CS 330: Network Applications & Protocols

Introduction to Computer Networks & the Internet

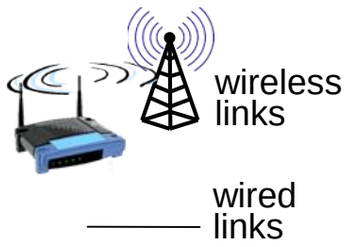
Galin Zhelezov
Department of Physical Sciences
York College of Pennsylvania

Introduction

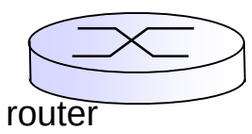
- **What is the Internet?**
- **Network edge**
  - End systems, access networks, links
- **Network core**
  - Packet switching, circuit switching, network structure
- **Delay, loss, throughput in networks**
- **Protocol layers, service models**
- **Networks under attack: security**
- **History**

What is the Internet?

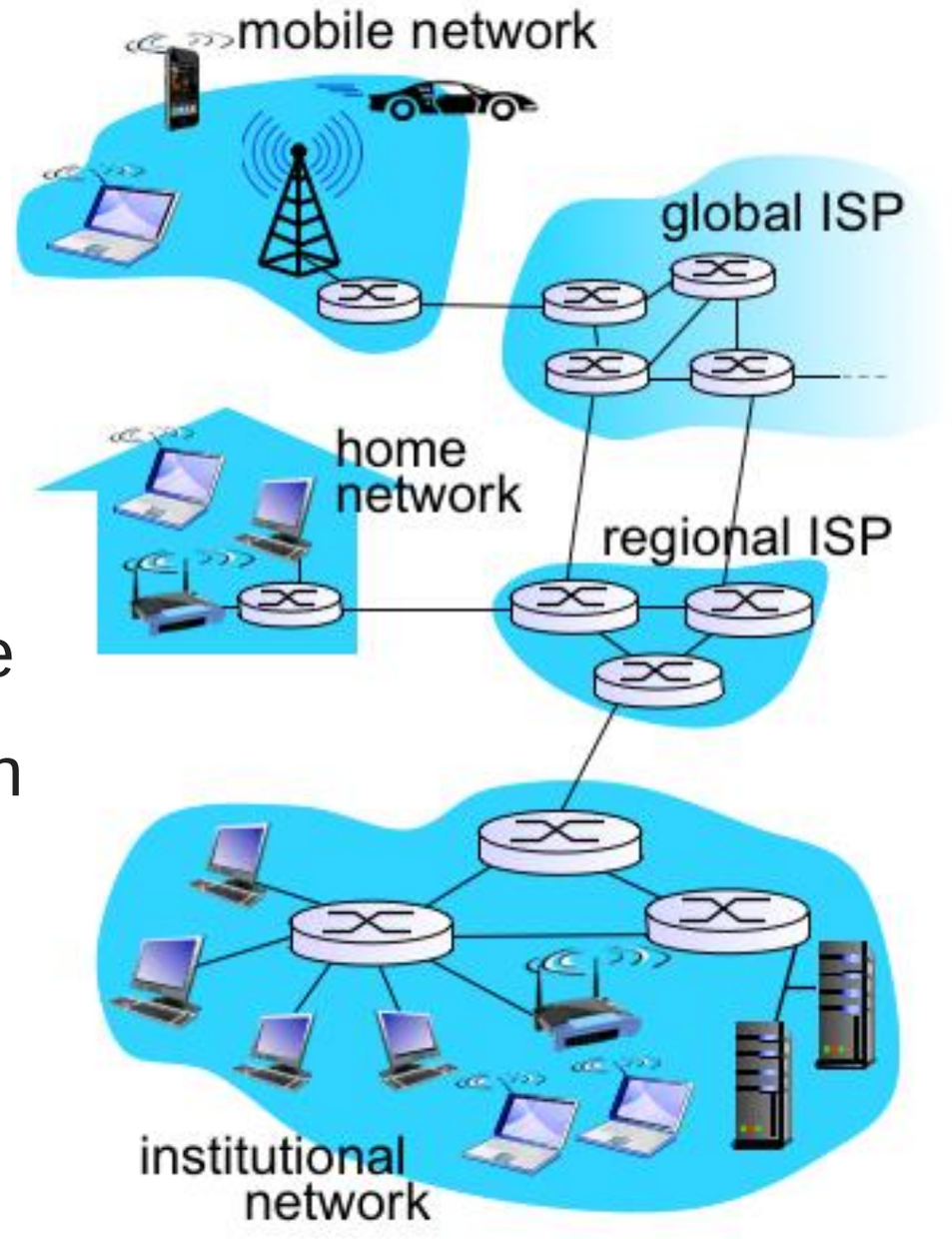
- **Millions of connected computing devices:**
  - hosts = end systems
  - running network apps



