CNT 4704
Analysis of Computer Communication Networks

Computer Networks and the Internet

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UCF

HOUSEKEEPING & ACKNOWLEDGEMENT

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CHAPTER 1: INTRODUCTION 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

“FUN” INTERNET-CONNECTED DEVICES

Amazon Echo

Internet refrigerator

IP picture frame

Pacemaker & Monitor

Tweet-a-watt: monitor energy use

Security Camera

Slingbox: remote control cable TV

Web-enabled toaster + weather forecaster

AR devices

Internet phones

Sensorized, bed mattress

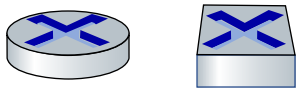
Fitbit

Others?

THE INTERNET: A "NUTS AND BOLTS" VIEW

Billions of connected computing *devices*:

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



Packet switches: forward packets (chunks of data)

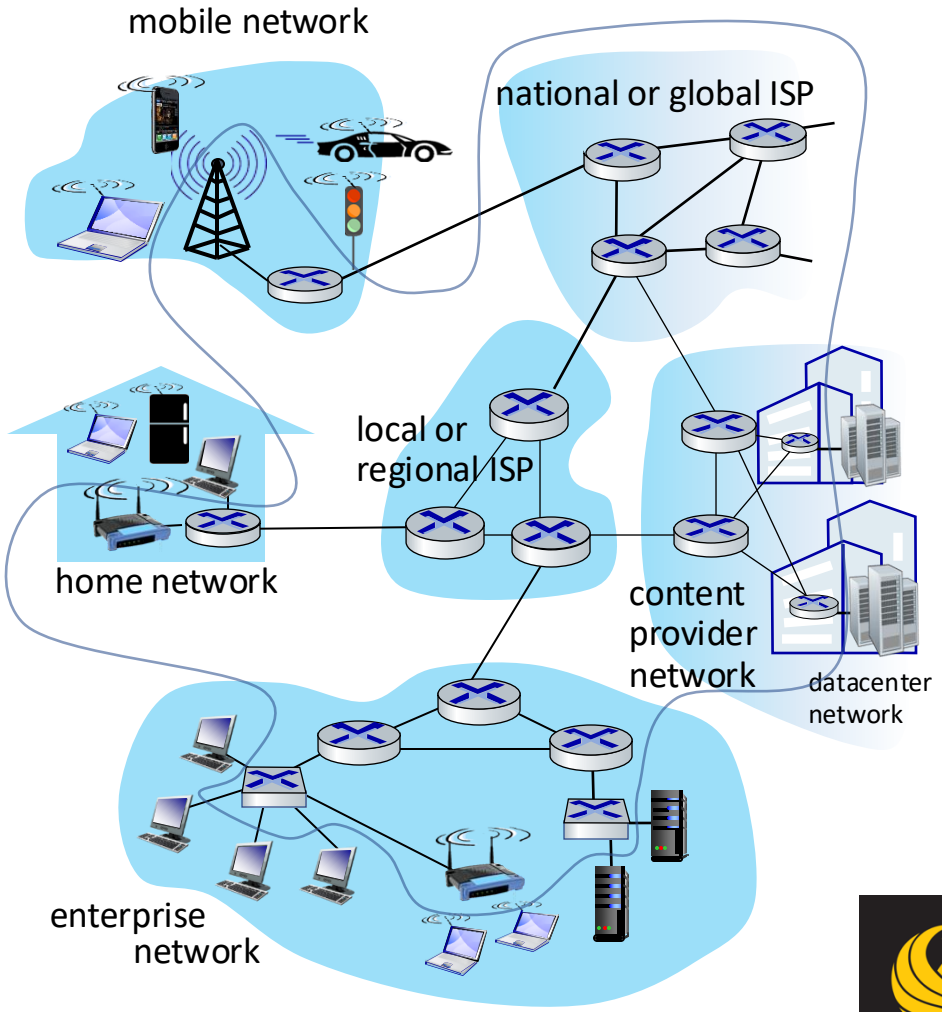
- *routers, switches*

Communication links

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

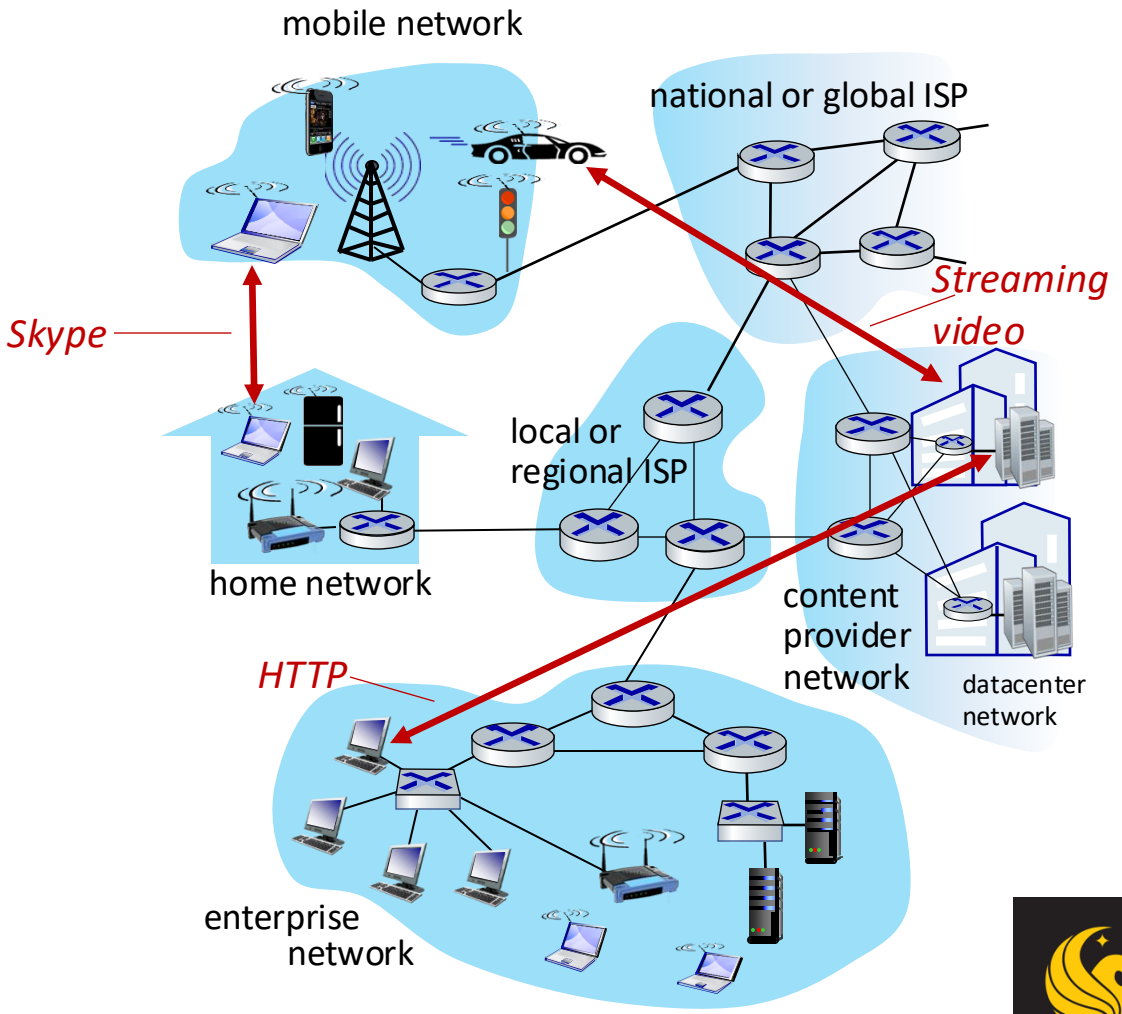
Networks

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



The Internet: a "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



WHAT'S A PROTOCOL?

Human protocols:

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

… specific messages sent

… specific actions taken when message received, or other events

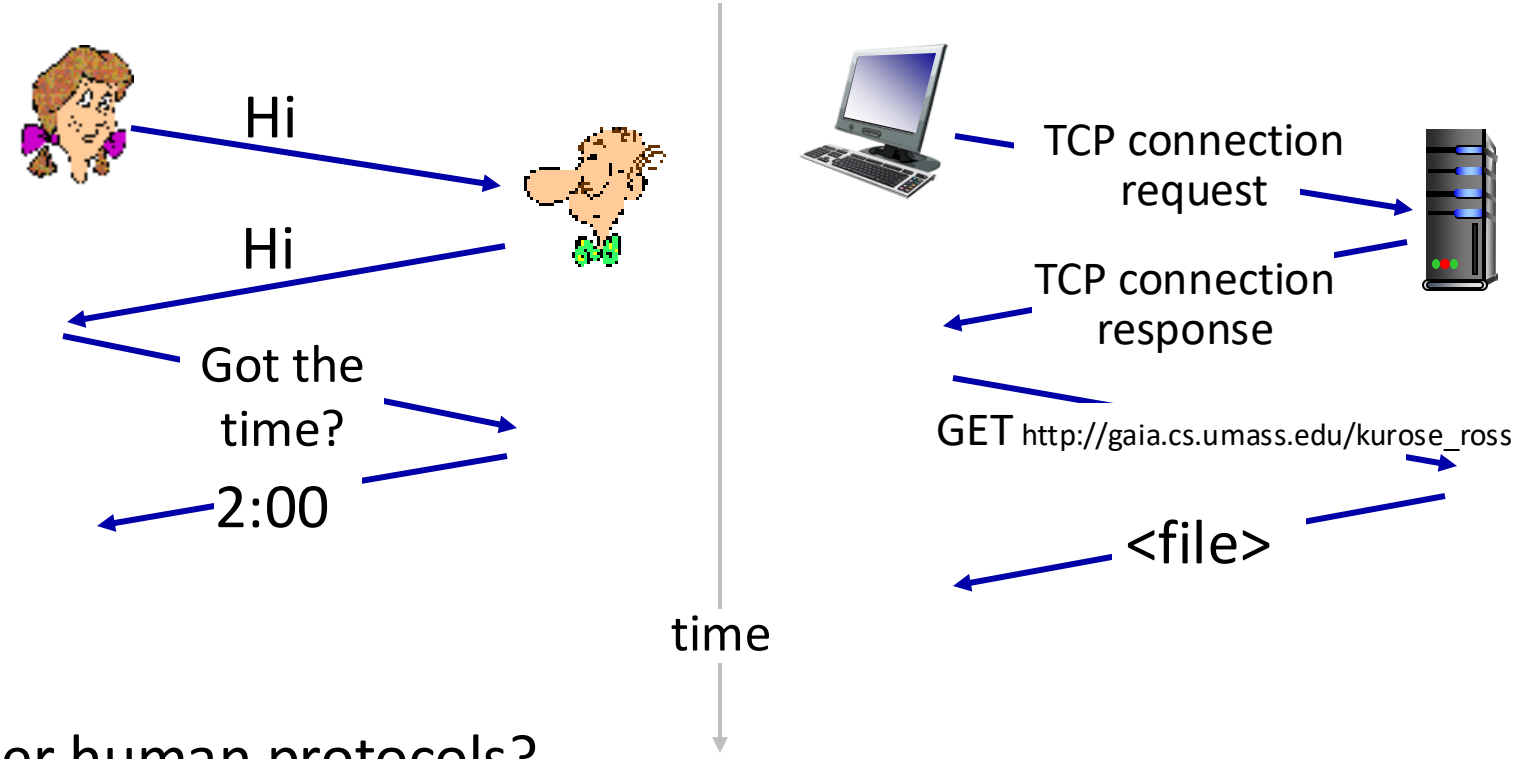
Network protocols:

- 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 msg transmission, receipt

WHAT'S A PROTOCOL? (CONT'D)

A human protocol and a computer network protocol:



Q: Other human protocols?

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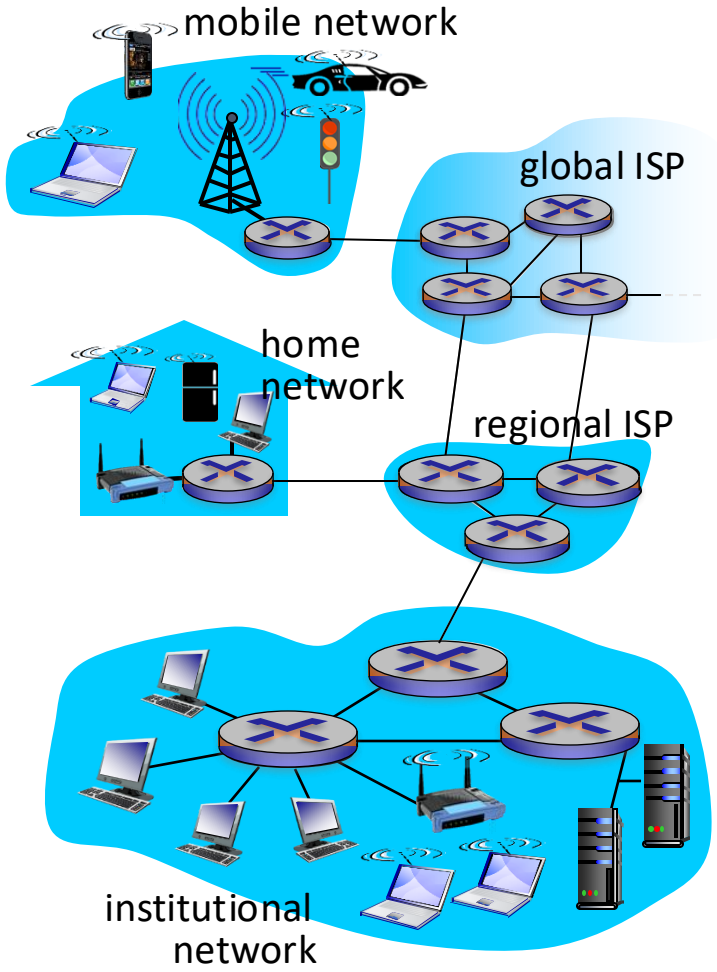
A CLOSER LOOK AT NETWORK STRUCTURE

