Introduction to Physical Layer

Computer Networks
Term B10

Physical Layer Outline

- Definitions
- Multiplexing
- Transmission Media
- End System Choices
- Residential Configurations

Physical Layer Definitions

- The time required to transmit a character depends on both the encoding method and the signaling speed (i.e., the modulation rate - the number of times/sec the signal changes its voltage).
- baud (D) - the number of changes per second.
- bandwidth (H) - the range of frequencies that is passed by a channel. The transmitted signal is constrained by the transmitter and the nature of the transmission medium in cycles/sec (hertz).
- channel capacity (C) – the rate at which data can be transmitted over a given channel under given conditions.{This is also referred to as data rate (R).}

Modulation Rate

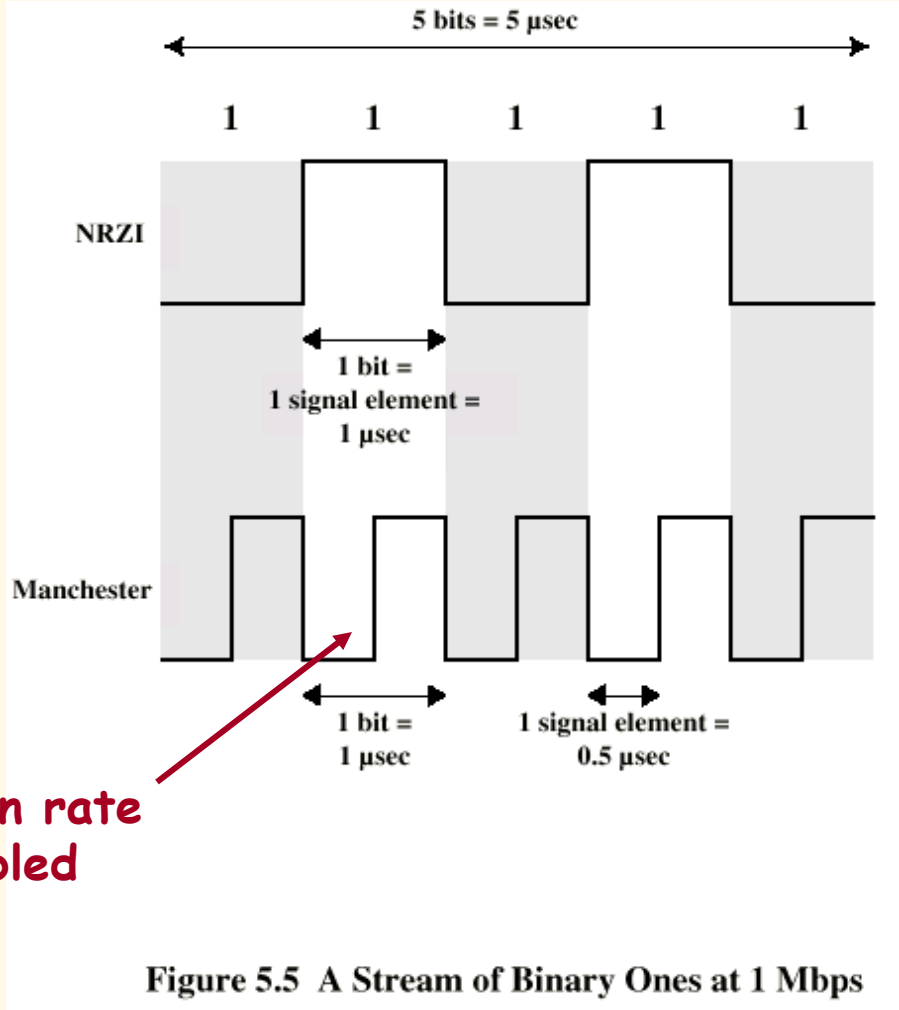

Figure 5.5 A Stream of Binary Ones at 1 Mbps

modulation rate is doubled

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Analog and Digital Signaling

signals:: electric or electromagnetic encoding of data.

signaling:: is the act of propagating the signal along a suitable medium.

