

# CS 305 Computer Networks

*Fall 2021*

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Department of Computer Science and Engineering

# Course Information

## *Lecture:*

- ❖ Instructor: Professor Jin Zhang, [zhangj4@sustech.edu.cn](mailto:zhangj4@sustech.edu.cn),  
Office: Room 414, College of Engineering (South)
- ❖ Lectures: Monday 10:20 am – 12:10 am
- ❖ Venue: Room 102, 1<sup>st</sup> building Liyuan

## *Lab:*

- ❖ Wei Wang, [wangw6@sustech.edu.cn](mailto:wangw6@sustech.edu.cn)  
Qing Wang, [wangq9@mail.sustech.edu.cn](mailto:wangq9@mail.sustech.edu.cn)
- ❖ Lab Venue: Room 204, 2<sup>nd</sup> Teaching building

# 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 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)

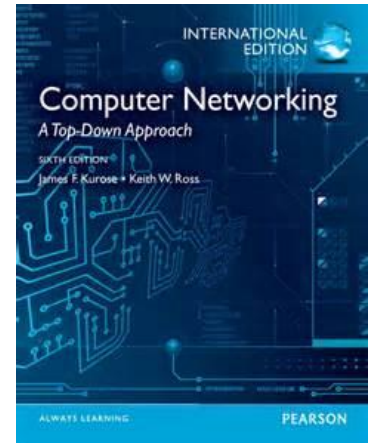
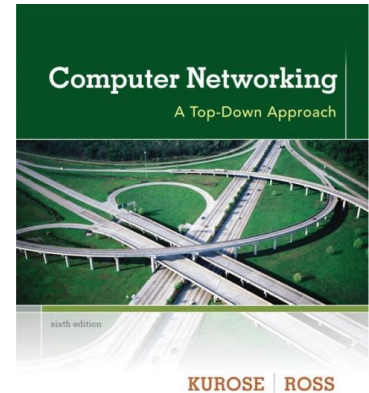
# Textbook information

## ❖ 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.sustech.edu.cn>
- Textbook in pdf
- Slides
- Videos (in blackboard system)
- Homework
- Projects



# How to use the textbook?

For each lecture:

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

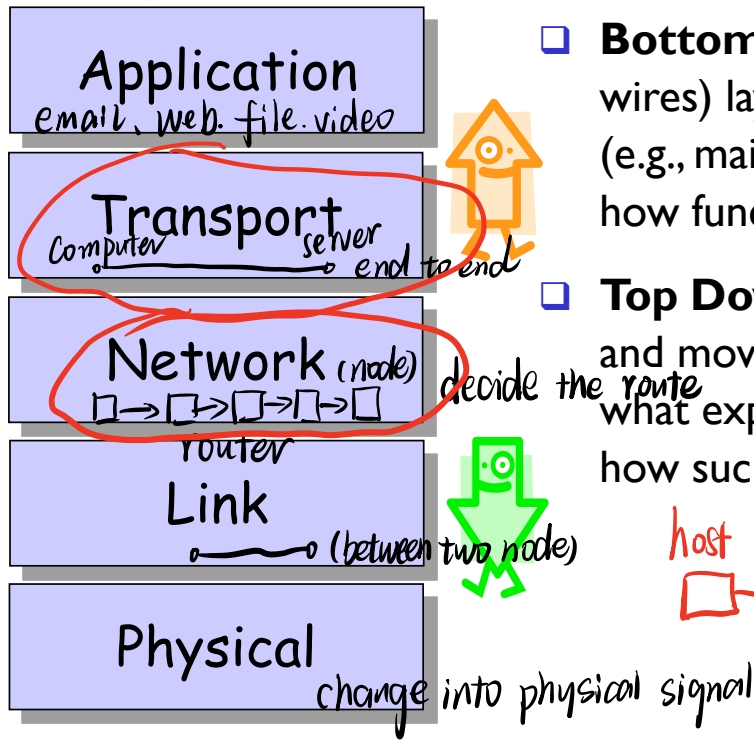
After each chapter

- ❖ read summary and interview if interested

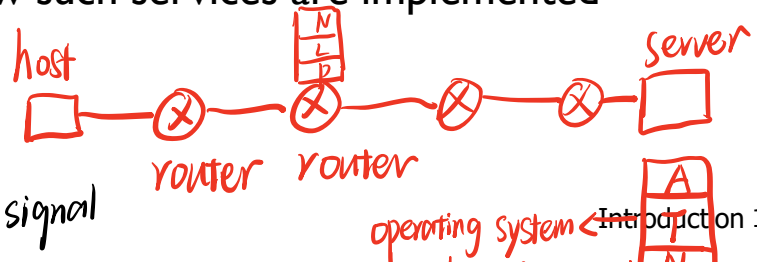
# Textbook information

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

## TOP/IP structure



- **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 域名系统
- ❖ 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 (some error)
- ❖ principles of reliable of data transfer
- ❖ TCP (no error) case study
- ❖ PROGRAMMING ASSIGNMENT 2
- ❖ principles of congestion control
- ❖ TCP congestion control
- ❖ ~~ATM ECN~~

← MIDTERM EXAM  
(approx)

soft define network.

