

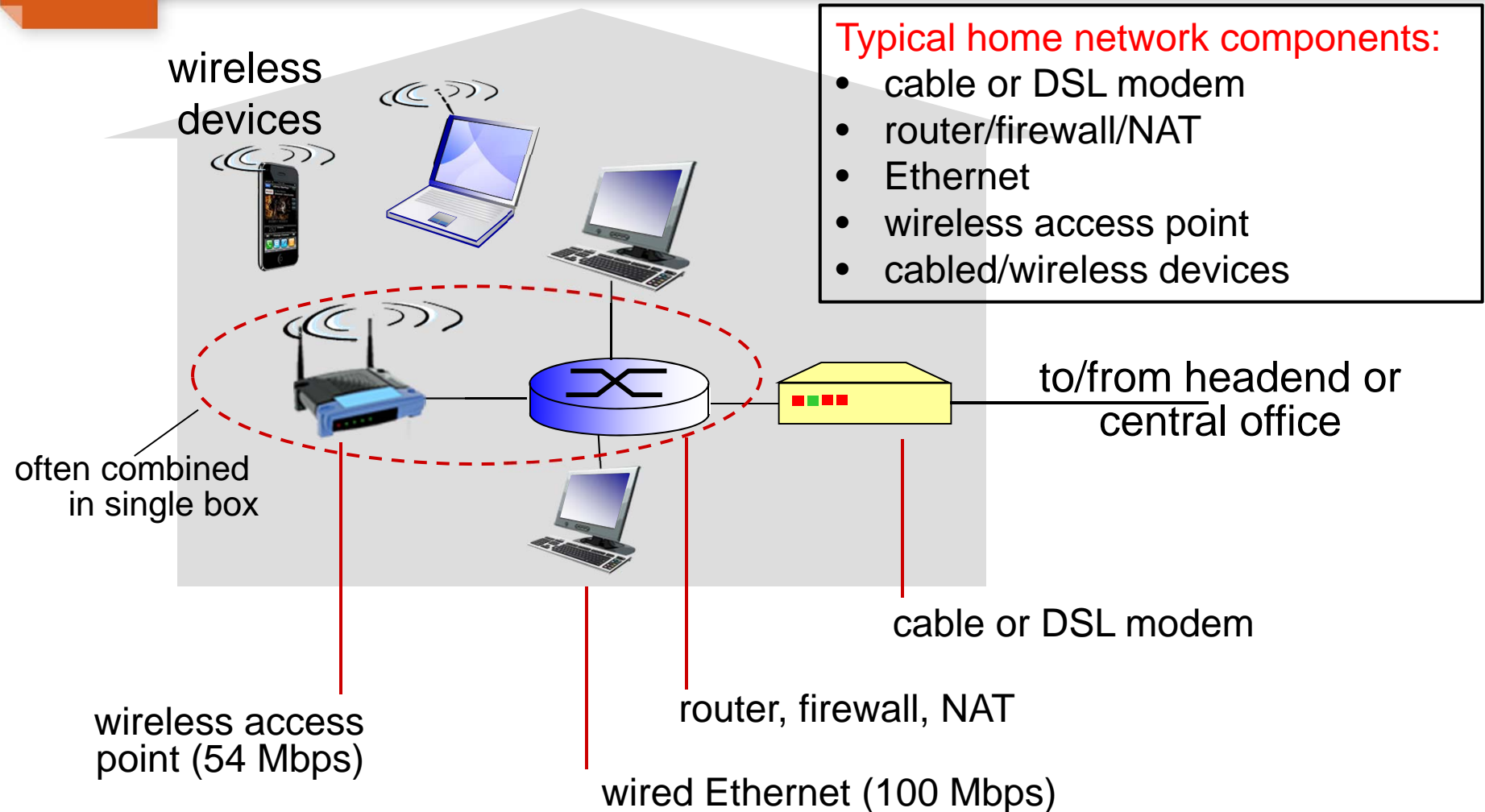
# CS 372 Lecture #5

## Overview of Networking:

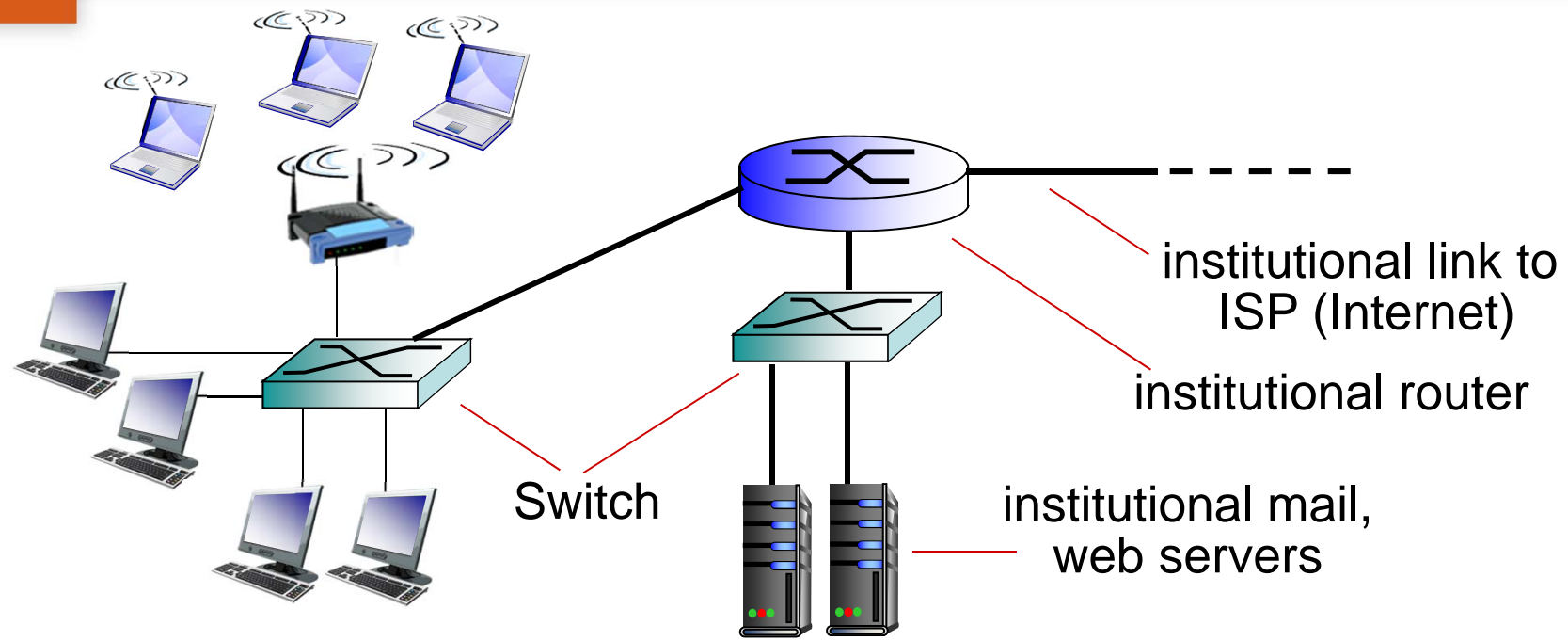
- more about access networks
- physical media

**Note:** Many of the lecture slides are based on presentations that accompany *Computer Networking: A Top Down Approach*, 6<sup>th</sup> edition, by Jim Kurose & Keith Ross, Addison-Wesley, 2013.

# Access networks: Home



# Access networks: Local Area Networks



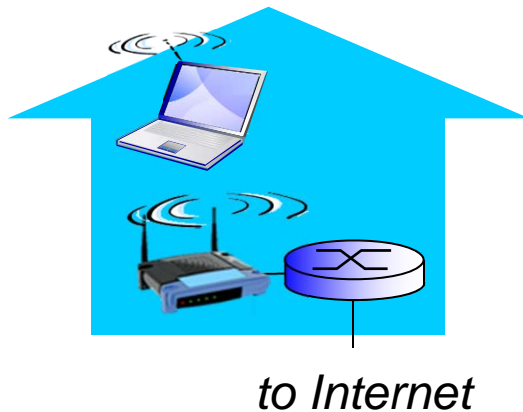
- Typically used in companies, universities, etc.
- Example: **Ethernet**
  - local servers, public servers
  - shared or dedicated link connects end systems to edge router
  - 10 Mbs, 100Mbps, 1 Gbps, 10 Gbps
- Much more later about LANs