Analog signal – a **continuously varying** electromagnetic wave that may be propagated over a variety of medium depending on the spectrum (e.g., wire, twisted pair, coaxial cable, fiber optic cable and atmosphere or space propagation).

Analog and Digital Signaling

digital signal – a sequence of voltage pulses that may be transmitted over a wire medium.

Note – analog signals to represent analog data and digital signals to represent digital data are not the only possibilities.

There is where modems and codecs come into the picture.

Analog vs Digital (three contexts)

Analog data	Two alternatives: (1) signal occupies the same spectrum as the analog data; (2) analog data are encoded to occupy a different portion of spectrum.	Analog data are encoded using a codec to produce a digital bit stream. codec
Digital data	Digital data are encoded using a modem to produce analog signal. modem	Two alternatives: (1) signal consists of two voltage levels to represent the two binary values; (2) digital data are encoded to produce a digital signal with desired properties.

(a) Data and signals

	Analog transmission	Digital transmission
Analog signal	Is propagated through amplifiers; same treatment whether signal is used to represent analog data or digital data.	Assumes that the analog signal represents digital data. Signal is propagated through repeaters; at each repeater, digital data are recovered from inbound signal and used to generatea new analog outbound signal.
Digital signal	Not used	Digital signal represents a stream of 1s and 0s, which may represent digital data or may be an encoding of analog data. Signal is propagated through repeaters; at each repeater, stream of 1s and 0s is recovered from inbound singal and used to generate a new digital outbound signal.

(b) Treatment of signals

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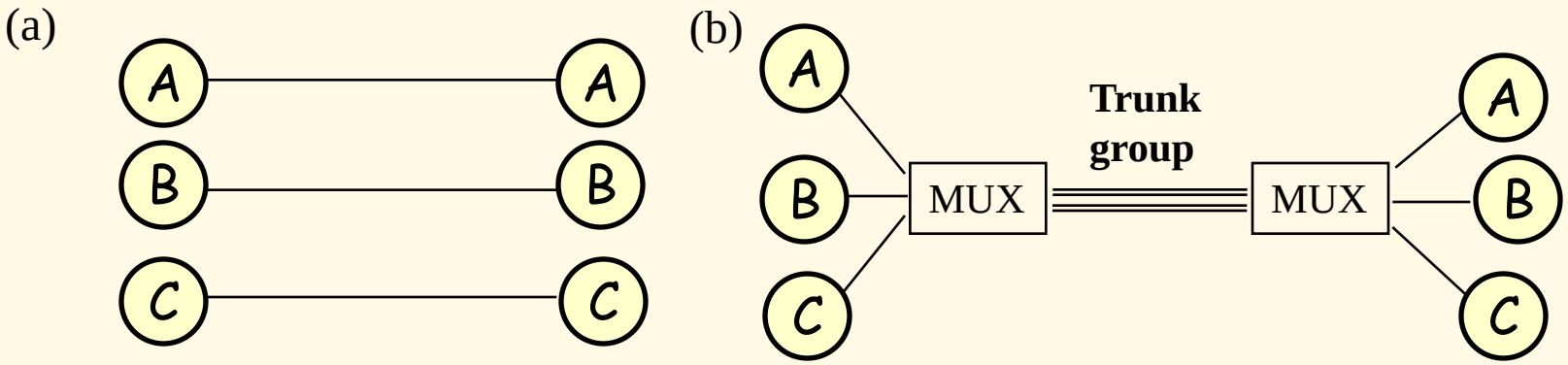
Multiplexing

Multiplexing {general definition} ::

Sharing a resource over time.