## 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 7<sup>th</sup> edition :

Network layer – Data Plane

Network layer – Control Plane

- ❖ Software defined network (SDN)

# Course overview:

wire : 802.3  
wireless: 802.11

non-wireless  
I

## 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)

针对不同的 media, 有不同的协议

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

# 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: (percentage is adjustable)

- ❖ Homework - 10%
- ❖ Lab - 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 200 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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  - ❖ Think how to design the protocol before learn it.
  - ❖ Try even
- ❖ 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

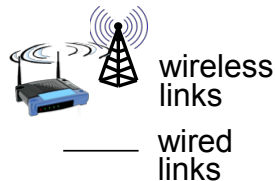
1.6 networks under attack: security

1.7 history

# What's the Internet: “nuts and bolts” view



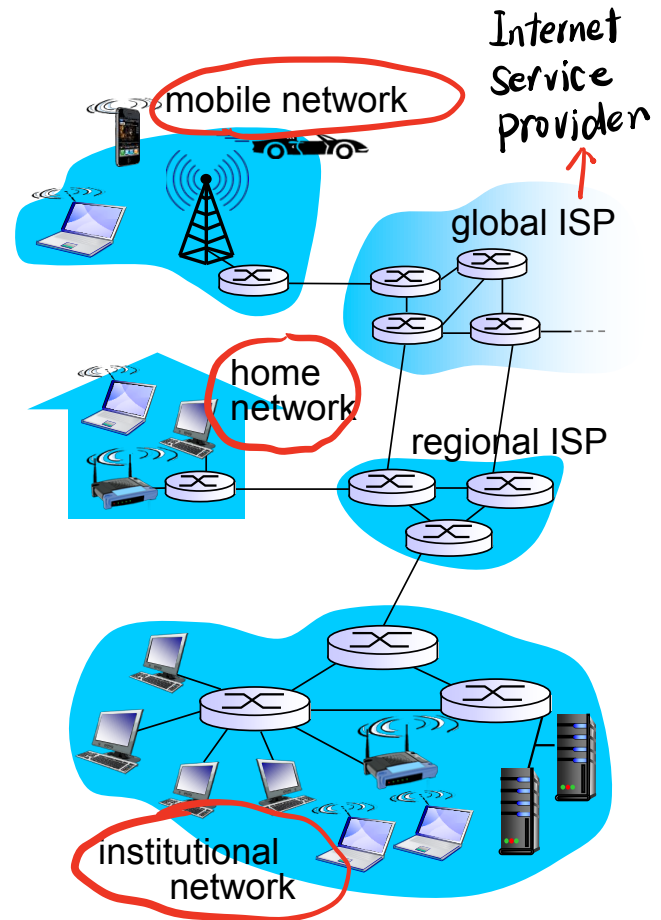
- ❖ millions of connected computing devices:
  - *hosts* = *end systems*
  - running *network apps*



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

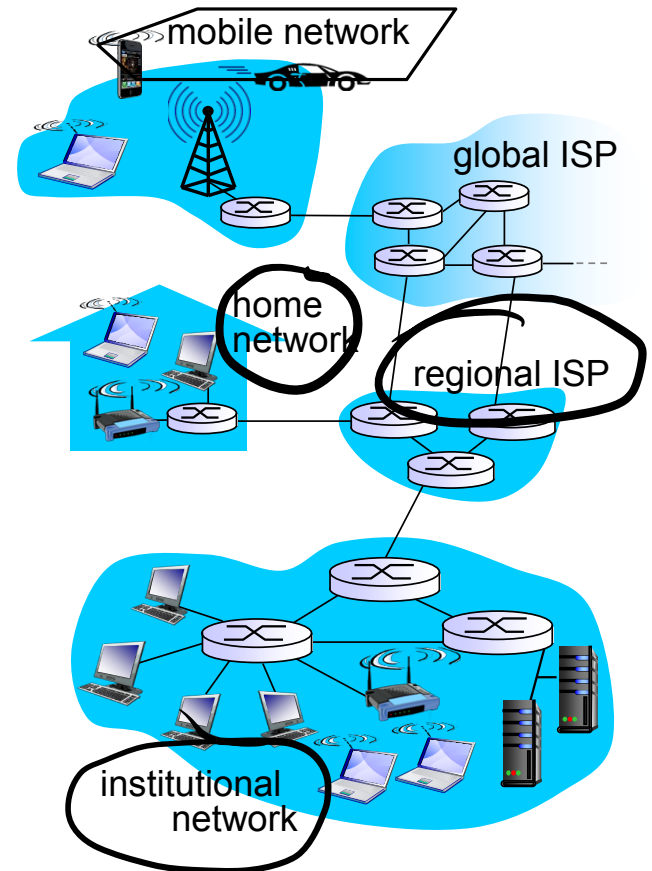


- ❖ *Packet switches*: 交换机 forward packets (chunks of data)
  - *routers* and *switches*