# Access networks: Wireless

- Shared *wireless* access network connects end system to router via base station (access point)

## wireless LANs:

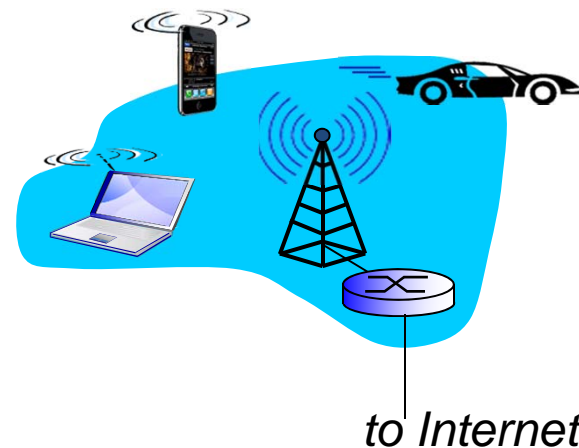
- within building (100 ft)
- 802.11b/g (WiFi): 11 or 54 Mbps transmission rate



**Discussion question:** What are 3G, 4G, and LTE?

## wide-area wireless access

- provided by phone company (cellular) 10 – 30 km
- 1 to 10 Mbps transmission rate
- 3G, 4G, LTE



# Physical Media

- Physical media
  - provides the required link between sender & receiver
  - propagates bits between sender/receiver pairs
- Two types of physical media:
  - guided media: signals propagate in solid media
  - unguided media: signals propagate freely, e.g., wireless radio

# Guided Media:

## twisted-pair copper wire

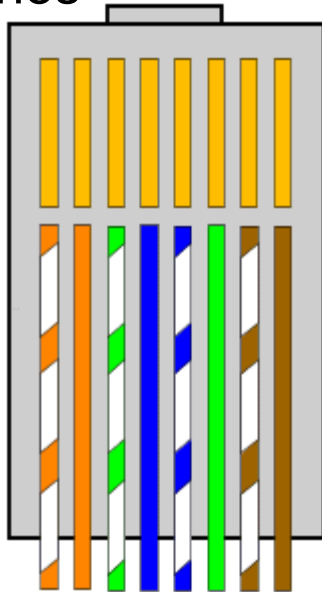
- two insulated copper wires
  - Category 3: 10Mbps Ethernet
  - Category 5: 100Mbps, 1Gbps Ethernet
  - Category 6: 1Gbps, 10Gbps Ethernet
- still used for high-speed LAN; e.g., ADSL
- rate depends on thickness and distance
- make up 99% of wired connections
- may pick up interference (“noise”)

**Discussion question:** Why are the pairs twisted?

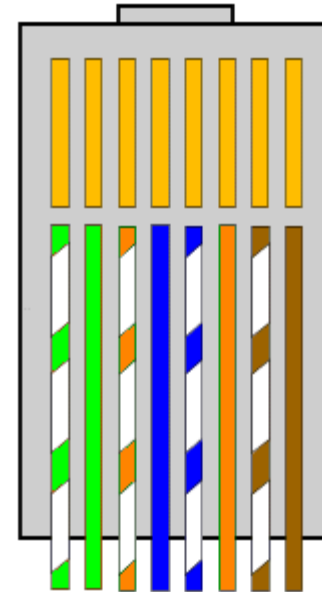


# Twisted pair connectors (RJ-45)

**connector:** same on both ends of the cable; used with hubs, switches



**crossover:** one of each; direct connection



Pins 1, 2: transmit

Pins 3, 6: receive

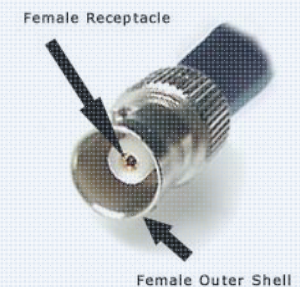
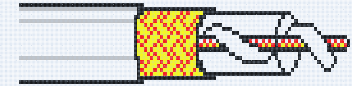
Pins 4, 5, 7, 8: not used for network data

