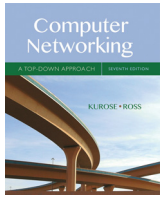
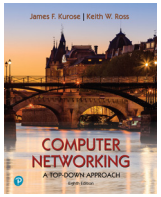
Chapter 1
Introduction

Courtesy to the textbooks' authors and Pearson Addison-Wesley because many slides are adapted from the following textbooks and their associated slides.



Jim Kurose, Keith Ross, "Computer Networking: A Top Down Approach", 7th Edition, Pearson, 2016.



Jim Kurose, Keith Ross, "Computer Networking: A Top Down Approach", 8th Edition, Pearson, 2020.

Chapter 1: introduction

Chapter goal:

- Get "big picture" and "feelings"
  - Introduction to terminology
  - more depth, detail later in course
- Use Internet as an example

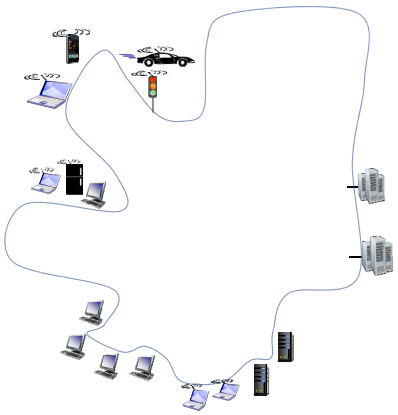
Overview/roadmap:

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

The Internet: a "nuts and bolts" view

Billions of connected *devices*:

- *end systems* = *hosts*
- running *network apps* at Internet's "edge"



"Fun" Internet-connected devices


Amazon Echo


smart phone


UAV or UAV fleet


Tweet-a-watt: monitor energy use


smart bracelet


bikes


Security Camera


Slingbox: remote control cable TV


AR devices


smart watch


cars


scooters


Internet phones


Gaming devices


sensorized, bed mattress

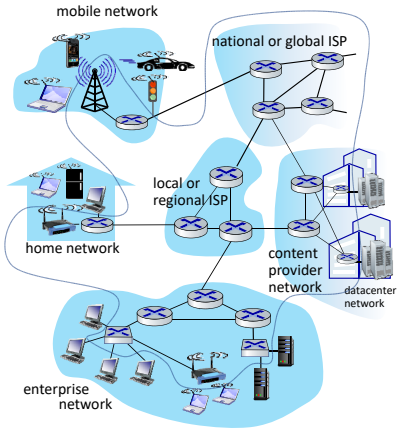
The Internet: a "nuts and bolts" view

Billions of connected *devices*:
- *end systems = hosts*
- running *network apps* at Internet's "edge"

Routers: forward packets (chunks of data)
- *routers, switches*

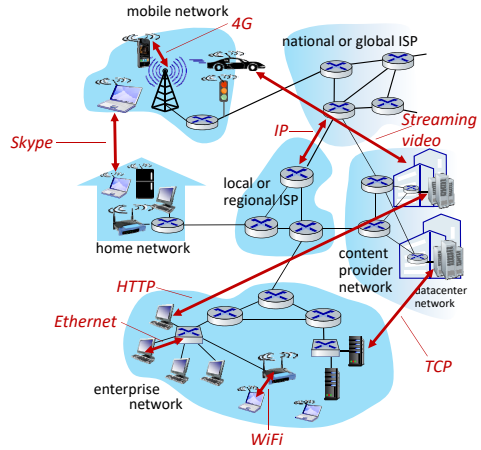
Communication links
- fiber, copper, radio, satellite
- transmission rate: *bandwidth*

Networks
- collection of devices, routers, links: managed by an organization



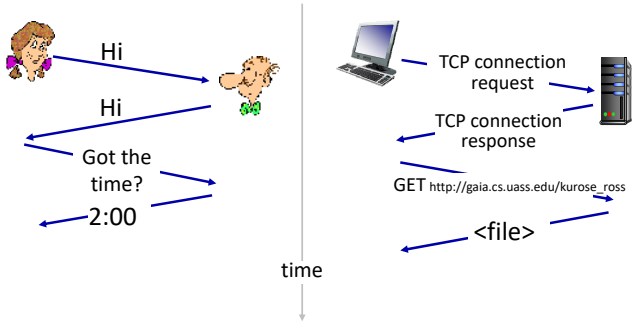
The Internet: a "nuts and bolts" view

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



What's a protocol?