# 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





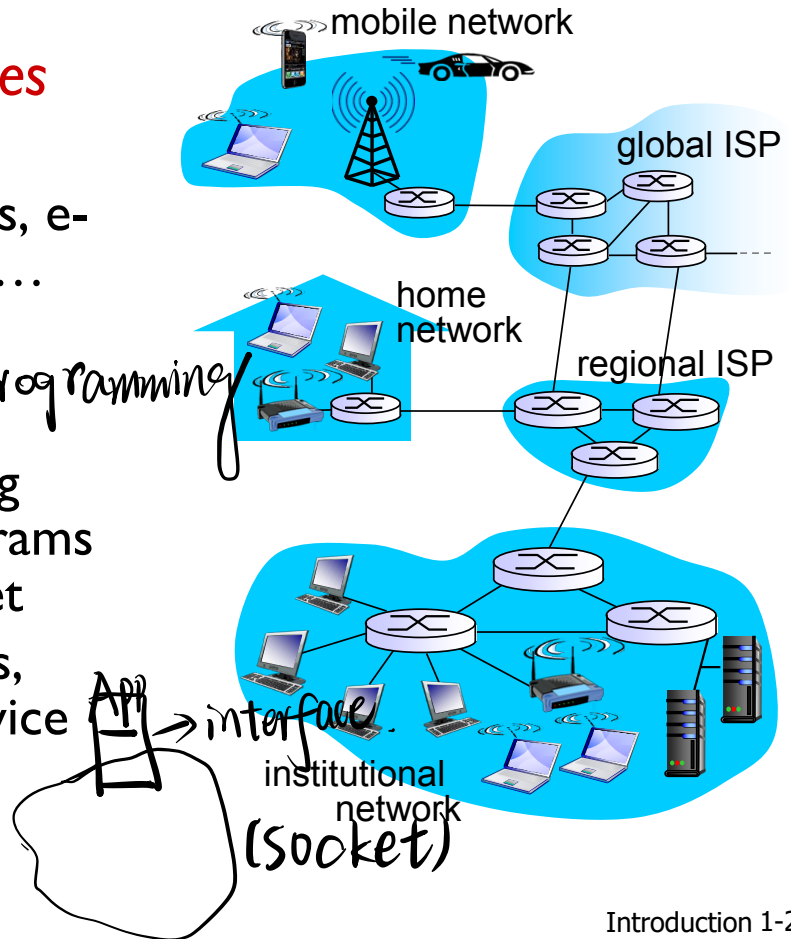
# What's the Internet: a service view

## ❖ Infrastructure that provides services to applications:

- Web, VoIP, email, games, e-commerce, social nets, ...