- *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



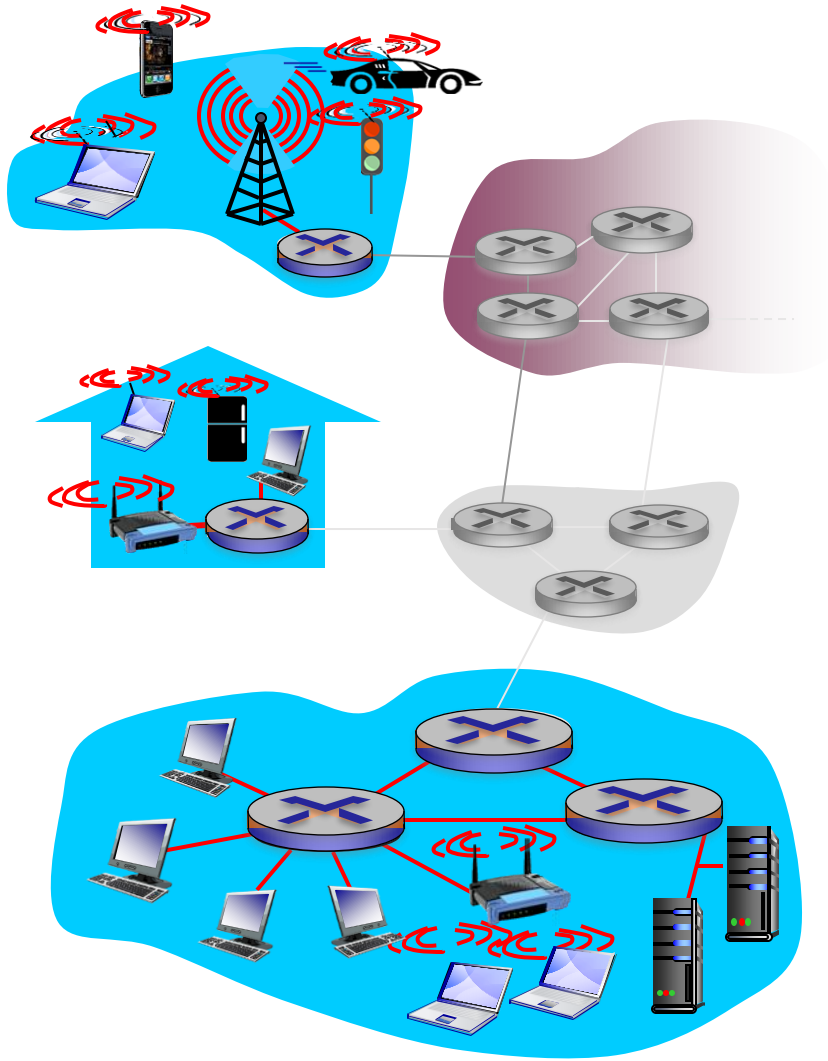
ACCESS NETWORKS AND PHYSICAL MEDIA

Q: How to connect end systems to edge router?

- residential access nets
- institutional access networks (school, company)
- mobile access networks (WiFi, 4G/5G)

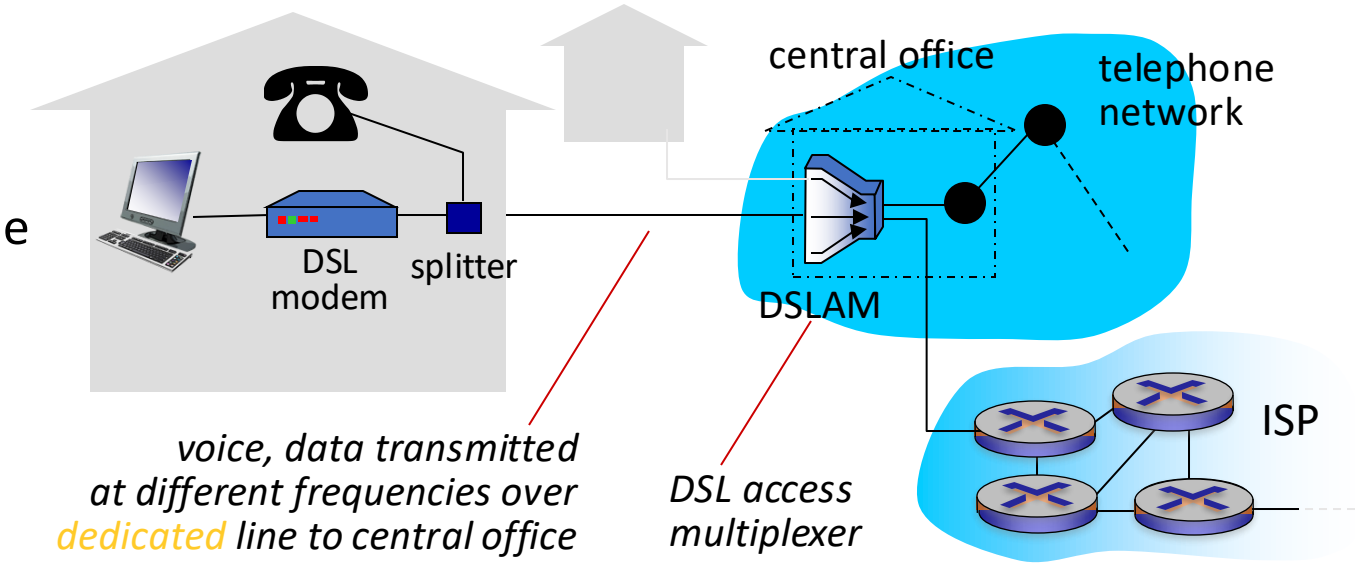
keep in mind:

- Bandwidth or transmission rate (bits per second) of access network?
- shared or dedicated access among users?

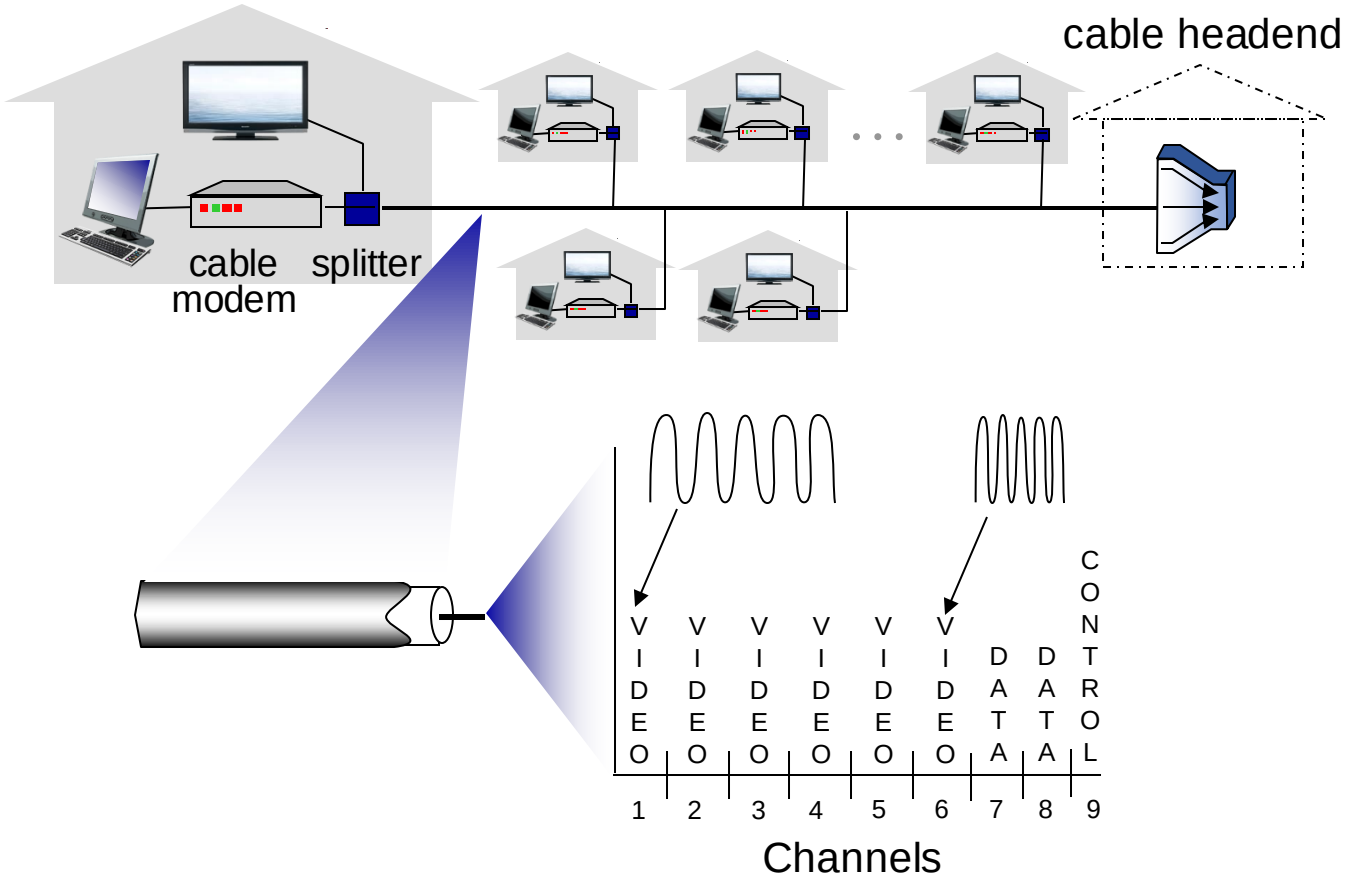


ACCESS NETWORK: DIGITAL SUBSCRIBER LINE (DSL)