A human protocol and a computer network protocol:



What's a protocol?

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

Rules for:
- … specific messages sent
- … specific actions taken when message received, or other events

Network protocols:
- computers (devices) rather than humans
- all communication activity in Internet governed by protocols

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

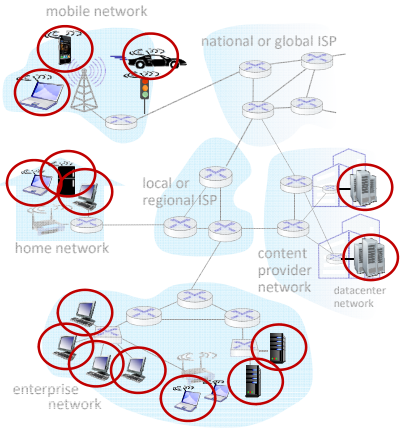
Chapter 1: roadmap

- 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

Network edge vs. network core

Network edge:

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



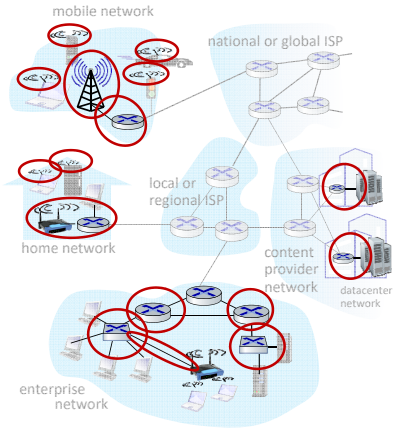
Network edge vs. network core

Network edge:

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

Access networks:

- the network that physically connects an end system to the first router (aka edge router)
  - wired, wireless communication links



Network edge vs. network core

Network edge:

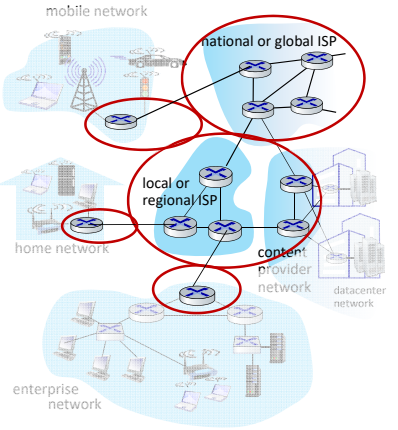
- hosts: clients and servers
- servers often in data centers

Access networks, physical media:

- wired, wireless communication links

Network core:

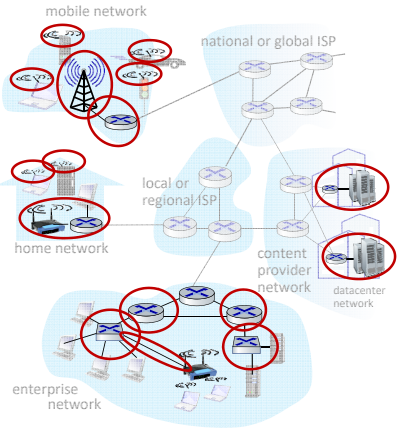
- interconnected routers
- network of networks