## ❖ provides programming interface to apps *socket programming*

- 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

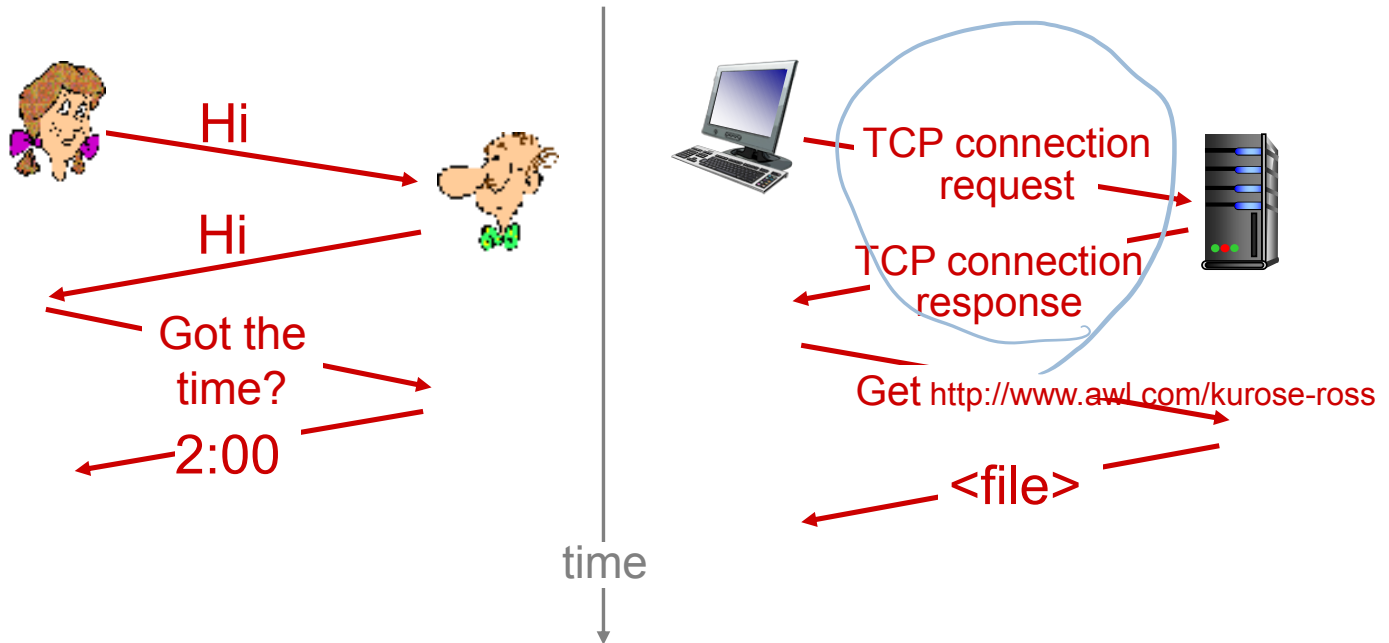
## *network protocols:*

- ❖ 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

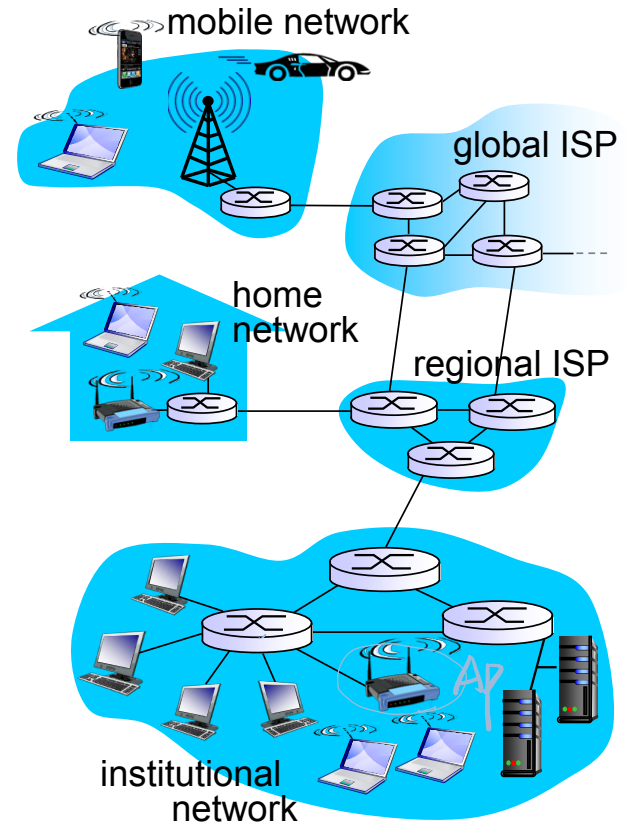
# A closer look at network structure:

## ❖ 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):

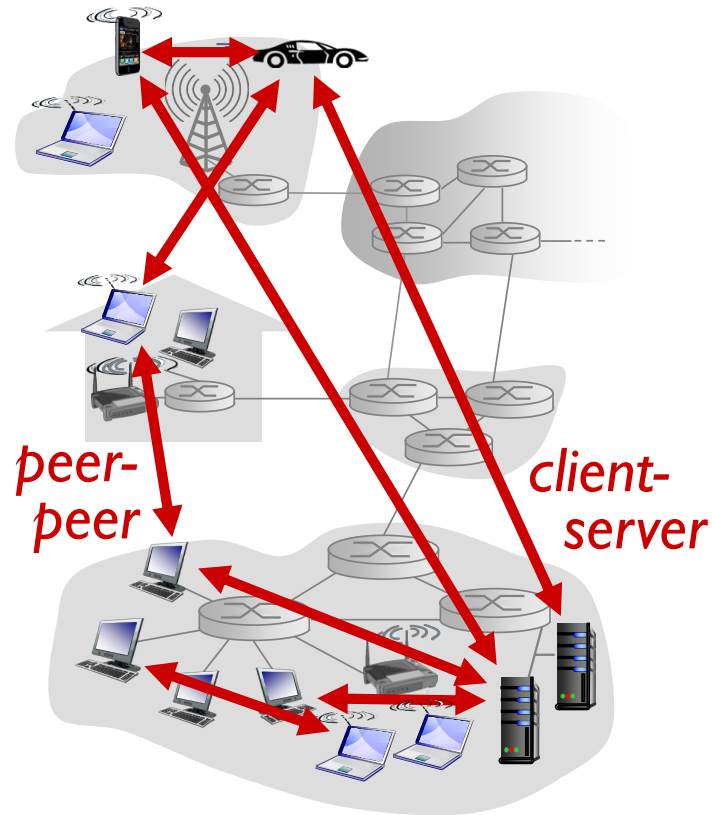
- run application programs
- e.g. Web, email
- at “edge of network”

