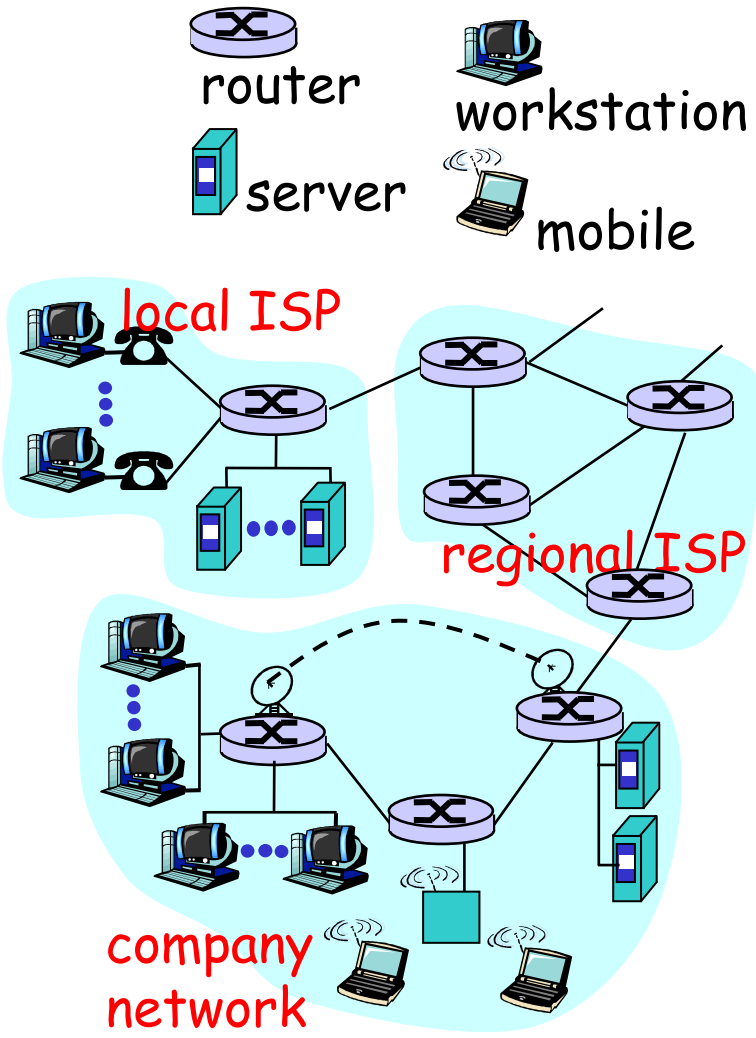
Networking

Based on the powerpoint presentation of Computer Networking: A Top Down Approach Featuring the Internet, Third Edition, J.F. Kurose and K.W. Ross, Addison-Wesley, ISBN: 0-321-22735-2.

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

- millions of connected computing devices called *hosts and end-systems*
  - PCs workstations, servers
  - PDAs phones, toasters

  running *network apps*
- *communication links*
  - fiber, copper, radio, satellite
  - transmission rate = *bandwidth*
- *routers:* forward packets (chunks of data)