NOTE: other standards exist (not compatible, consistency essential)

# Guided Media: coaxial cable

- two concentric copper conductors
- baseband:
  - single channel on cable
  - legacy Ethernet
- broadband:
  - multiple channels on cable
  - hybrid fiber-coax cable (HFC)
- Cable TV
- rate depends on thickness and distance
- less interference than twisted pair

coax cable and  
BNC connectors  
for Ethernet





# Baseband and broadband

- *Baseband* uses a small part of the wave spectrum and sends only one signal at a time
- *Broadband* uses a larger part of the wave spectrum and uses frequency division multiplexing to send multiple signals simultaneously

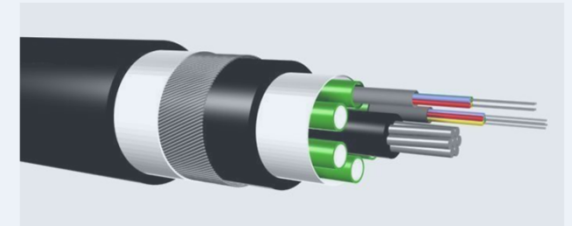
# Frequency division multiplexing (FDM)

- Achieves multiplexing by using different carrier frequencies
- Frequencies must be separated to avoid interference
- Receiver can "tune" to specific frequency and extract modulation for that one channel
- Useful only in media that can carry multiple signals with different frequencies
  - high-bandwidth required

# Guided Media: fiber optic cable

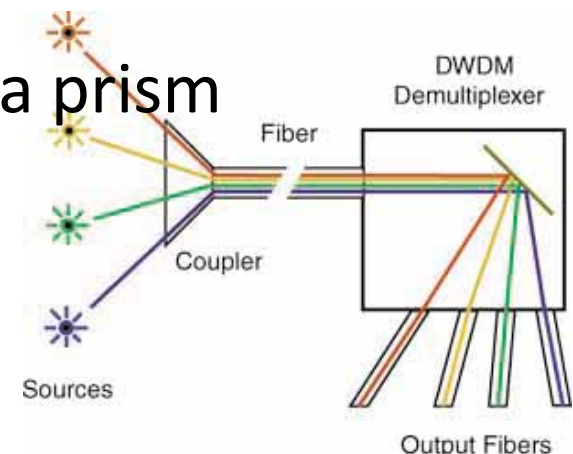
- glass fiber carrying light pulses, each pulse represents one bit
- high-speed operation:
  - high-speed point-to-point transmission (e.g., 10's-100's Gbps)
- low error rate:
  - immune to electromagnetic noise and other interference

fiber optic cable and example connector



# Wave-length division

- Frequency division multiplexing can be applied to optical transmission
  - known as *wave-length division multiplexing (WDM)*
  - When many wavelengths are used, the term becomes *Dense Wave Division Multiplexing (DWDM)*
- Informally, *color division multiplexing*
- Receiver separates frequencies using a prism
  - red, orange, etc
- More information at <http://www.thefoa.org/PPT/index.html>



Source: <http://www.thefoa.org>

# Unguided media: wireless radio

- signal carried in electromagnetic spectrum
  - in the “air”
- no physical wire
- effects of **propagation environment**:
  - reflection
  - obstruction by objects
  - interference

# Radio link types

- **terrestrial microwave** (directional)
  - up to 45 Mbps channels
- **LAN** (e.g., Wifi)
  - 11Mbps, 54 Mbps
- **wide-area** (e.g., cellular)
  - 3G, 4G, LTE: hundreds of Kbps
- **satellite**
  - 1 Kbps to 45Mbps channel (or multiple smaller channels)
    - Geostationary (36000 km) minimum 280 ms propagation delay
    - Low-earth orbit (usually 300 – 600 km)
    - Propagation delays depend on configuration
      - Earth  $\Leftrightarrow$  Satellite  $\Leftrightarrow$  Earth
      - Earth  $\Leftrightarrow$  Satellite  $\Leftrightarrow$  Satellite  $\Leftrightarrow$  ...  $\Leftrightarrow$  Satellite  $\Leftrightarrow$  Earth

- Definitions:
  - baseband, broadband
  - multiplexing
- Physical media
  - guided, unguided