## ❖ *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



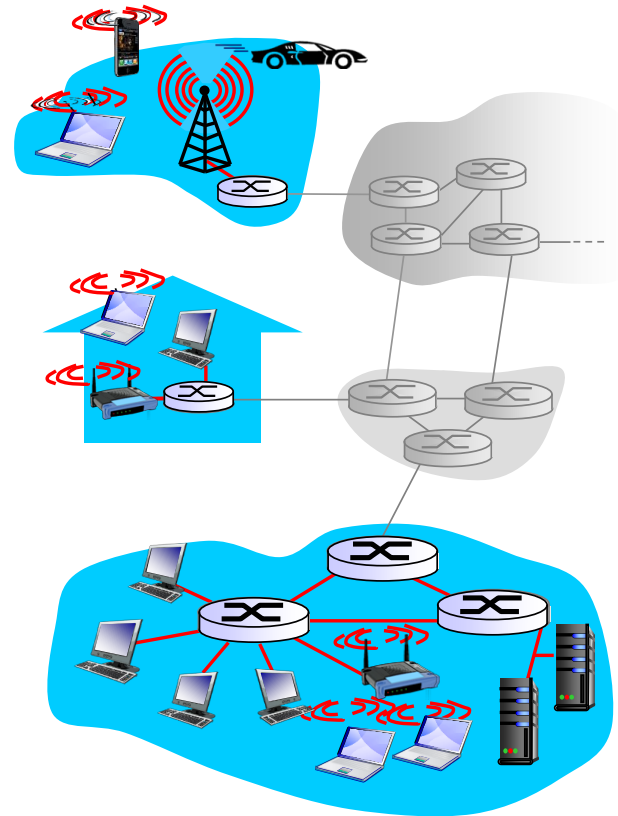
# Access networks and physical media

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

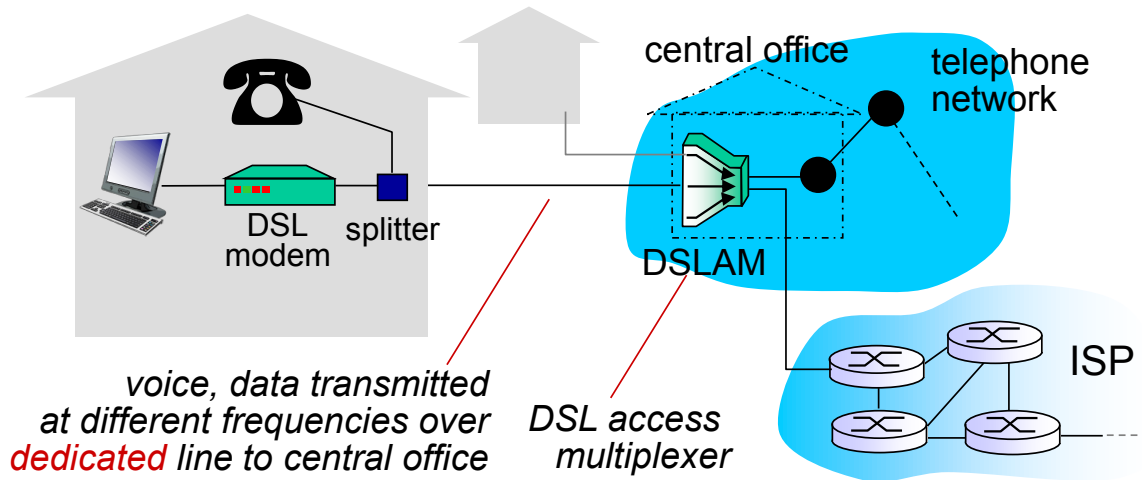
- ❖ residential access nets
- ❖ institutional access networks (school, company)
- ❖ mobile access networks