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



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



“Fun” Internet Appliances

IP picture frame

Web-enabled toaster + weather forecaster

Tweet-a-watt: monitor energy use

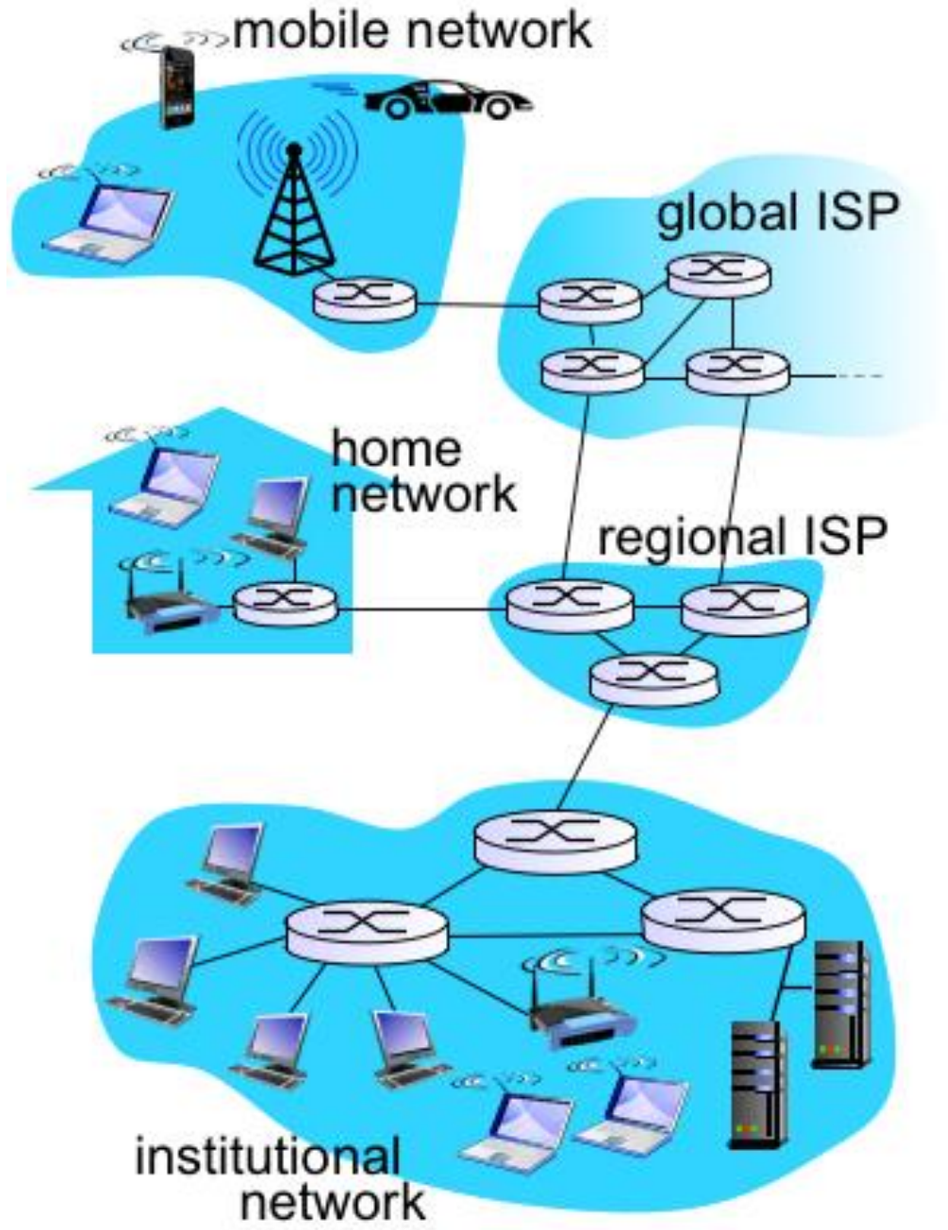
Internet refrigerator

Slingbox: watch, control cable TV remotely

Internet phones

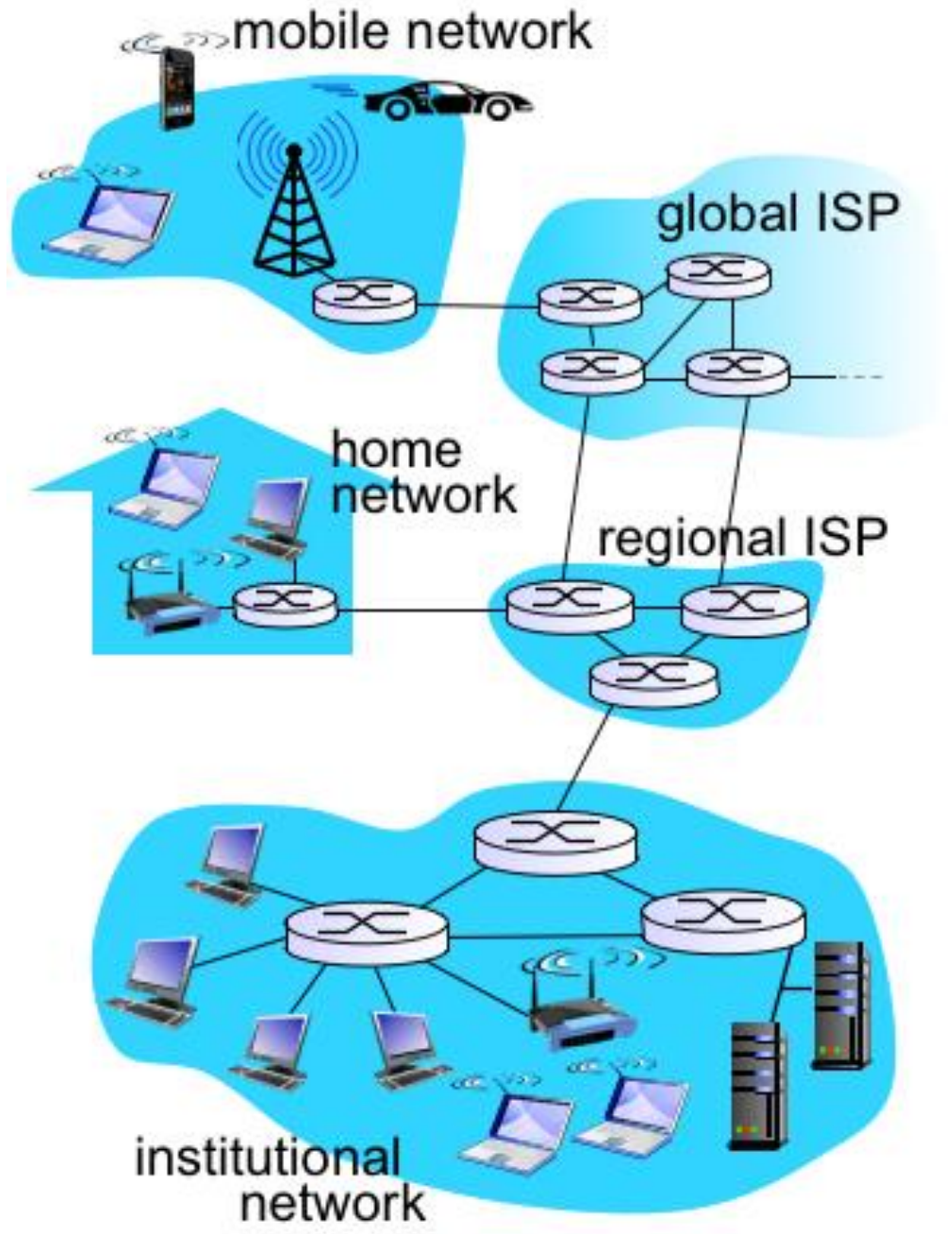
What is the Internet: The Nuts and Bolts

- **Internet: "network of networks"**
  - Interconnected ISPs
- **Protocols control sending, receiving of messages**
  - e.g. TCP, IP, HTTP, Skype, 802.11
- **Internet standards**
  - RFC: Request for comments
  - IETF: Internet Engineering Task Force



What is the Internet: A Service View

- **Infrastructure that provides services to applications:**
  - Web, VoIP, email, games, e-commerce, social networks, etc.
- **Provides programming interface to applications**
  - Hooks that allow sending and receiving applications to "connect" to Internet
  - Provides service options, analogous to postal service



What is a Protocol?