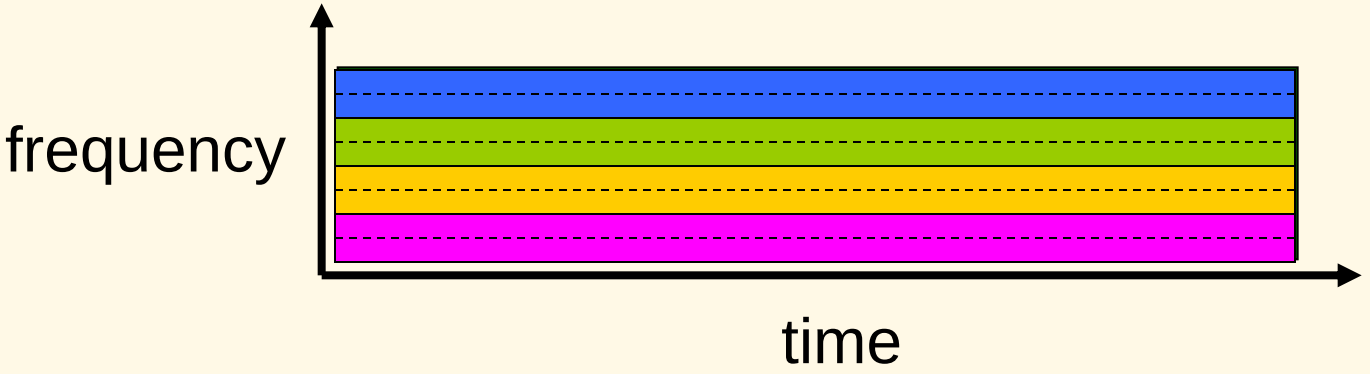
Leon-Garcia & Widjaja: *Communication Networks*

Frequency Division Multiplexing (FDM) vs Time Division Multiplexing (TDM)

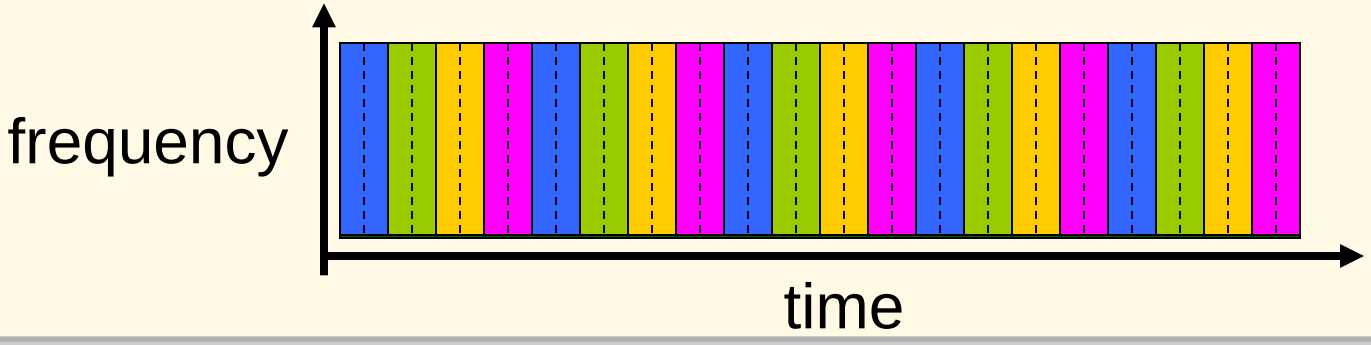
Example:

4 users

FDM



TDM



K & R

Frequency Division Multiplexing

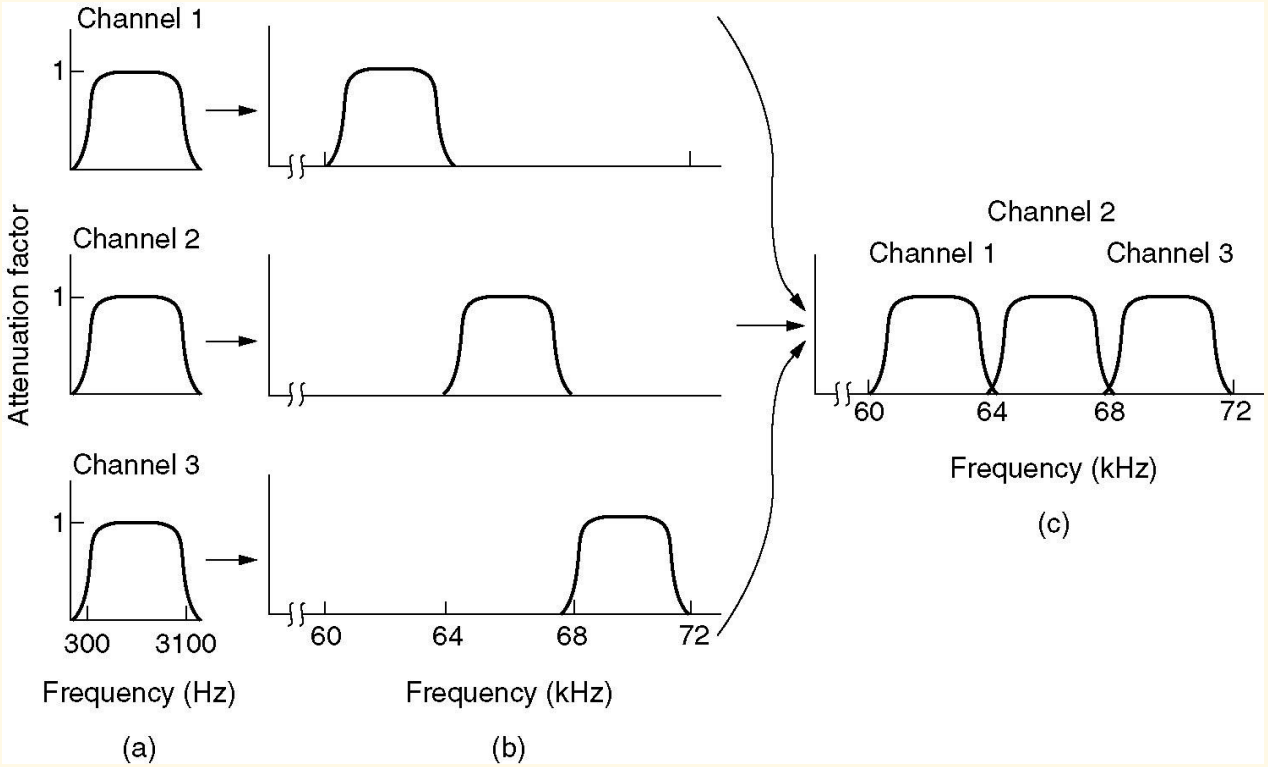


Figure 2-31. (a) The original bandwidths. (b) The bandwidths raised in frequency. (c) The multiplexed channel.