*keep in mind:*

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



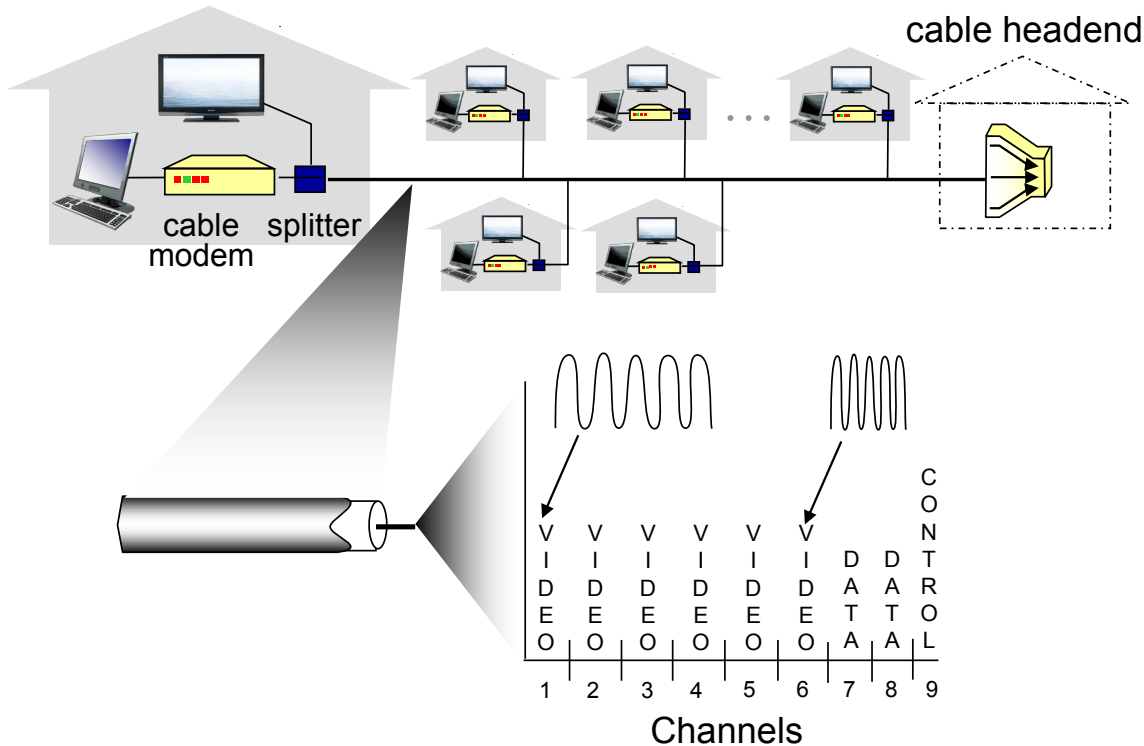
# Access net: digital subscriber line (DSL)



- ❖ 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)

