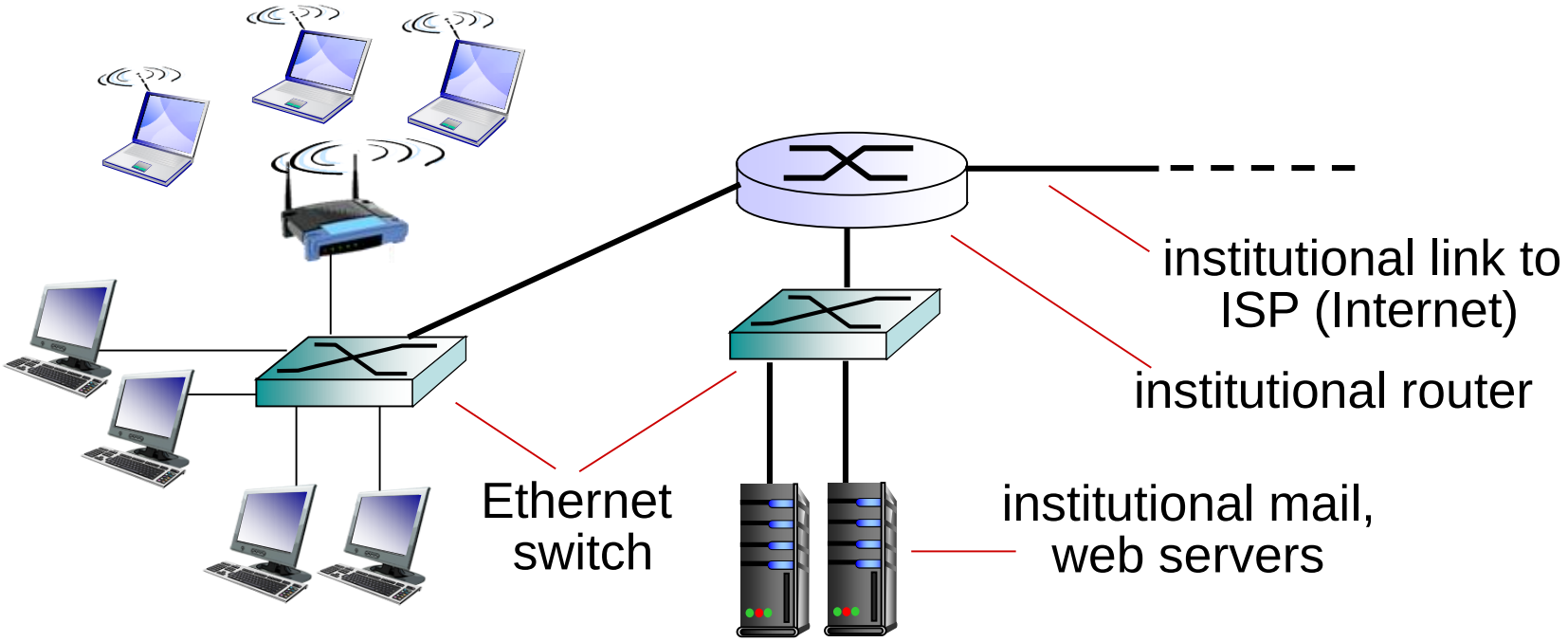


- HFC: hybrid fiber coax
  - asymmetric: up to 30Mbps downstream transmission rate, 2 Mbps upstream transmission rate
- network of cable, fiber attaches homes to ISP router
  - homes *share access network* to cable headend
  - unlike DSL, which has dedicated access to central office

Access net: home network



Enterprise access networks (Ethernet)



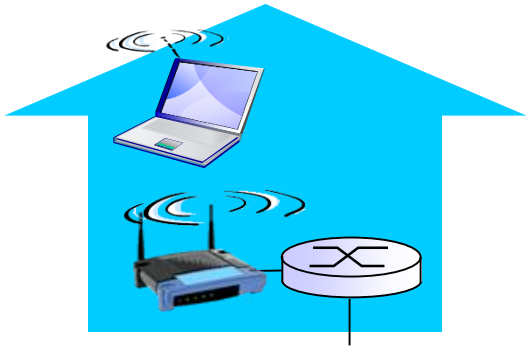
- typically used in companies, universities, etc
- 10 Mbps, 100Mbps, 1Gbps, 10Gbps transmission rates
- today, end systems typically connect into Ethernet switch