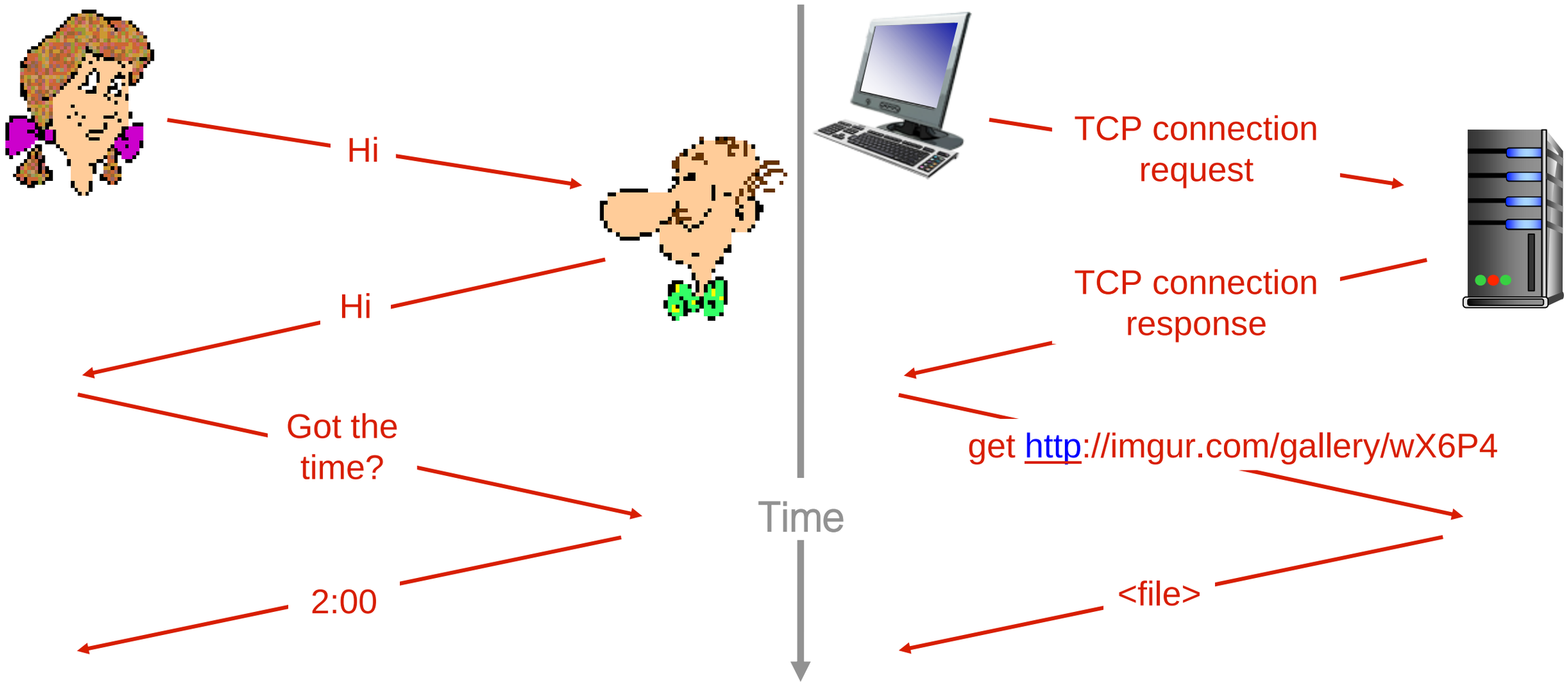
- **Human protocols:**
  - "What time is it?"
  - "I have a question"
  - Introductions
- **Specific messages are sent**
- **Specific actions taken when messages received, or other events**

- **Network protocols:**
  - Machines rather than humans
  - All communication activity on Internet governed by protocols

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

What is a Protocol?

A human protocol and a computer network protocol:



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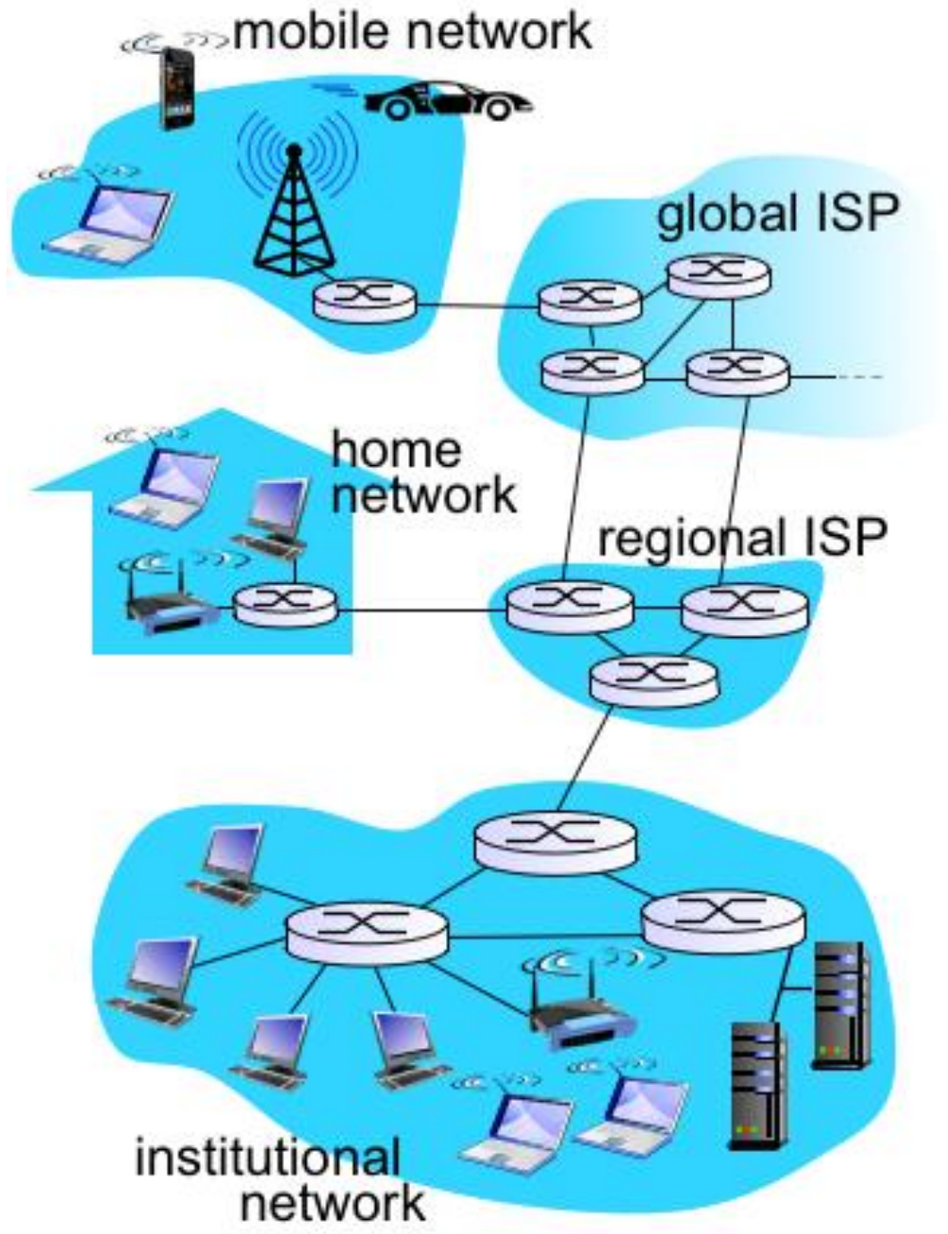
A Closer Look at Network Structure

- **Network edge:**
  - Hosts: clients and servers
  - Servers are often located in data centers

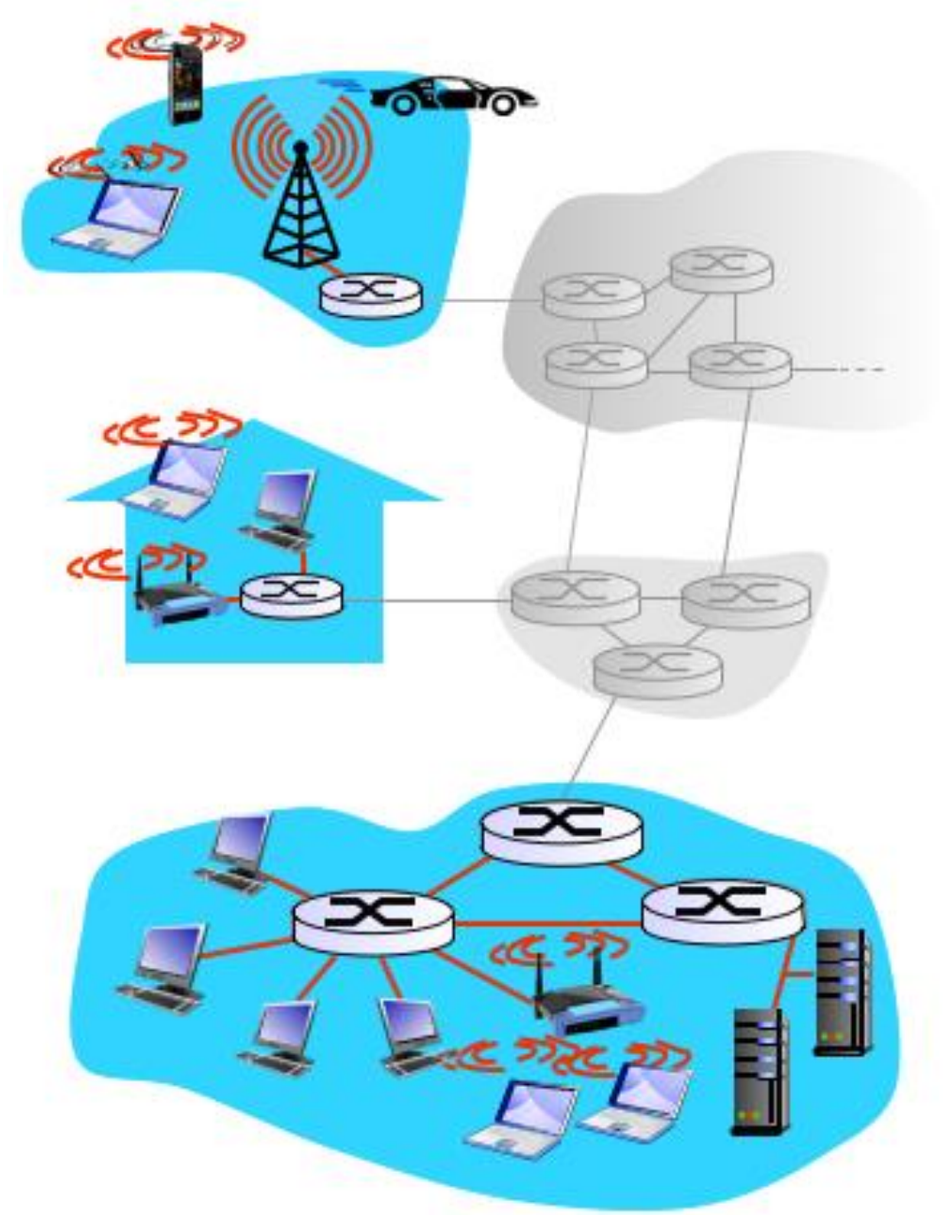
- **Access networks, physical media: wired, wireless communication links**
  - Access networks connect devices at edge to the first router on the network