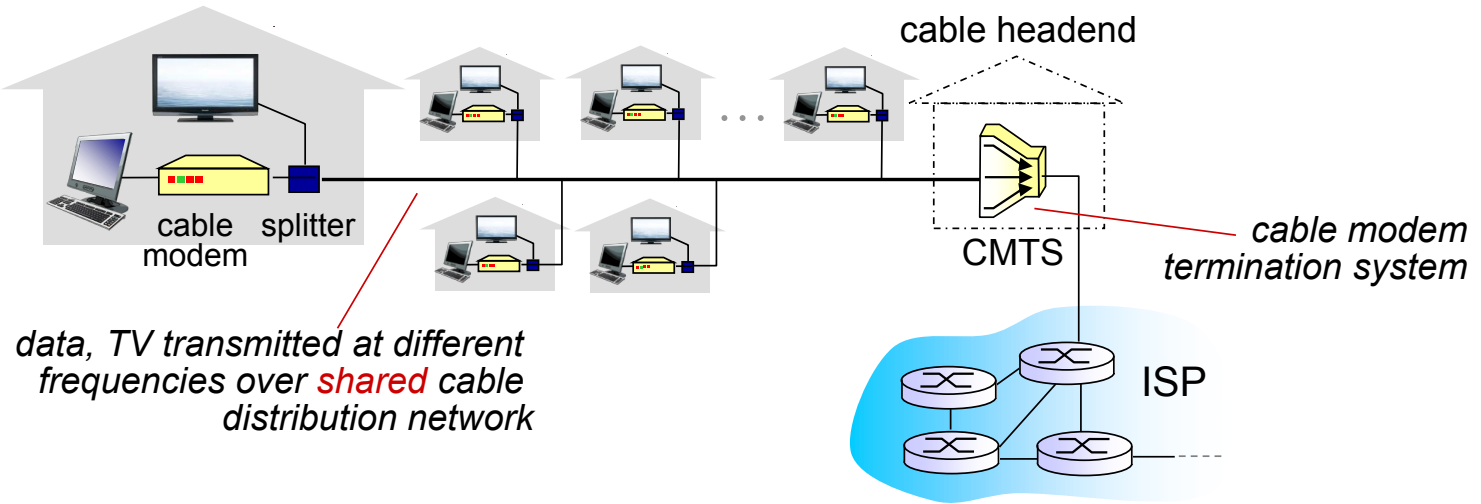


# Access net: cable network



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

# Access net: cable network



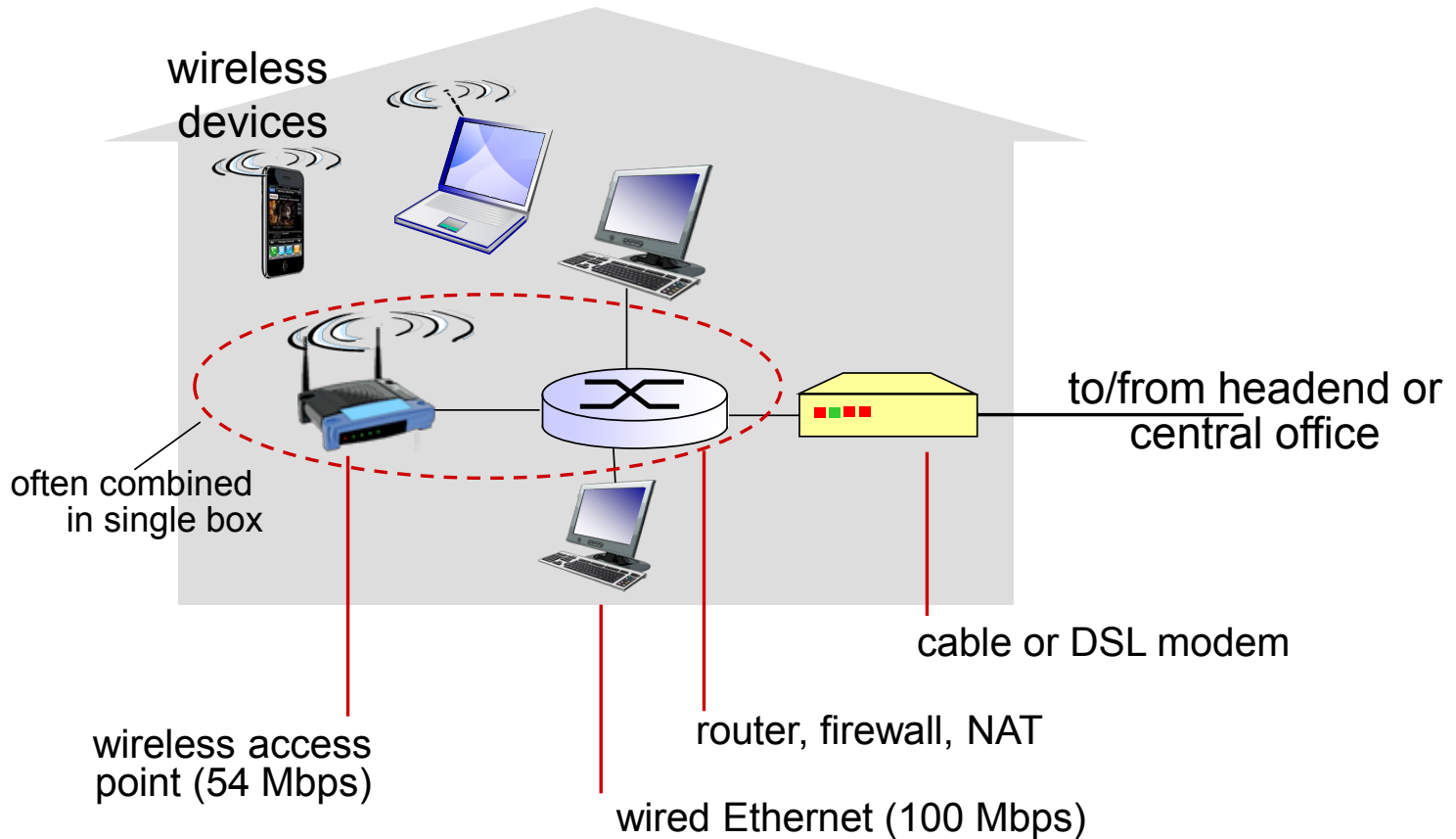
## ❖ HFC: hybrid fiber coax

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

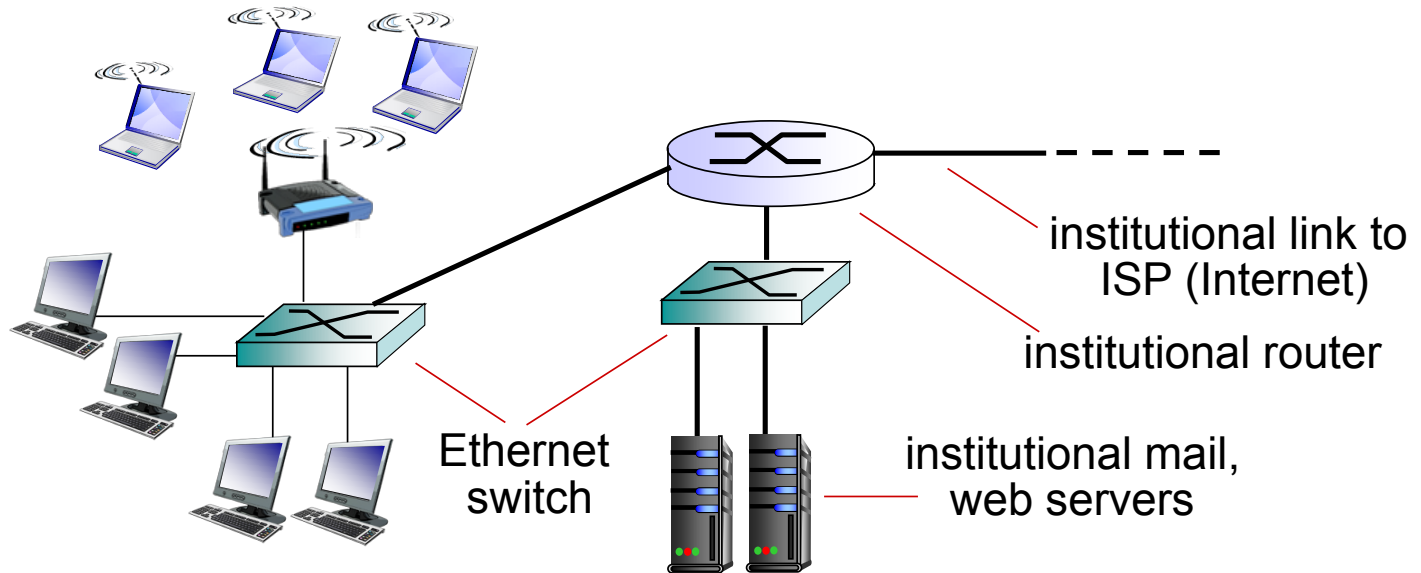
## ❖ network of cable, fiber attaches homes to ISP router

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

# Access net: home network



# Enterprise access networks (Ethernet)



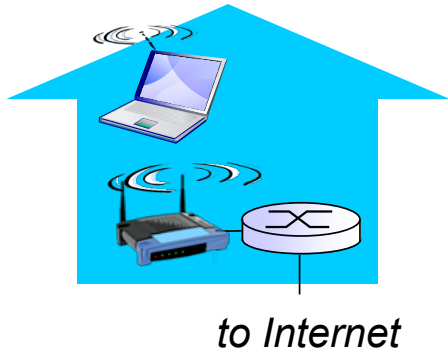