"Cool" internet appliances

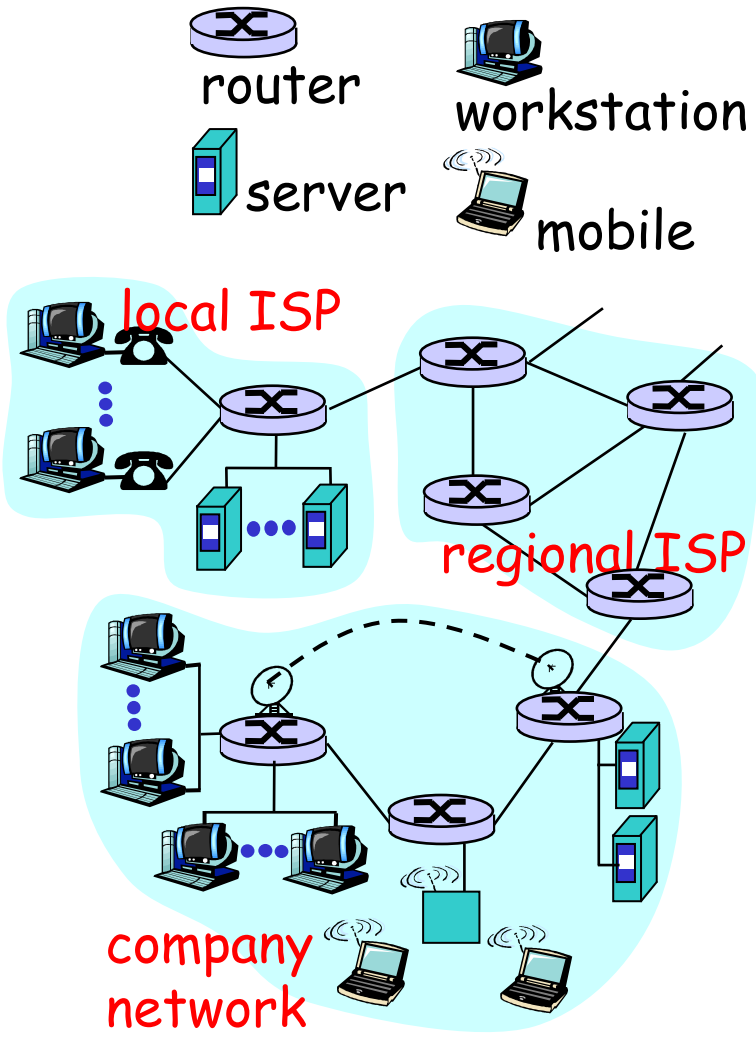
IP picture frame
http://www.ceiva.com/

Web-enabled toaster+weather forecaster

Surfing

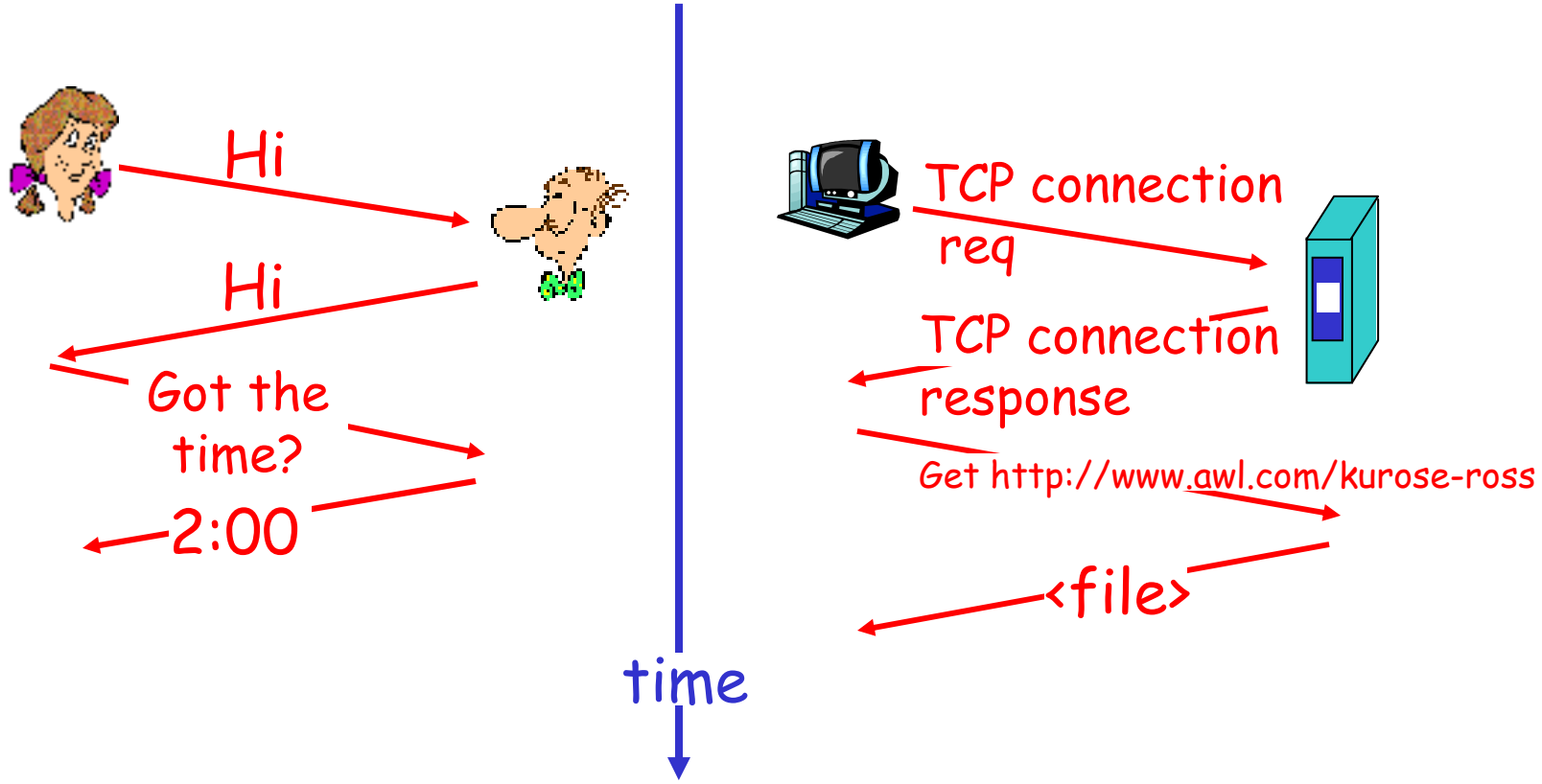
What's the Internet: "nuts and bolts" view

- *protocols* control sending, receiving of msgs
  - e.g., TCP, IP, HTTP, FTP, PPP
- *Internet:* "network of networks"
  - loosely hierarchical
  - public Internet versus private intranet
- Internet standards
  - RFC: Request for comments
  - IETF: Internet Engineering Task Force



What's a protocol?

a human protocol and a computer network protocol:



Q: Other human protocols?

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

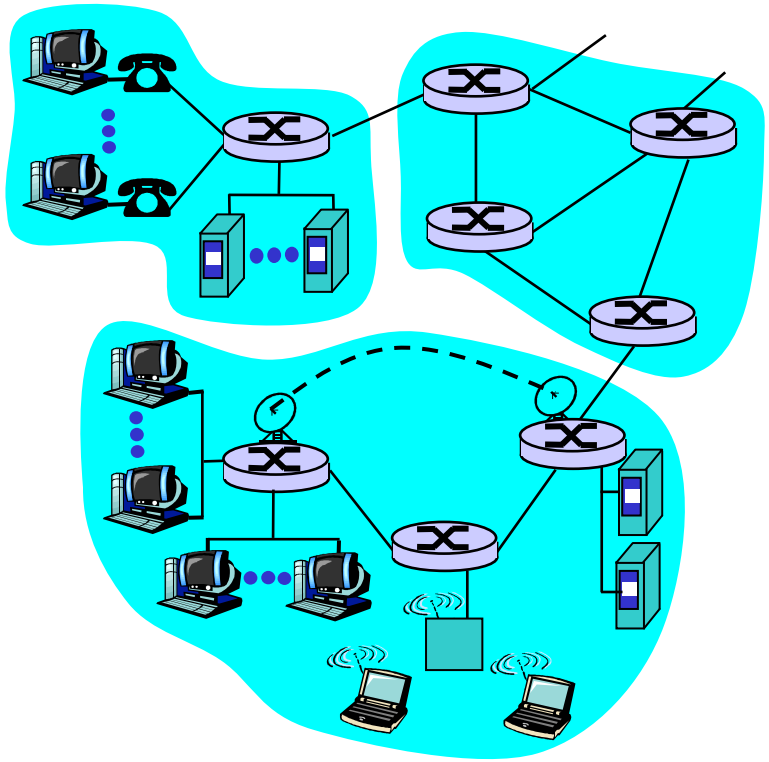
network protocols:

- 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, other events*

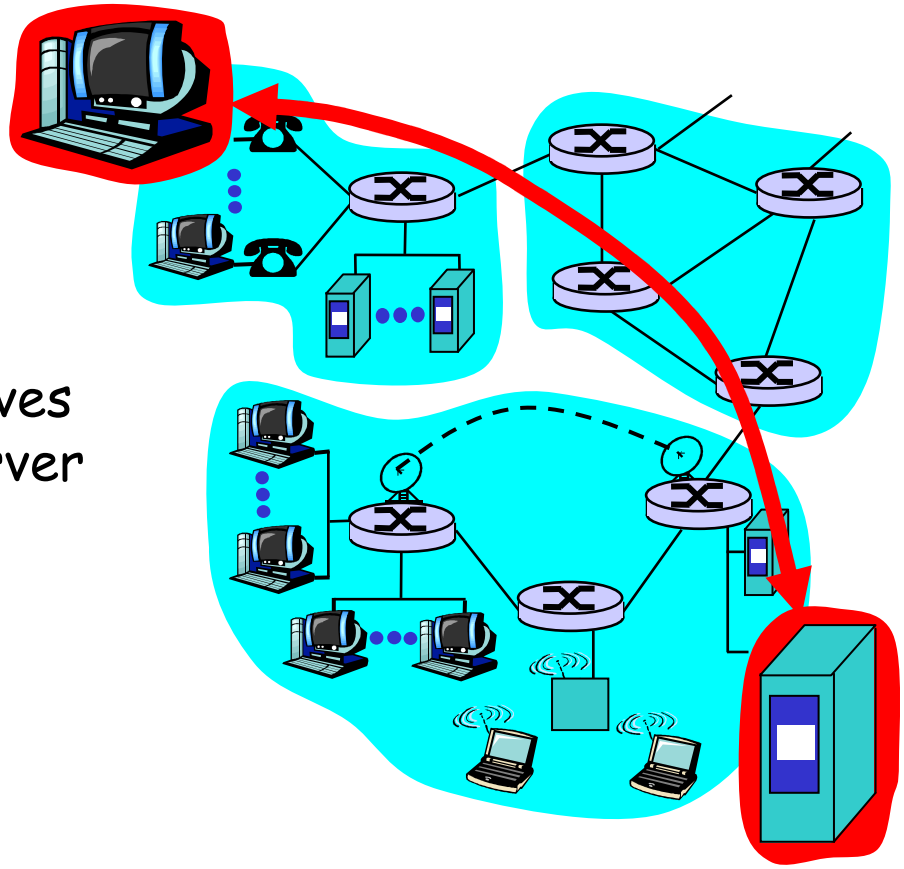
network structure:

- network edge:
  applications and hosts
- network core:
  - routers
  - network of networks



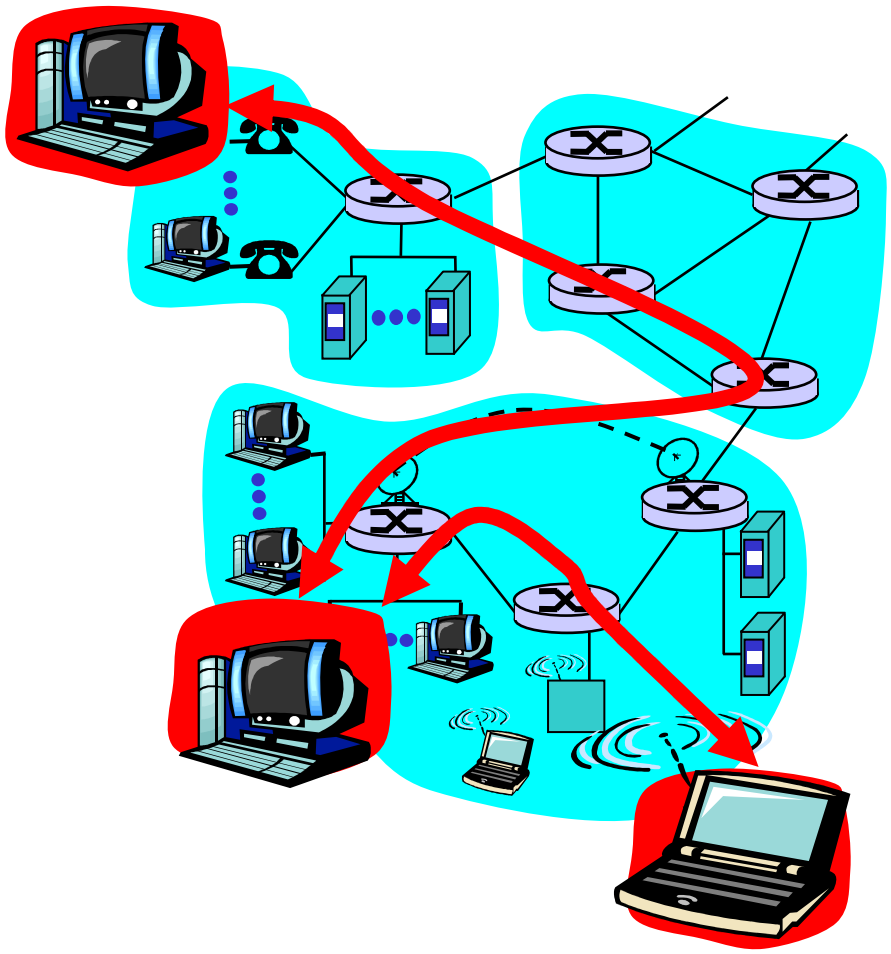
The network edge:

- 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



The network edge:

- peer-peer model:
  - minimal (or no) use of dedicated servers
  - e.g. Gnutella, KaZaA



Network edge: connection-oriented service

Goal: data transfer between end systems

- *handshaking*
  - Hello, hello back human protocol
  - *set up "state"* in two communicating hosts
- TCP - Transmission Control Protocol
  - Internet's connection-oriented service

TCP service [RFC 793]

- *reliable, in-order byte-stream data transfer*
- *flow control*
  - sender won't overwhelm receiver
- *congestion control*
  - senders "slow down sending rate" when network congested

Network edge: connectionless service

Goal: data transfer between end systems

- UDP - User Datagram Protocol [RFC 768]: Internet's connectionless service
  - unreliable data transfer
  - no flow control
  - no congestion control

App's using TCP:

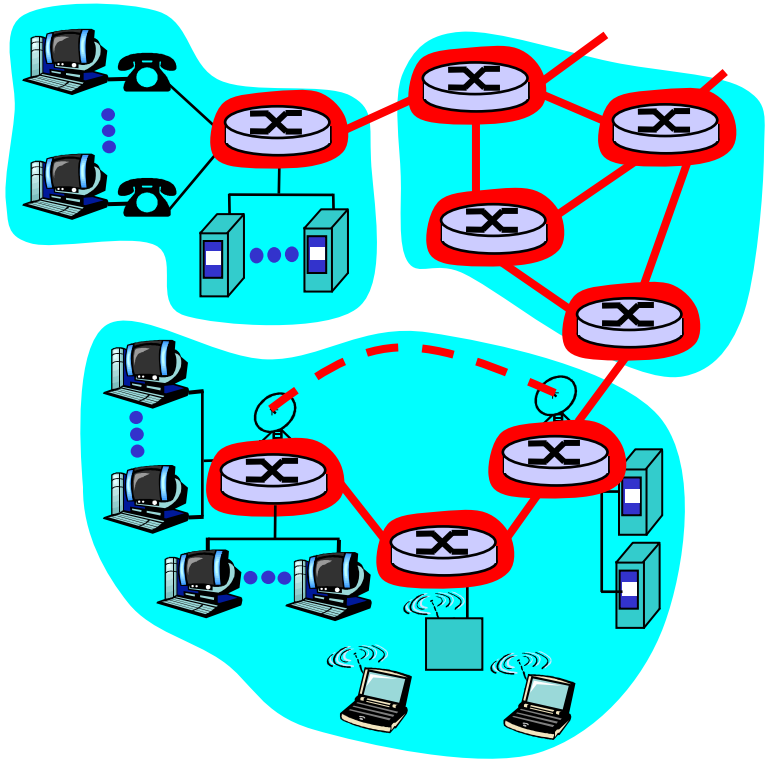
- HTTP (Web), FTP (file transfer), Telnet (remote login), SMTP (email)

App's using UDP:

- streaming media, teleconferencing, DNS, Internet telephony

The Network Core

- mesh of interconnected routers
- *the* fundamental question: how is data transferred through net?
  - **packet-switching**: data sent thru net in discrete "chunks"



Network Core: Packet Switching

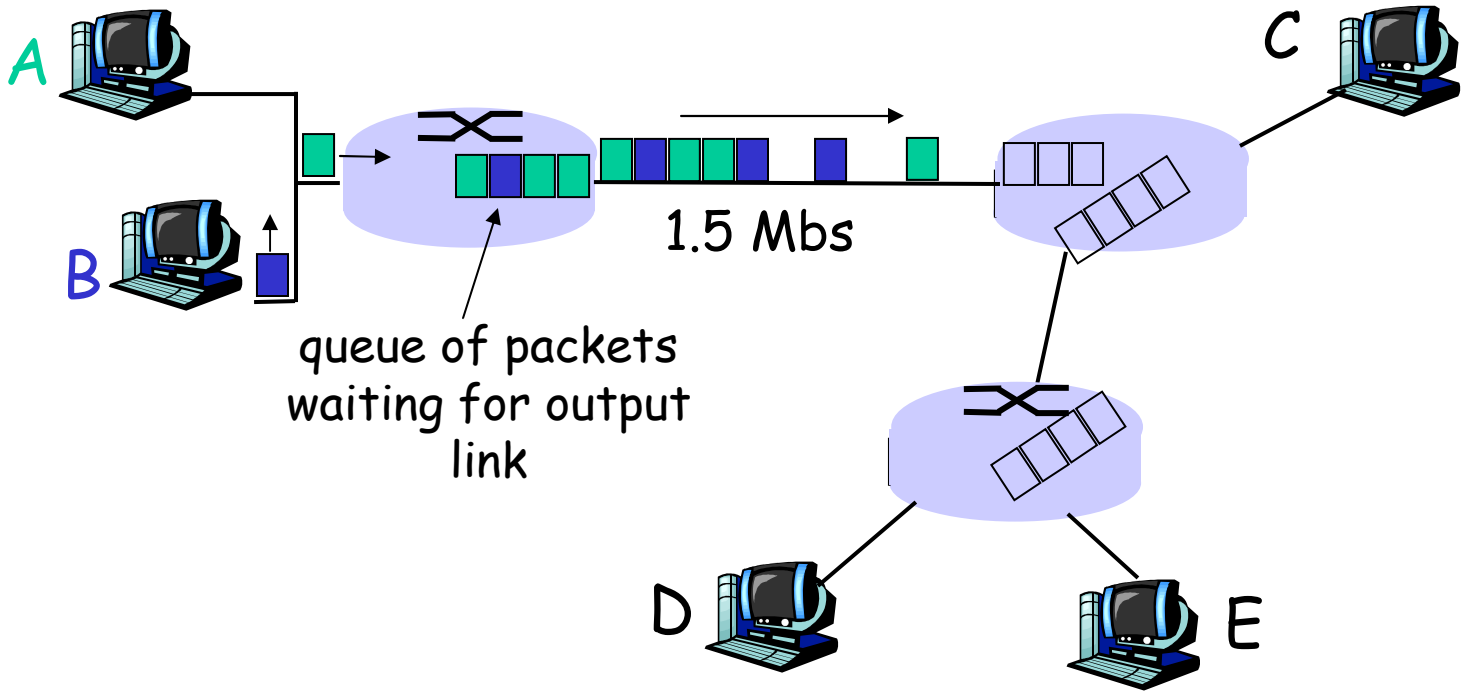
each end-end data stream divided into *packets*