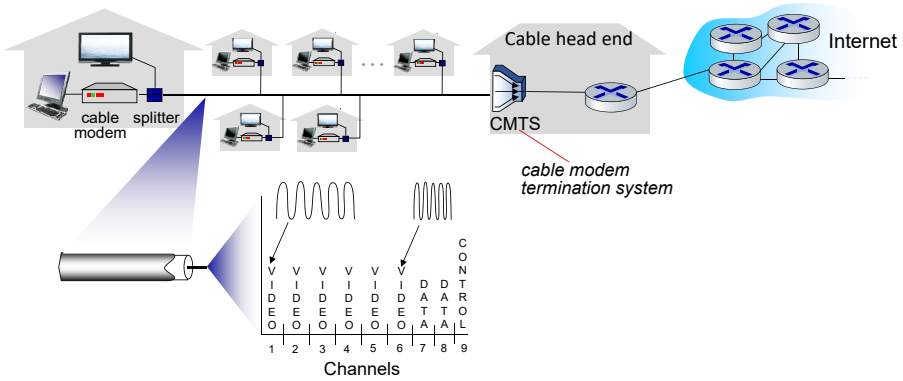
Access networks and physical media

Q: How to connect end systems to edge router?

- residential access networks
  - DSL (digital subscriber line)
  - Cable
  - with multiple wired and wireless devices
- institutional access networks (school, company)
- mobile access networks (WiFi, 4G/5G)

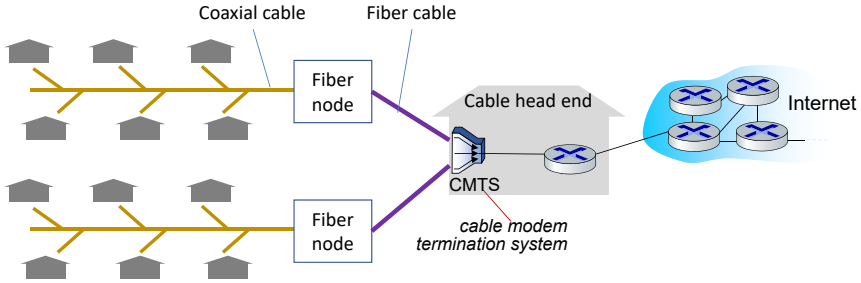


Access networks: cable-based access



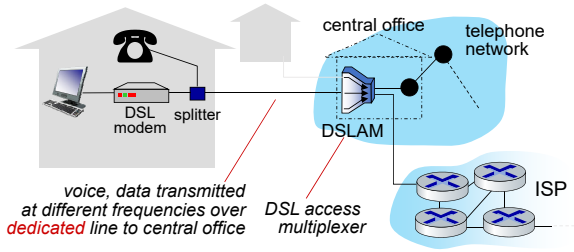
- cable Internet access makes use of existing cable TV infrastructure
- *frequency division multiplexing (FDM):* different channels transmitted in different frequency bands
- homes *share access network* to cable headend and ISP

Access networks: cable-based access



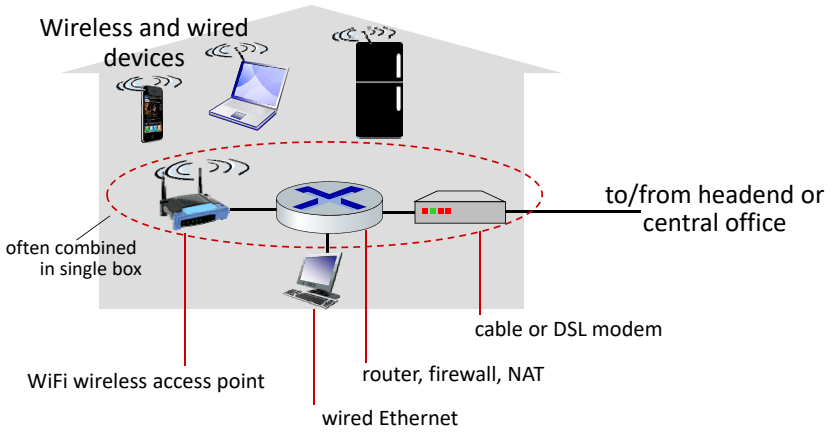
- HFC: hybrid fiber coax
  - asymmetric: up to 40 Mbps – 1.2 Gbps downstream transmission rate, 30-100 Mbps upstream transmission rate
- network of cable and fiber attaches homes to ISP router
  - homes *share access network* to cable headend