- ❖ typically used in companies, universities, etc
- ❖ 10 Mbps, 100Mbps, 1Gbps, 10Gbps transmission rates
- ❖ today, end systems typically connect into Ethernet switch

# 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*

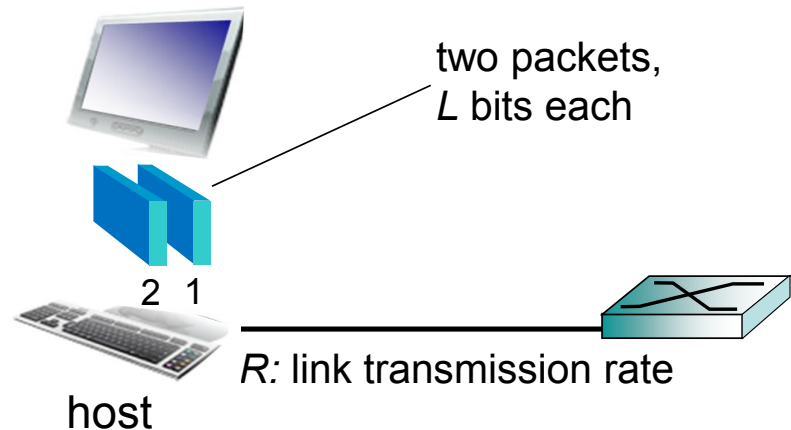
- provided by telco (cellular) operator, 10's km
- 10 Mbps, 100Mbps, 10Gbps
- 3G, 4G, 5G



# 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 Gbps 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)
  - 11 Mbps, 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