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T1 - TDM Link

TDM:: each host gets a fixed slot in revolving TDM frame

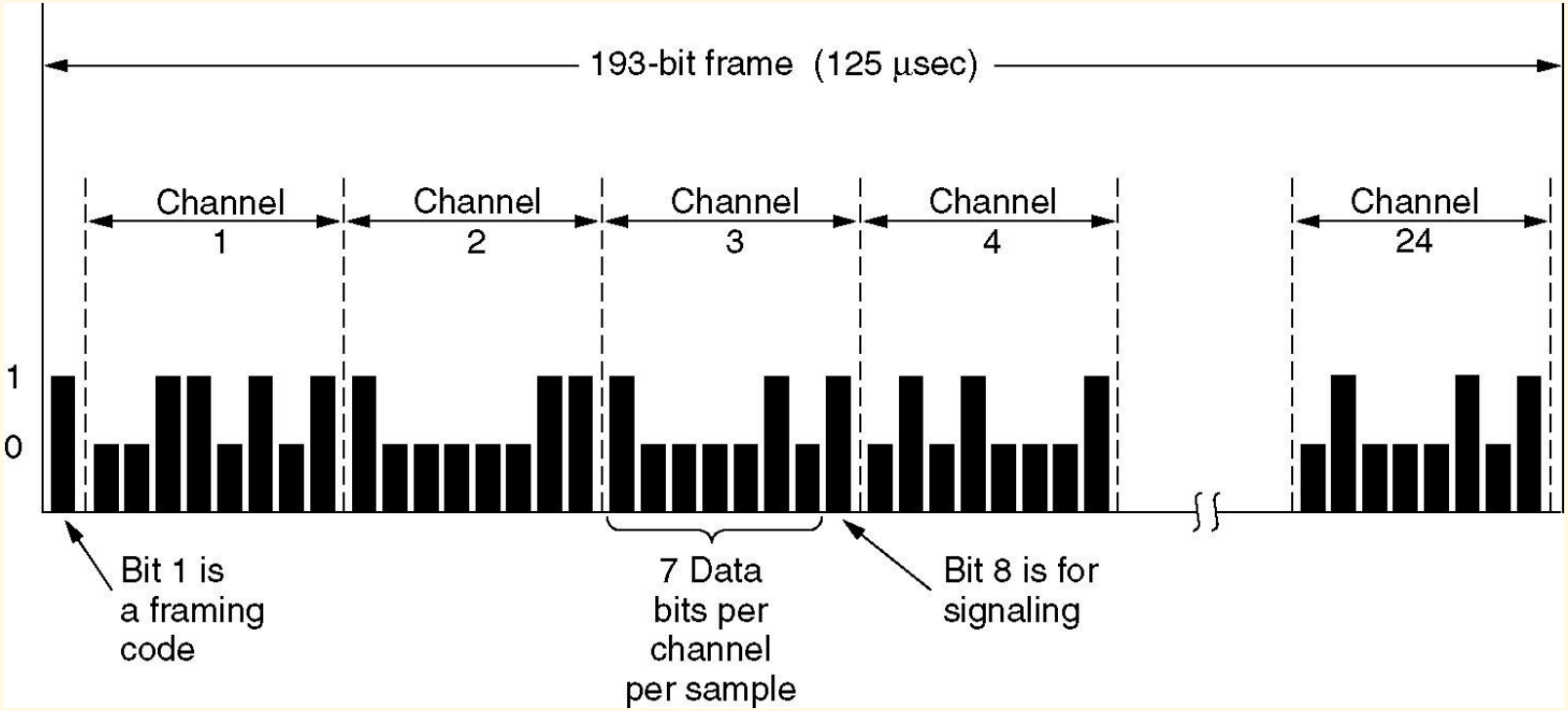

Figure 2-33.T1 Carrier (1.544Mbps)