- **Network core:**
  - Interconnected routers
  - Network of networks



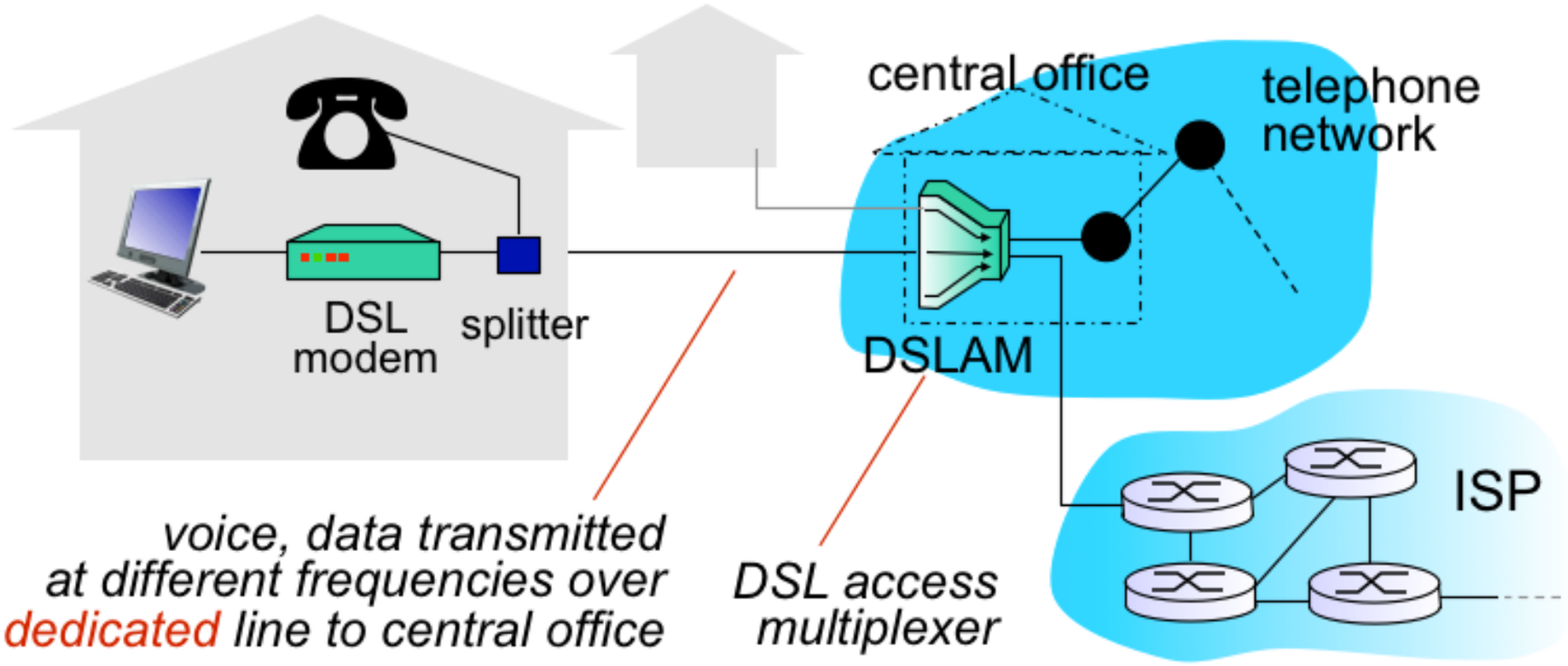
Access Networks and Physical Media

- **Question: How do different systems connect to an edge router?**
  - Residential access networks
  - Institutional access networks (school, company)
  - Mobile access networks



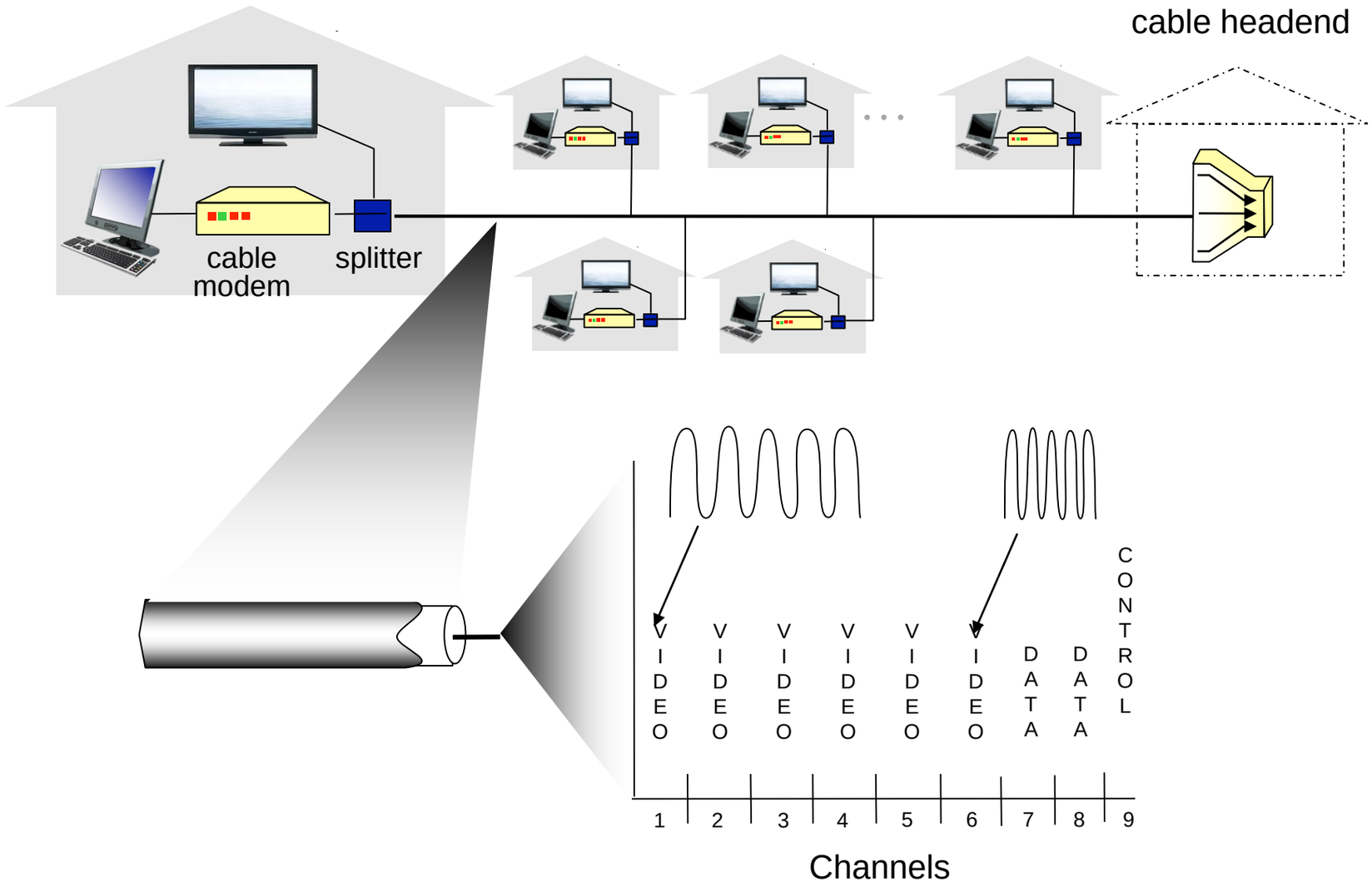
- **Must keep in mind:**
  - Bandwidth (bits per second) of access network?
  - Is the bandwidth shared or dedicated?