- 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
- 3.5-16 Mbps dedicated upstream transmission rate

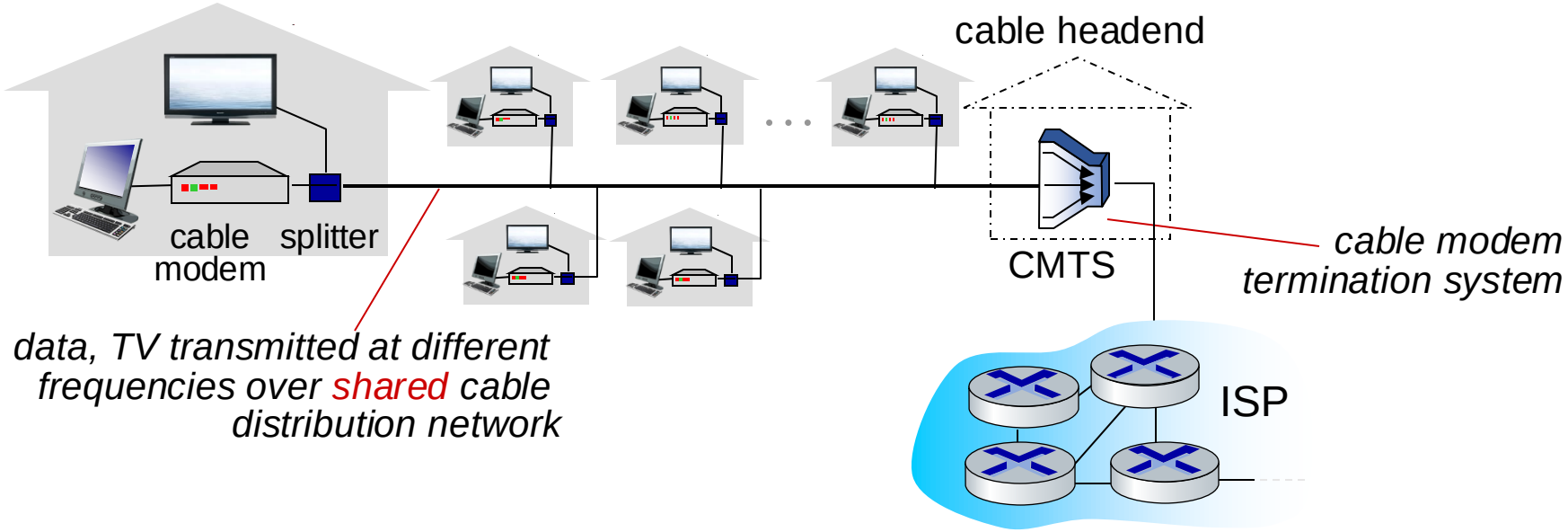


Access network: cable-based access



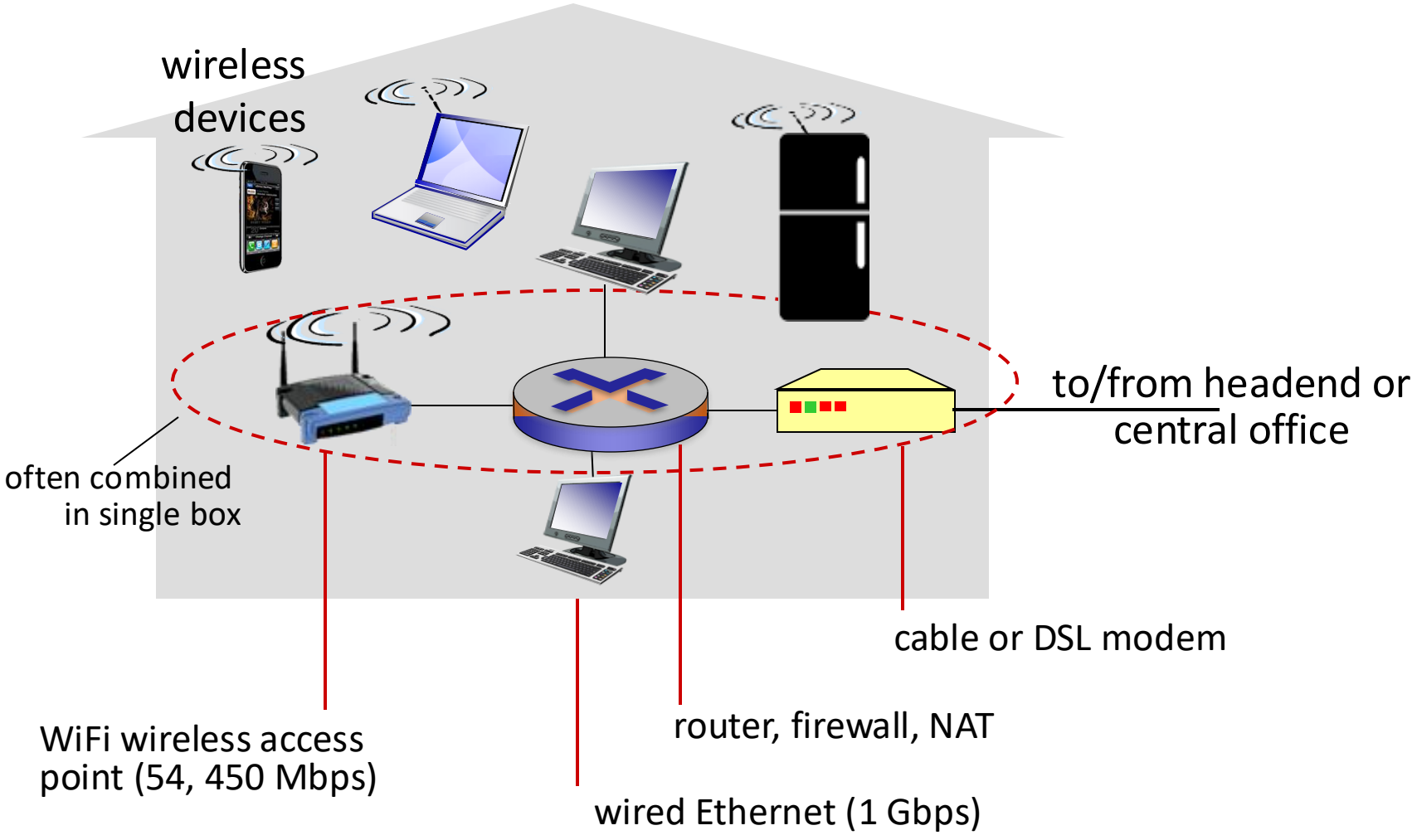
frequency division multiplexing (FDM): different channels transmitted in different frequency bands (**More in Chapter6**)