- user A, B packets *share* network resources
- each packet uses full link bandwidth

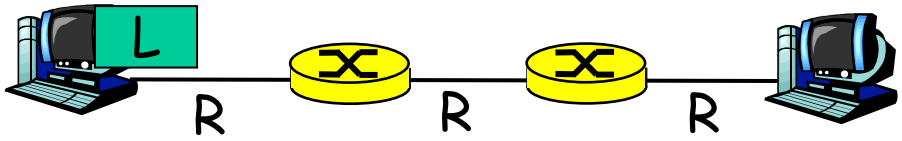
resource contention:

- demand can exceed available capacity
- congestion: packets queue, wait for link use
- store and forward: packets move one hop at a time
  - transmit over link
  - wait turn at next link

Packet Switching:



Packet-switching: store-and-forward

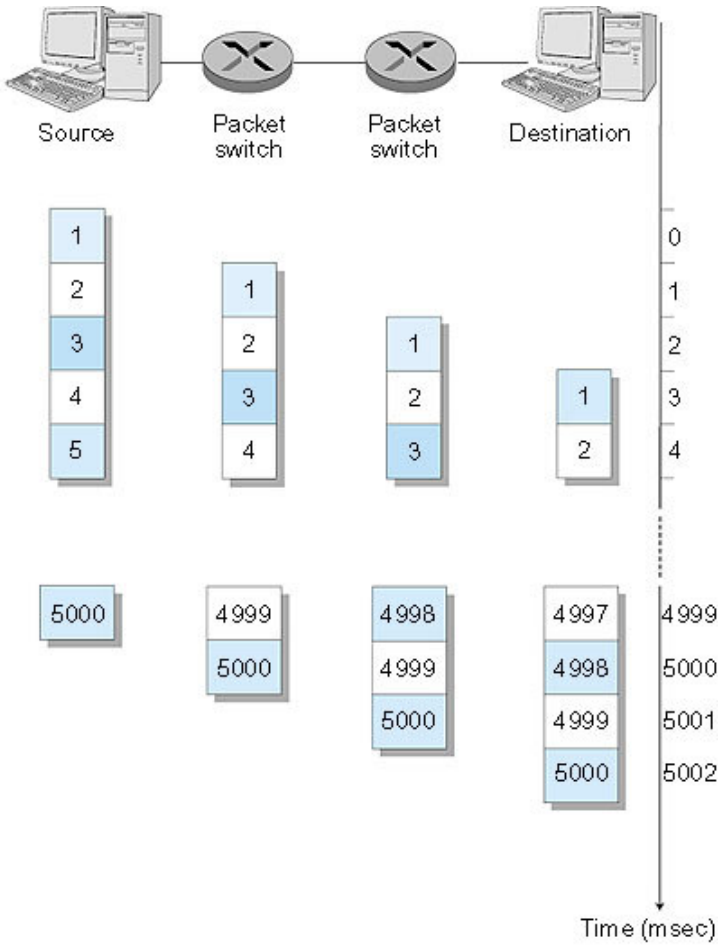


- Takes 4 seconds to transmit (push out) packet of 5000 bits on to link or 1250 bps
- Entire packet must arrive at router before it can be transmitted on next link: *store and forward*

Example:

- L = 7.5 Mbits
- R = 1.5 Mbps
- delay = 15 sec

Packet Switching: Message Fragmentation



Now break up message into 1500 bits packets

- Total of 5000 packets
- 1 msec to transmit packet on one link
- *pipelining:* each link works in parallel

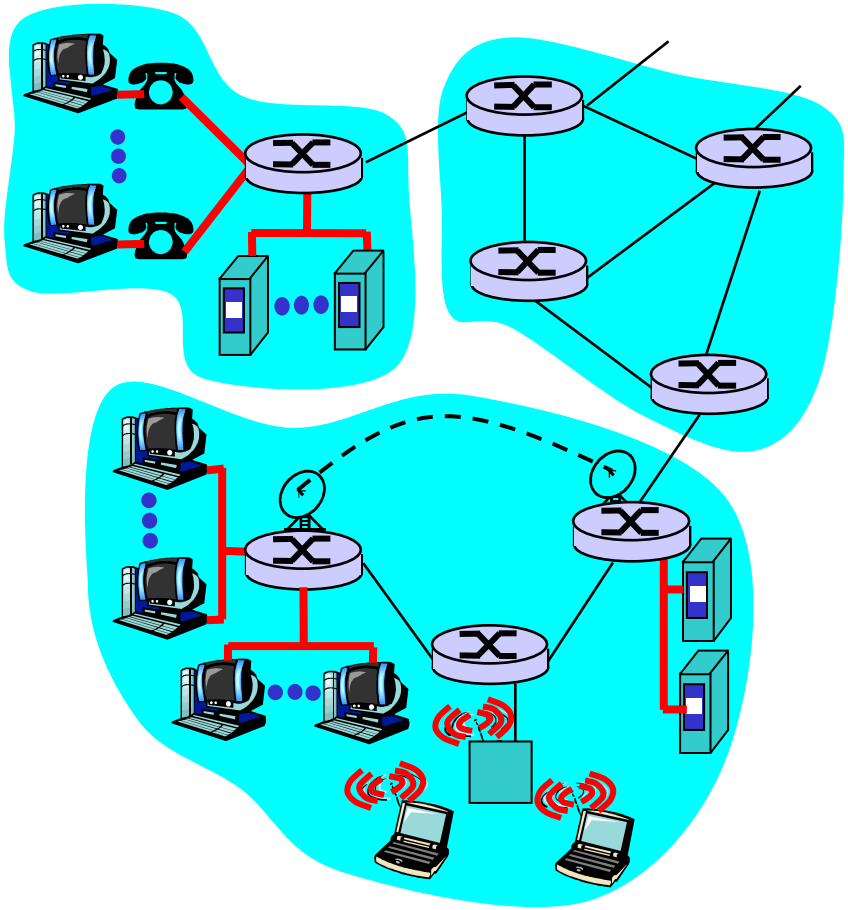
Access Networks

Q: How to connect end systems to edge router?