Access Network: Digital Subscriber Line (DSL)



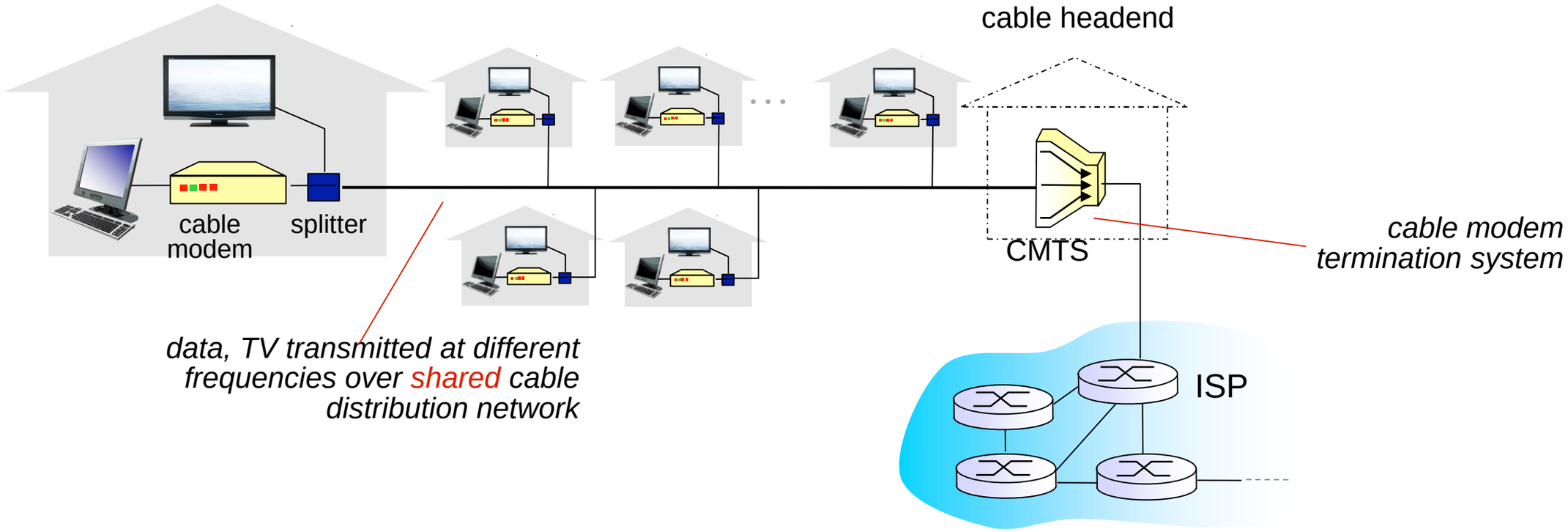
- **Use *existing* telephone line to central office DSLAM**
  - Data over DSL phone line goes to Internet
  - Voice over DSL phone line goes to telephone network
- **Less than 2.5 Mbps upstream transmission rate (typically < 1 Mbps)**
- **Less than 24 Mbps downstream transmission rate (typically < 10 Mbps)**