Wireless access networks

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

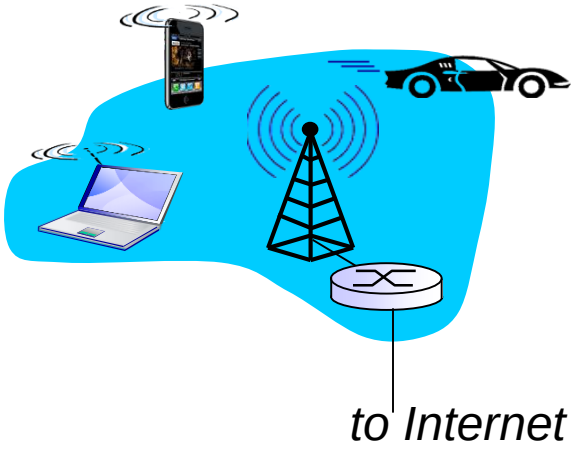
wireless LANs:

- within building (100 ft)
- 802.11b/g/n/ac (WiFi): 11, 54, 800, 1733 Mbps transmission rate



wide-area wireless access

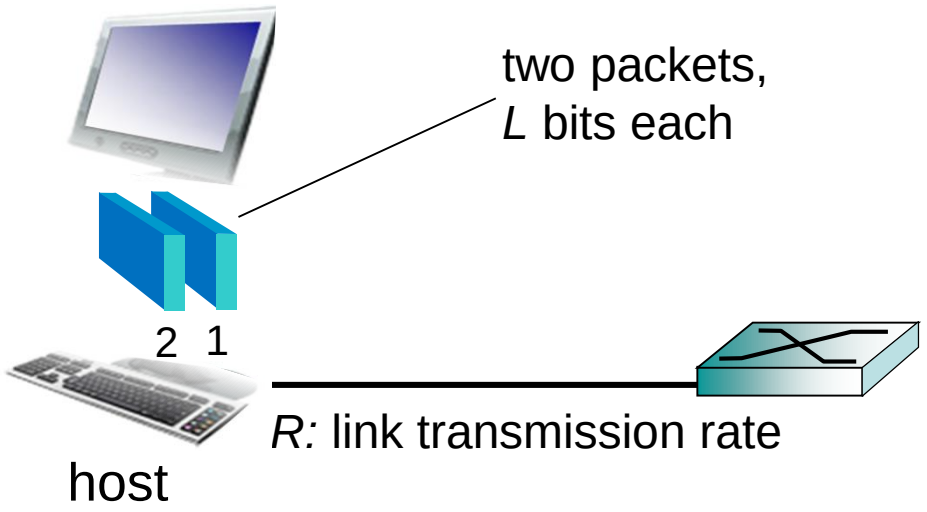
- provided by telco (cellular) operator, 10's km
- 10 Mbps, 100Mbps, 10Gbps
- 3G, 4G, 5G



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*



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

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

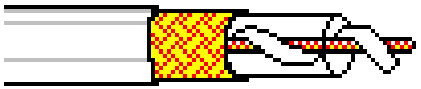
twisted pair (TP)

- two insulated copper wires
  - Category 5: 100 Mbps, 1 Gpbs Ethernet
  - Category 6: 10Gbps

Physical media: coax, fiber

coaxial cable:

- two concentric copper conductors
- bidirectional
- broadband:
  - multiple channels on cable
  - HFC



fiber optic cable:

- glass fiber carrying light pulses, each pulse a bit
- high-speed operation:
  - high-speed point-to-point transmission (e.g., 10's-100's Gpbs transmission rate)
- low error rate:
  - repeaters spaced far apart
  - immune to electromagnetic noise

Physical media: radio

- signal carried in electromagnetic spectrum
- no physical "wire"
- bidirectional
- propagation environment effects:
  - reflection
  - obstruction by objects
  - interference

radio link types:

- terrestrial microwave
  - e.g. up to 45 Mbps channels
- LAN (e.g., WiFi)
  - 11Mbps, 54 Mbps
- wide-area (e.g., cellular)
  - 3G cellular: ~ few Mbps
- satellite
  - Kbps to 45Mbps channel (or multiple smaller channels)
  - 270 msec end-end delay
  - geosynchronous versus low altitude