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

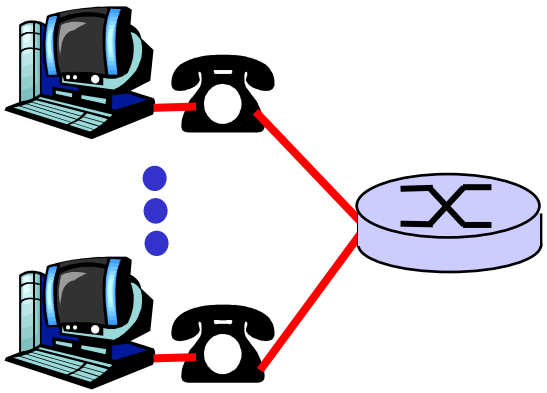
Keep in mind:

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



Residential access: point to point access

- Dialup via modem
  - up to 56Kbps direct access to router (often less)
- ISDN: integrated services digital network
  - 128kbps + regular phone line

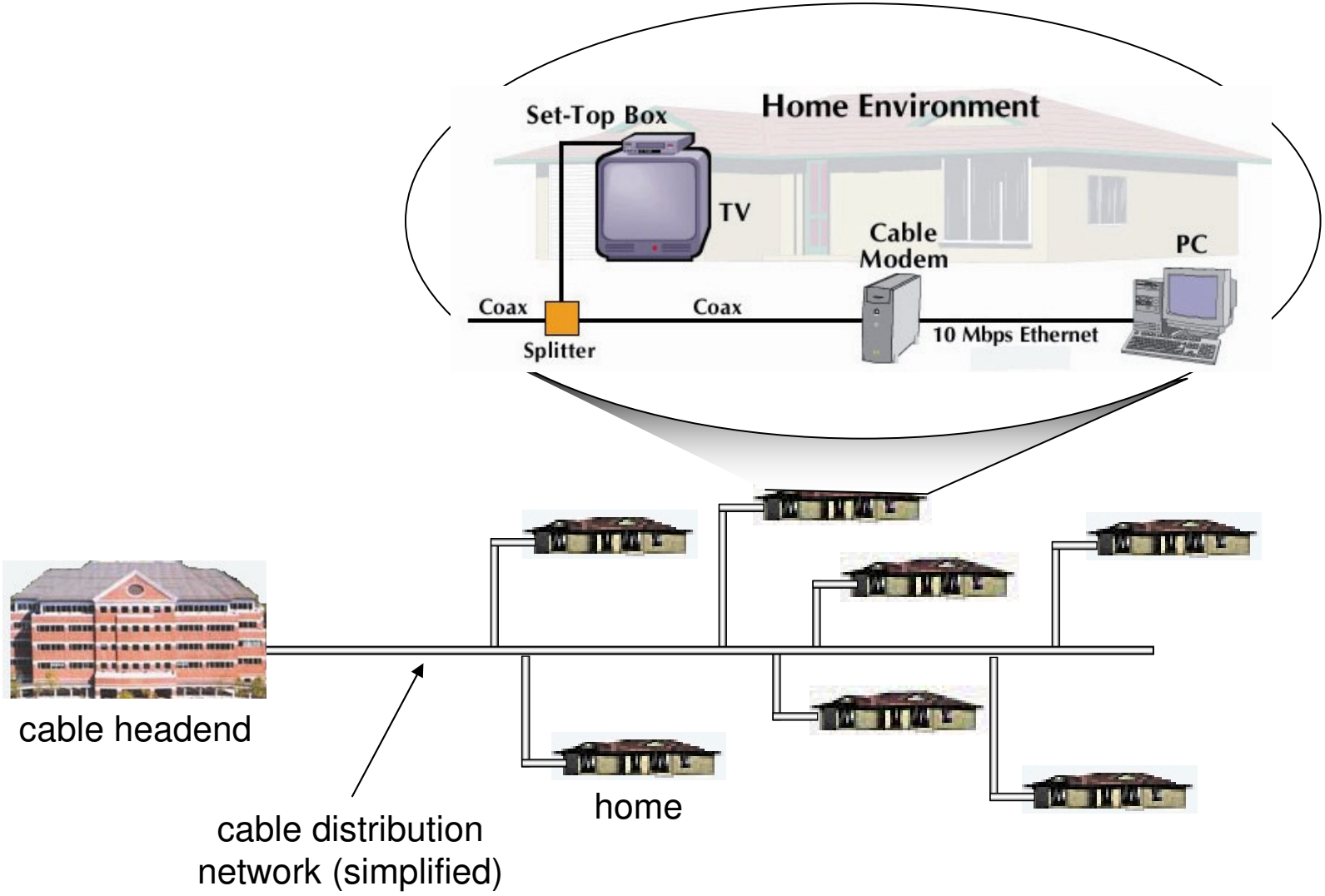


- ADSL: asymmetric digital subscriber line
  - up to 1 Mbps upstream (today typically < 256 kbps)
  - up to 8 Mbps downstream (today typically < 1 Mbps)