Access Network: Cable Network



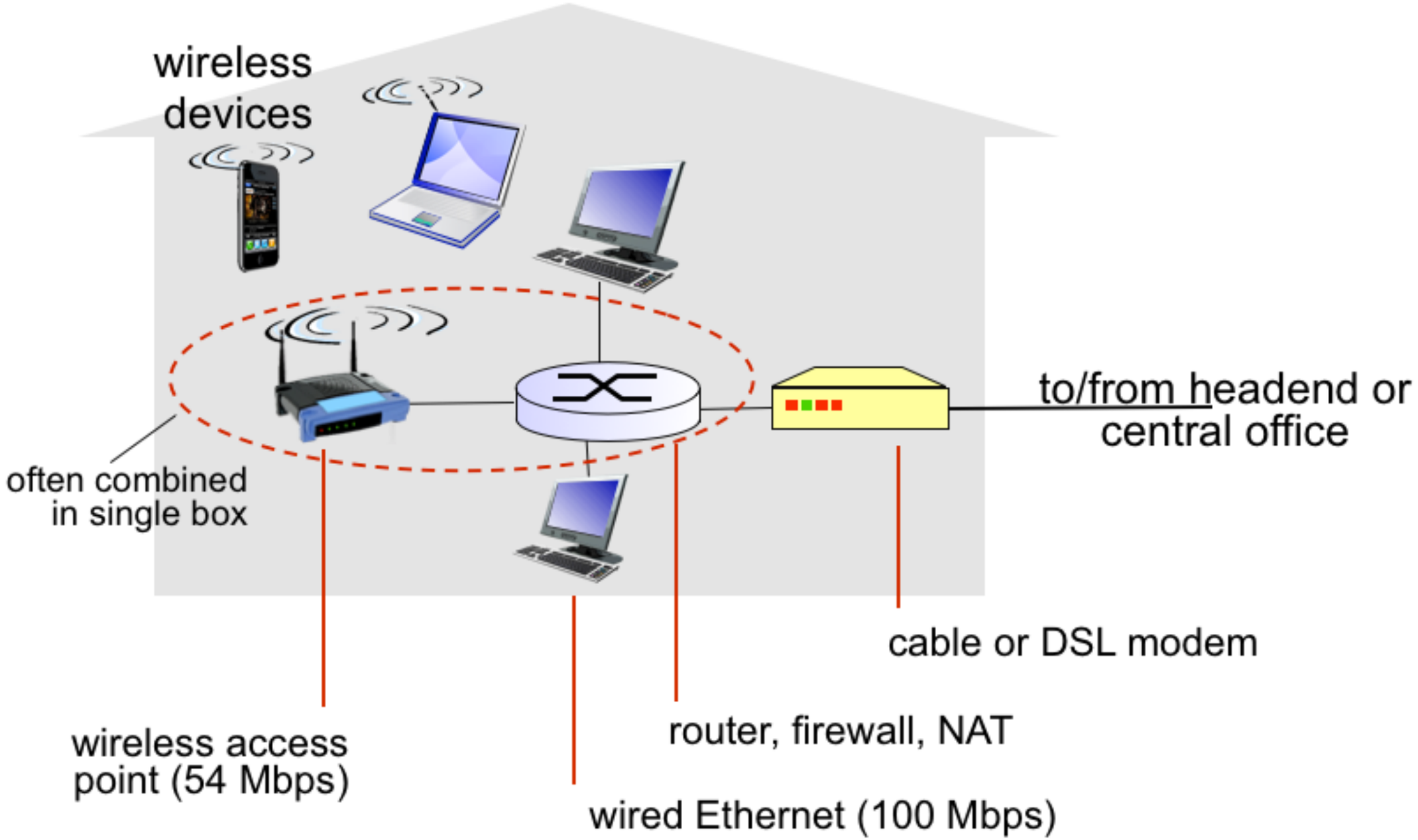
- **Use frequency division multiplexing: different channels transmitted in different frequency bands**

Access Network: Cable Network

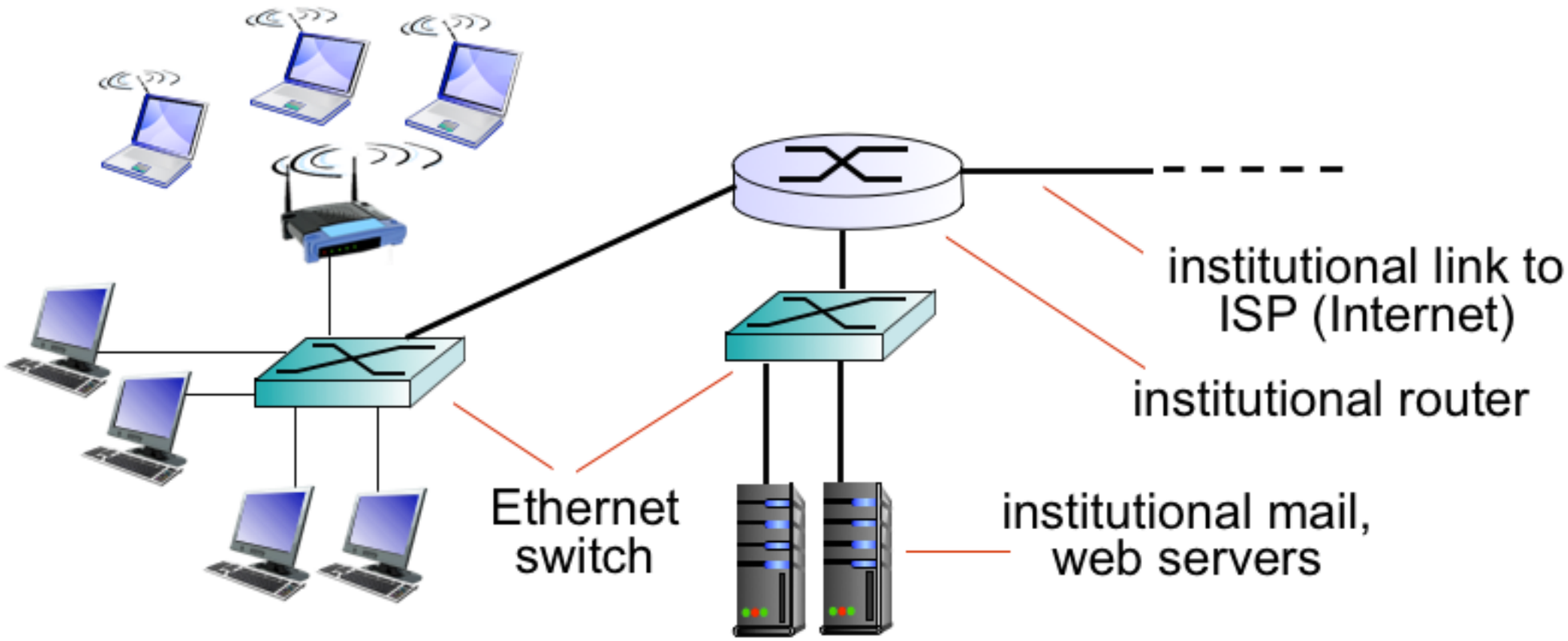


- **HFC: hybrid fiber coax**
  - Asymmetric: up to 30Mbps downstream transmission rate, 2 Mbps upstream transmission rate
- **Network of cable, fiber attaches homes to ISP router**
  - Homes share access network to cable headend
  - Unlike DSL, which has dedicated access to central office