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 for each line
- 3.5-16 Mbps dedicated upstream transmission rate for each line

Access networks: home networks



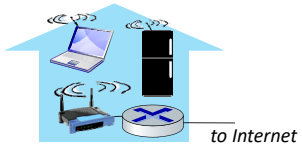
Wireless access networks

Shared *wireless* access network connects end system to router

- via base station aka "access point"

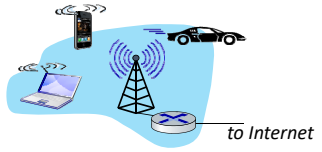
Wireless local area networks (WLANs)

- typically within or around building (~100 ft)
- 802.11b/g/n/ac/ax (WiFi): 11, 54, 450, 1560, 2400 Mbps tx rate

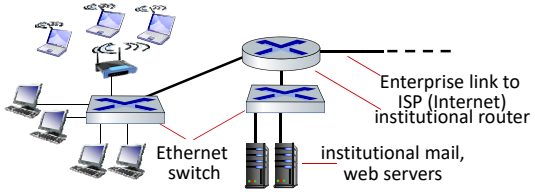


Wide-area cellular access networks

- provided by mobile, cellular network operator (10's km)
- 10's or 100's Mbps (5G peak: 20Gbps)
- 4G/5G cellular networks (6G coming)



Access networks: enterprise networks

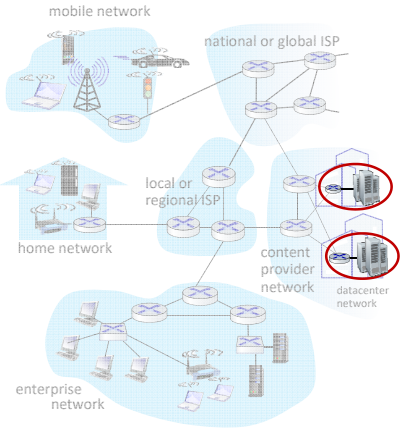


- companies, universities, etc.
- mix of wired, wireless link technologies, connecting a mix of switches and routers (we'll cover differences shortly)
  - Ethernet: wired access at 100Mbps, 1Gbps, 10Gbps
  - WiFi: wireless access points at 11, 54, 450, 1560, 2400 Mbps

Access networks: data center networks

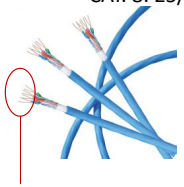
- high-bandwidth links (10s to 100s Gbps) connect hundreds to thousands of servers together, and to Internet

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



Links: wired media

- Twisted pair (TP)
  - two insulated copper wires
    - Category 5 (CAT. 5): 100 Mbps, 1 Gbps Ethernet
    - CAT. 6: 10 Gbps Ethernet
    - CAT. 8: 25/40 Gbps Ethernet



4 twisted pairs
(8 insulated copper wires)

RJ45 connector

- Coaxial cable

- Fiber optic cable:
  - high-speed operation:
    - 10's-100's Gbps
    - low error rate
  - slow attenuation
  - immune to electromagnetic noise

Links: wireless 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 include:

- Bluetooth: cable replacement
  - short distances
  - limited rates
- wireless LAN or WLAN (e.g.,WiFi)
  - rate: 10-1000's Mbps
  - coverage: 10's of meters
- wireless wide-area network or WWAN (e.g., 4G)
  - rate: 10's Mbps
  - coverage: 10's Km
- satellite
  - long end-to-end propagation delay
    - except for LEO satellites