Access network: cable-based access



- HFC: hybrid fiber coax
  - asymmetric: up to 40 Mbps – 1.2 Gbs 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 network: home network



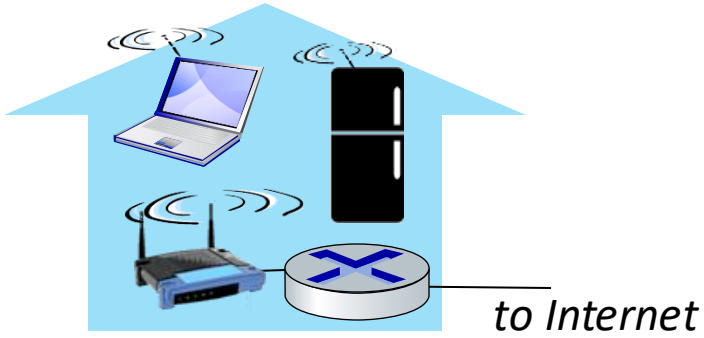
Wireless access networks

Shared *wireless* access network connects end system to router

- via base station aka “access point”

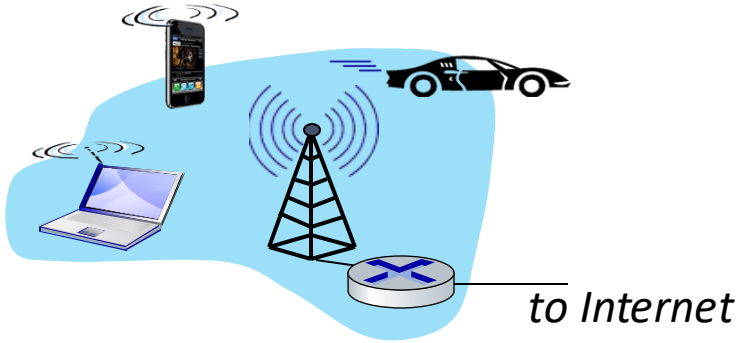
Wireless local area networks (WLANs)