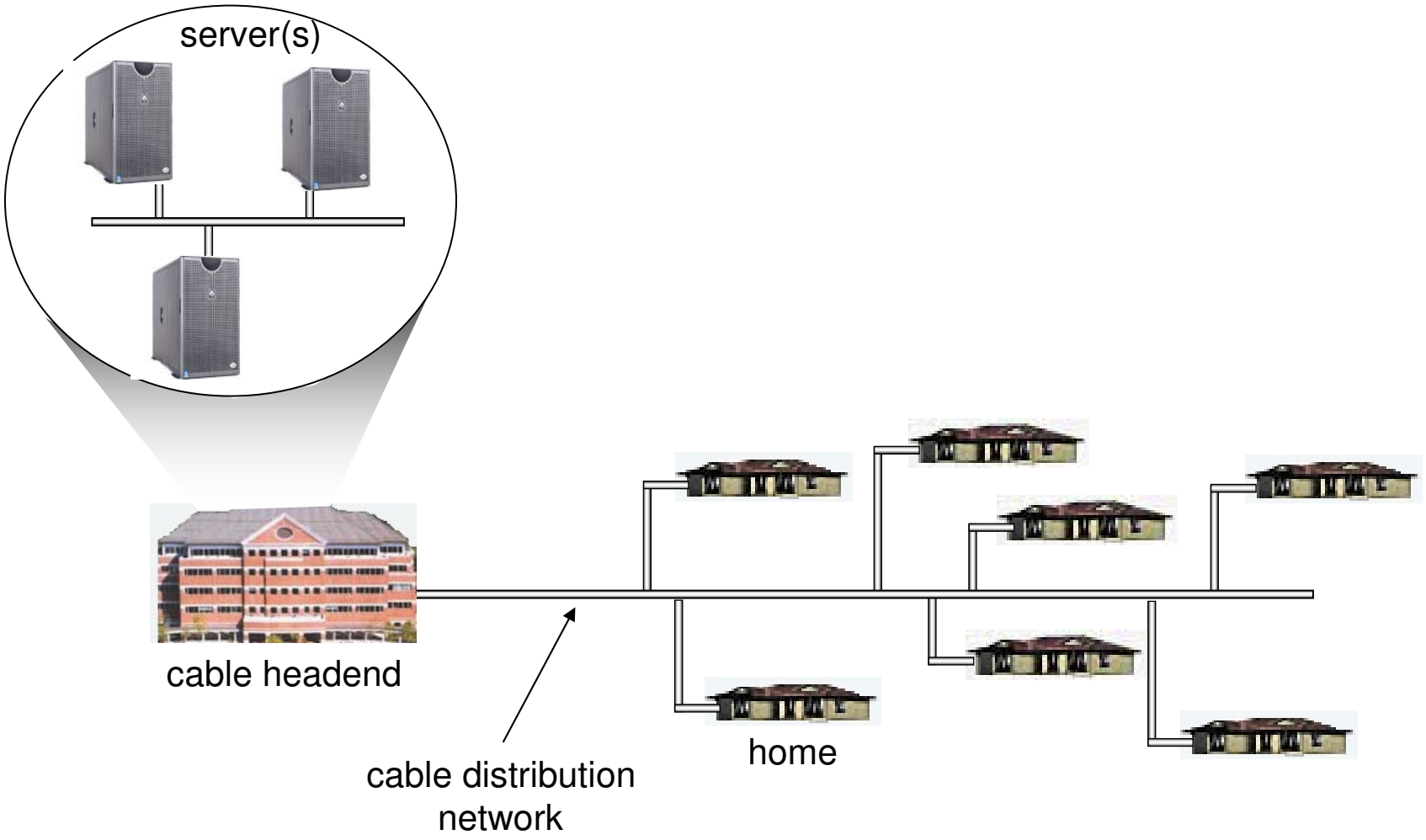
Residential access: cable modems

- HFC: hybrid fiber coax
  - asymmetric: up to 10Mbps downstream, 1 Mbps upstream
- network of cable and fiber attaches homes to ISP router
  - shared access to router among home
  - issues: congestion, dimensioning
- deployment: available via cable companies, e.g., MediaOne, ATT, Comcast