Access Network: 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

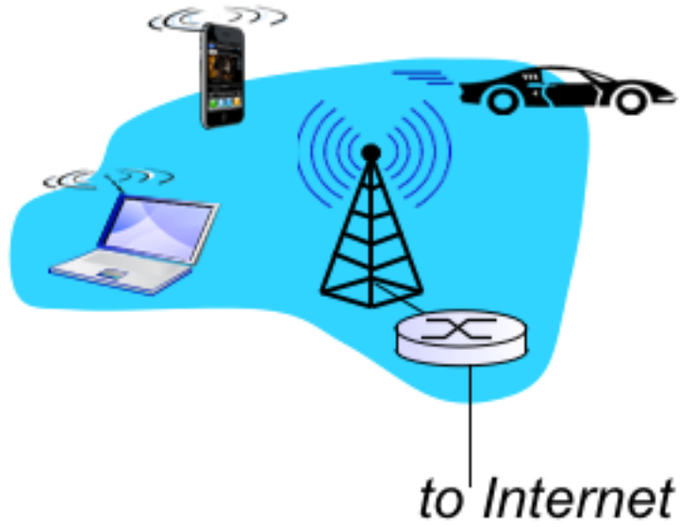
- **Shared wireless access network connects end system to router via base station a.k.a. "access point"**

Wireless LANs:

- Within building (100 ft)
- 802.11a/b/g/n (WiFi): 11, 54 Mbps transmission rate

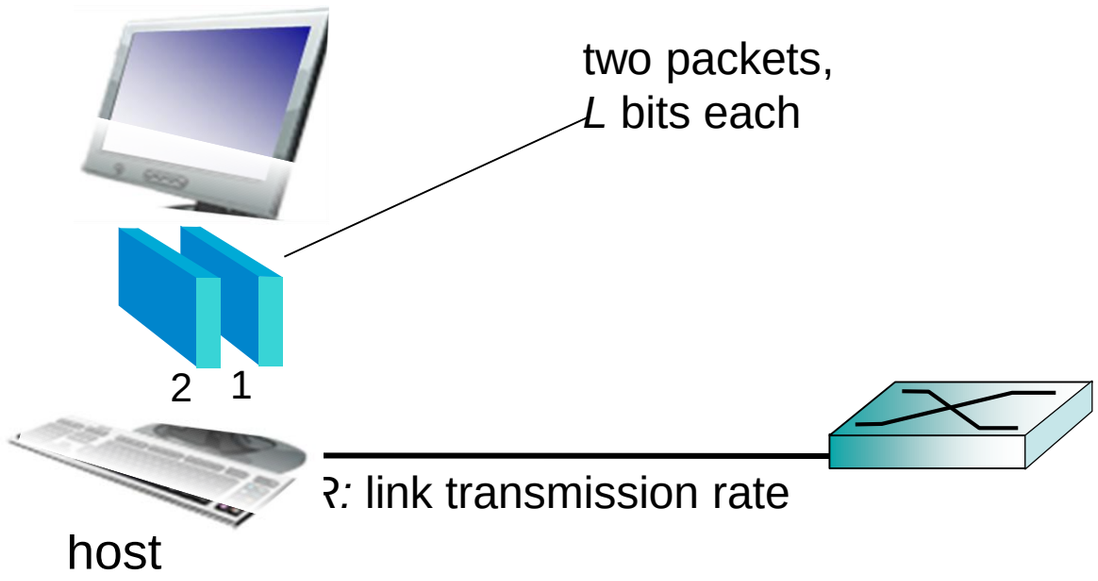
Wide-area Wireless Access:

- Provided by telco (cellular) operator, 10's km
- Between 1 and 10 Mbps
- 3G, 4G: LTE



Host: Sending Packets of Data

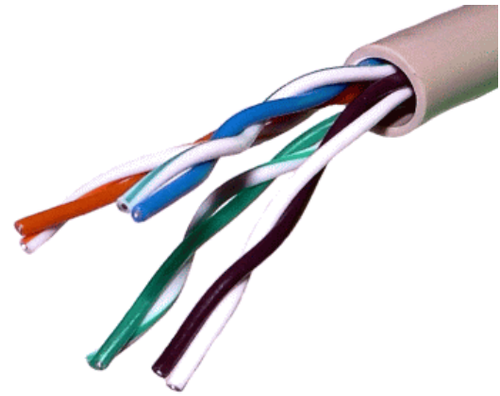
- **Host sending function:**
  - Takes application message
  - Breaks into smaller chunks, known as packets, of length *L* bits
  - Transmits packet into access network at transmission rate *R*
    - Link transmission rate (a.k.a. link capacity, a.k.a. link bandwidth)



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

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)**

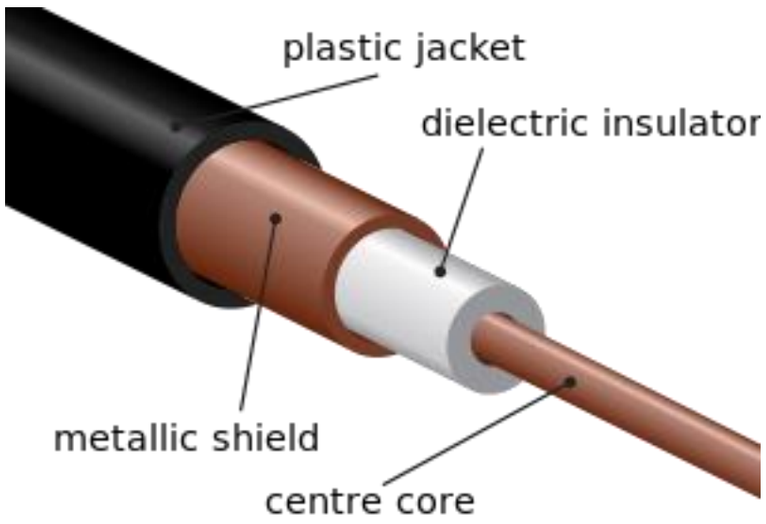


Twisted Pair:

- 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 is a bit
- High-speed operation:
  - High-speed point-to-point transmission (10's-100's Gbps transmission rate)
- Low error rate:
  - Repeaters can be 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 (up to 45 Mbps channels)
  - LAN (e.g. WiFi)
    - 11Mbps, 54 Mbps
  - Wide-area (e.g. cellular)
    - 4G cellular: ~ 10 Mbps
  - Satellite
    - Kbps to 45Mbps channel (or multiple smaller channels)
    - Geosynchronous satellites (270 ms end-to-end delay)
    - Low-earth orbit satellites