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

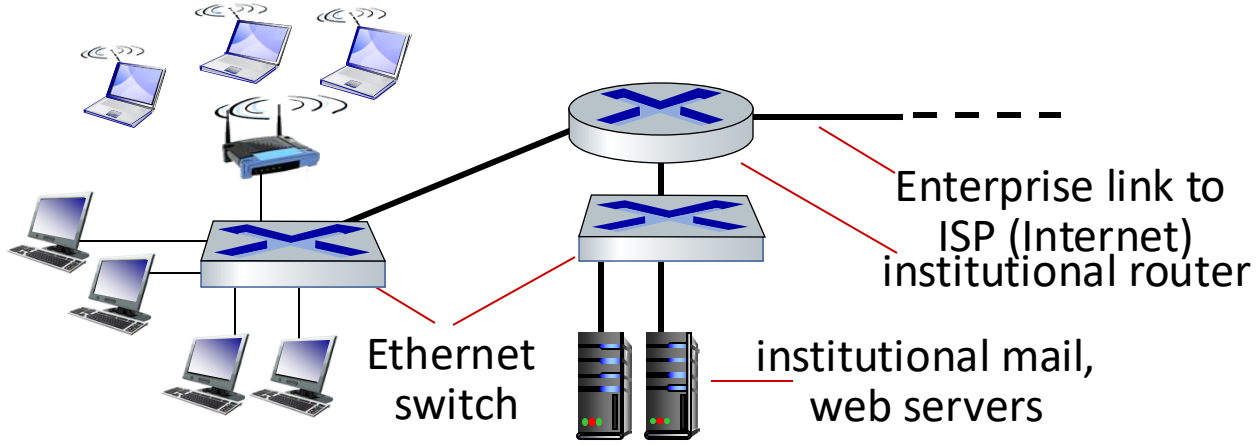


Wide-area cellular access networks

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



Access networks: enterprise networks

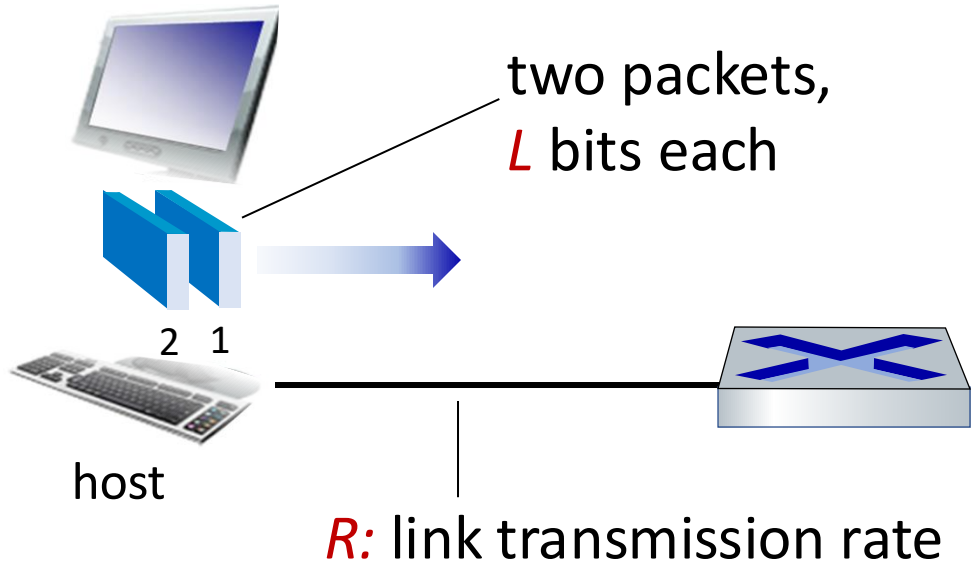


- companies, universities, etc.
- mix of wired, wireless link technologies, connecting a mix of switches and routers (we'll cover differences shortly)
  - Ethernet: wired access at 100Mbps, 1Gbps, 10Gbps
  - WiFi: wireless access points at 11, 54, 450 Mbps

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*



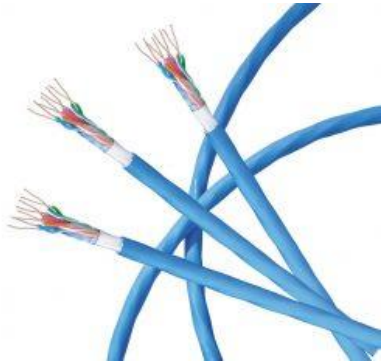
$$\text{packet transmission delay} = \text{time needed to transmit } L\text{-bit packet into link} = \frac{L \text{ (bits)}}{R \text{ (bits/sec)}}$$

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



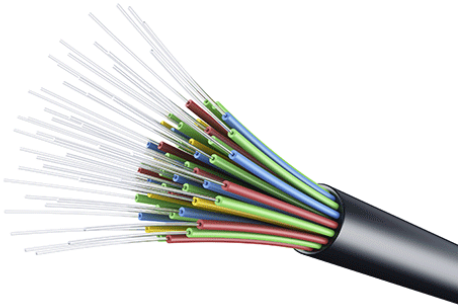
Links: physical media (CONT'D)

Coaxial cable:

- two concentric copper conductors
- 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 (CONT'D)

Wireless radio

- signal carried in electromagnetic spectrum
- no physical "wire"
- broadcast and "half-duplex" (sender to receiver)
- propagation environment effects:
  - obstruction by objects
  - reflection
  - interference

Radio link types:

- terrestrial microwave
  - up to 45 Mbps channels
- Wireless LAN (WiFi)
  - Up to 100's Mbps
- wide-area (e.g., cellular)
  - 4G/5G cellular: ~ 10's Mbps
- satellite
  - up to 45 Mbps per channel
  - 270 msec end-end delay
  - geosynchronous versus low-earth-orbit

Questions?