Cable Network Architecture: Overview

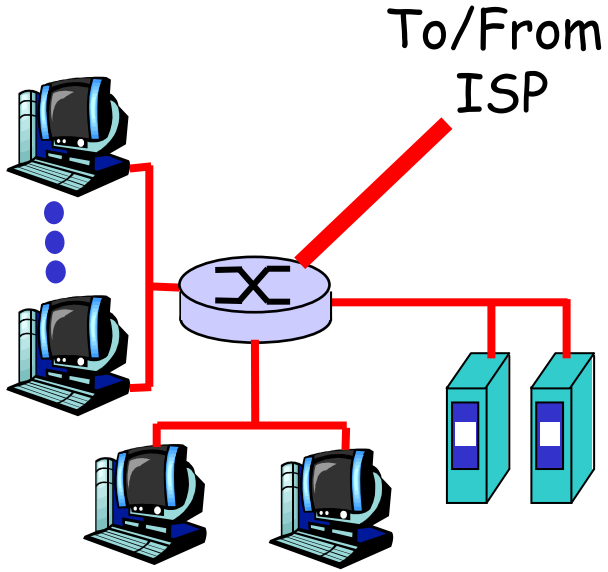


Cable Network Architecture: Overview



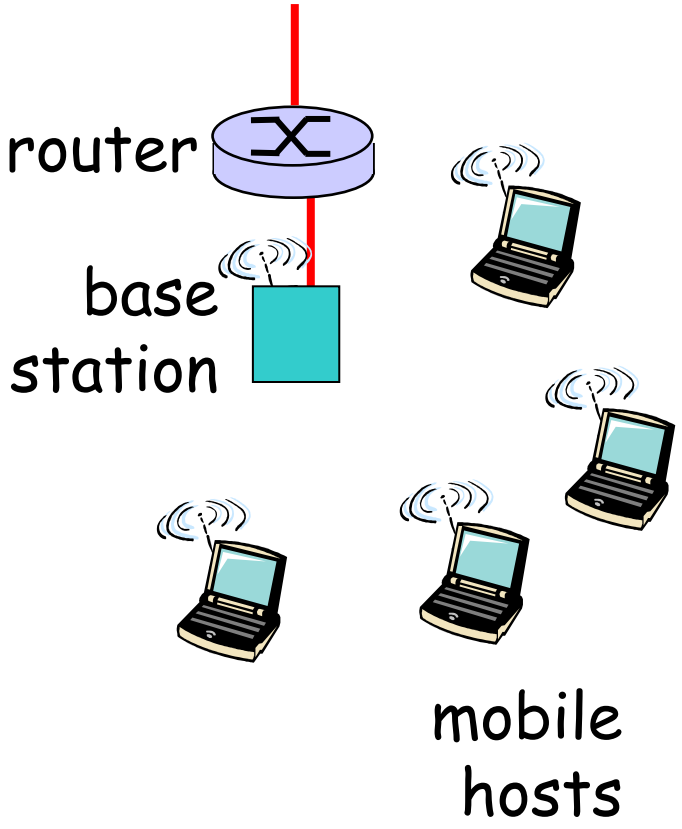
Company access: local area networks

- company/univ local area network (LAN) connects end system to edge router
- Ethernet:
  - shared or dedicated link connects end system and router
  - 10 Mbs, 100Mbps, Gigabit Ethernet



Wireless access networks

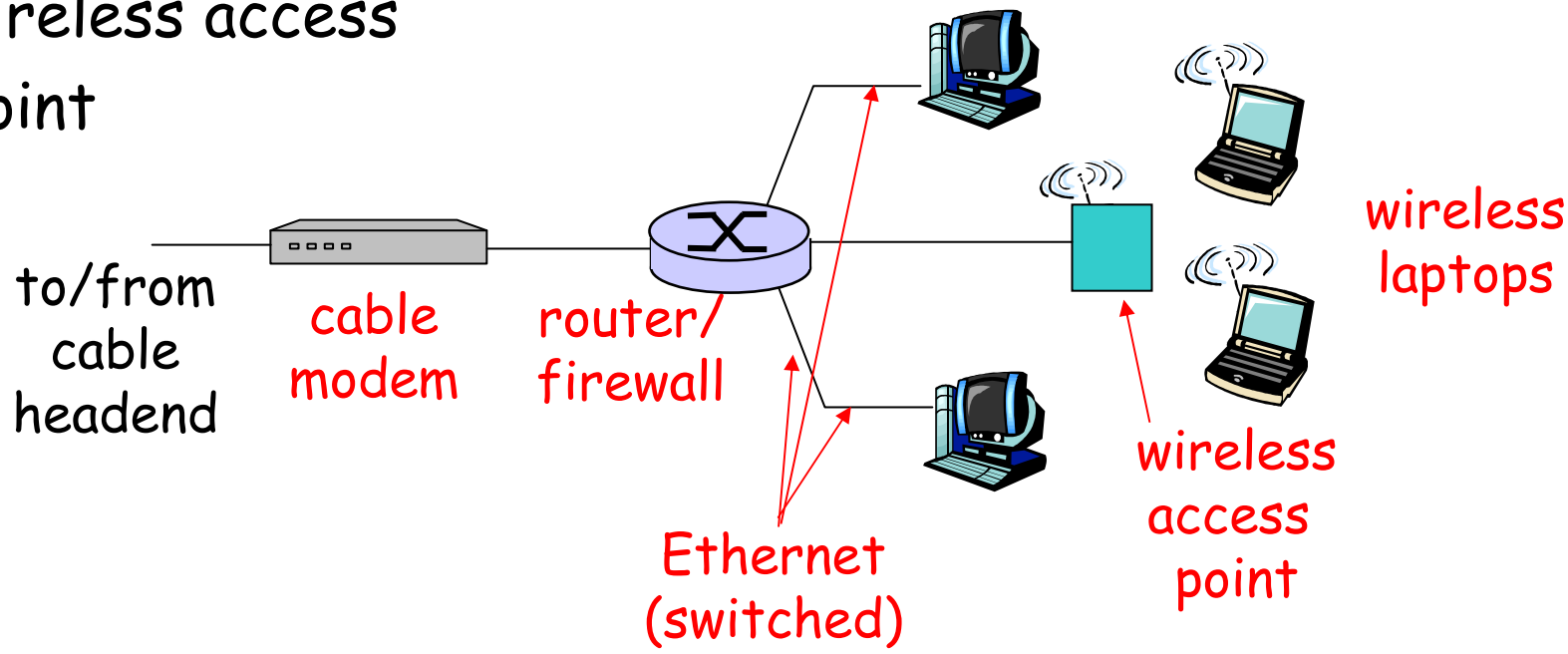
- shared *wireless* access network connects end system to router
  - via base station aka "access point"
- wireless LANs:
  - 802.11b (WiFi): 11 Mbps



Home networks

Typical home network components:

- ADSL or cable modem
- router/firewall/NAT
- Ethernet
- wireless access point



Physical Media

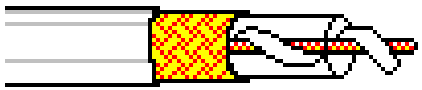
Twisted Pair (TP)

- two insulated copper wires
  - Category 3: traditional phone wires, 10 Mbps Ethernet
  - Category 5 TP: 100Mbps Ethernet

Physical Media: coax, fiber

Coaxial cable:

- two concentric copper conductors



Fiber optic cable:

- glass fiber carrying light pulses, each pulse a bit
- high-speed operation:
  - high-speed point-to-point transmission (e.g., 5 Gps)
- low error rate: repeaters spaced far apart ; immune to electromagnetic noise

Physical media: radio

- 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., WaveLAN)
  - 2Mbps, 11Mbps
- wide-area (e.g., cellular)
  - e.g. 3G: hundreds of kbps
- satellite
  - up to 50Mbps channel (or multiple smaller channels)
  - 270 msec end-end delay
  - geosynchronous versus LEOS