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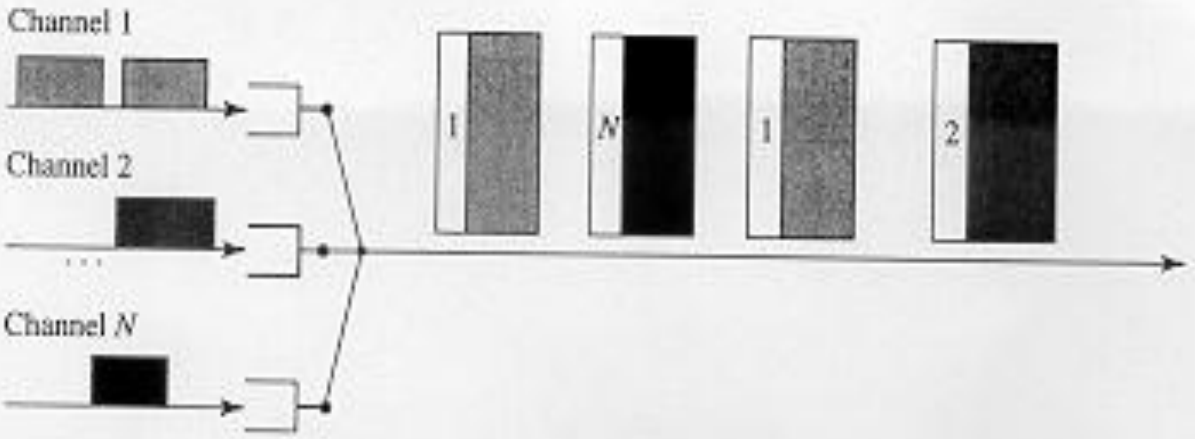
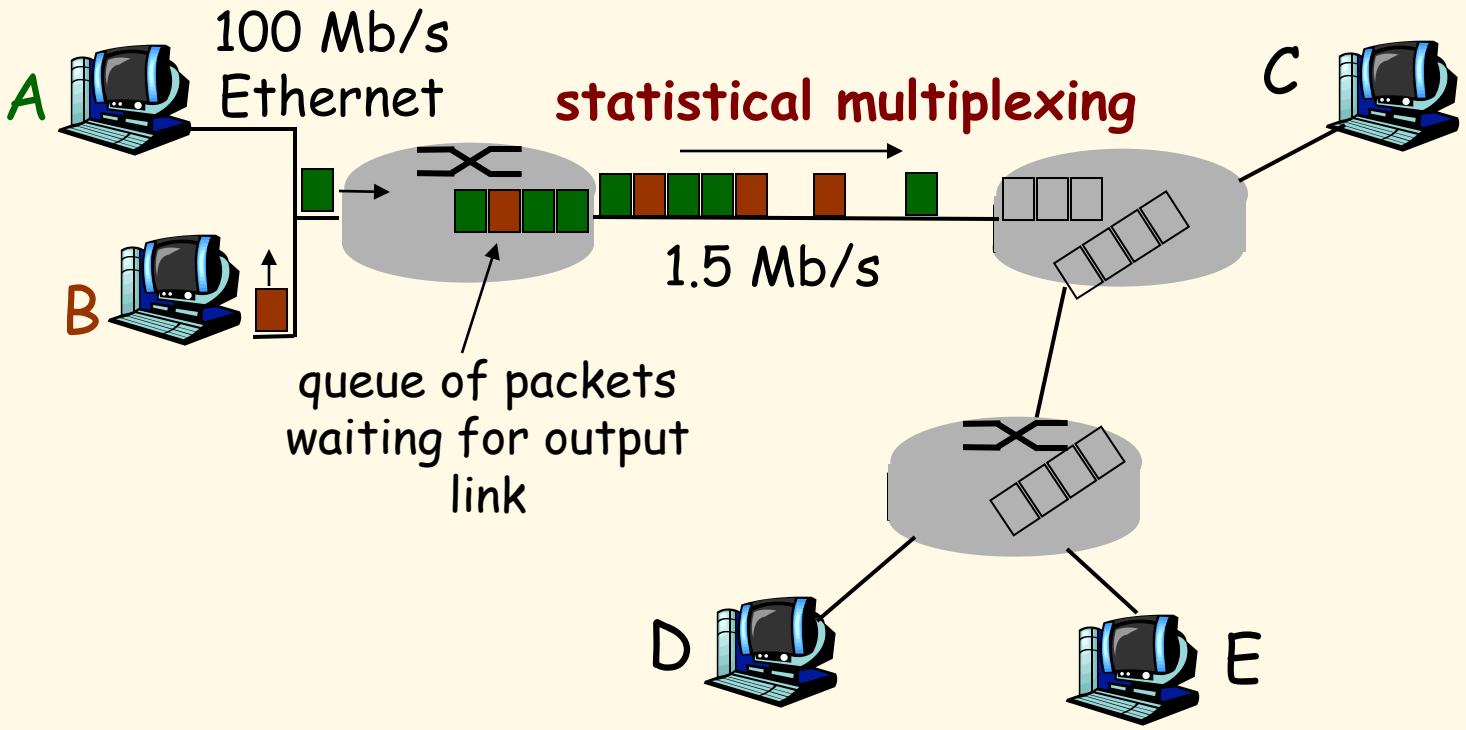
Concentrator [Statistical Multiplexing]



2.10 FIGURE

In statistical multiplexing, the multiplexer visits the incoming channel buffers in some order. The multiplexer empties a buffer before moving to the next one. The buffer contents are tagged to indicate their incoming channel. An idle channel does not waste transmission time.

Packet Switching: Statistical Multiplexing



Sequence of A & B packets does NOT have fixed pattern, bandwidth shared on demand ➔ statistical multiplexing.

Wavelength Division Multiplexing

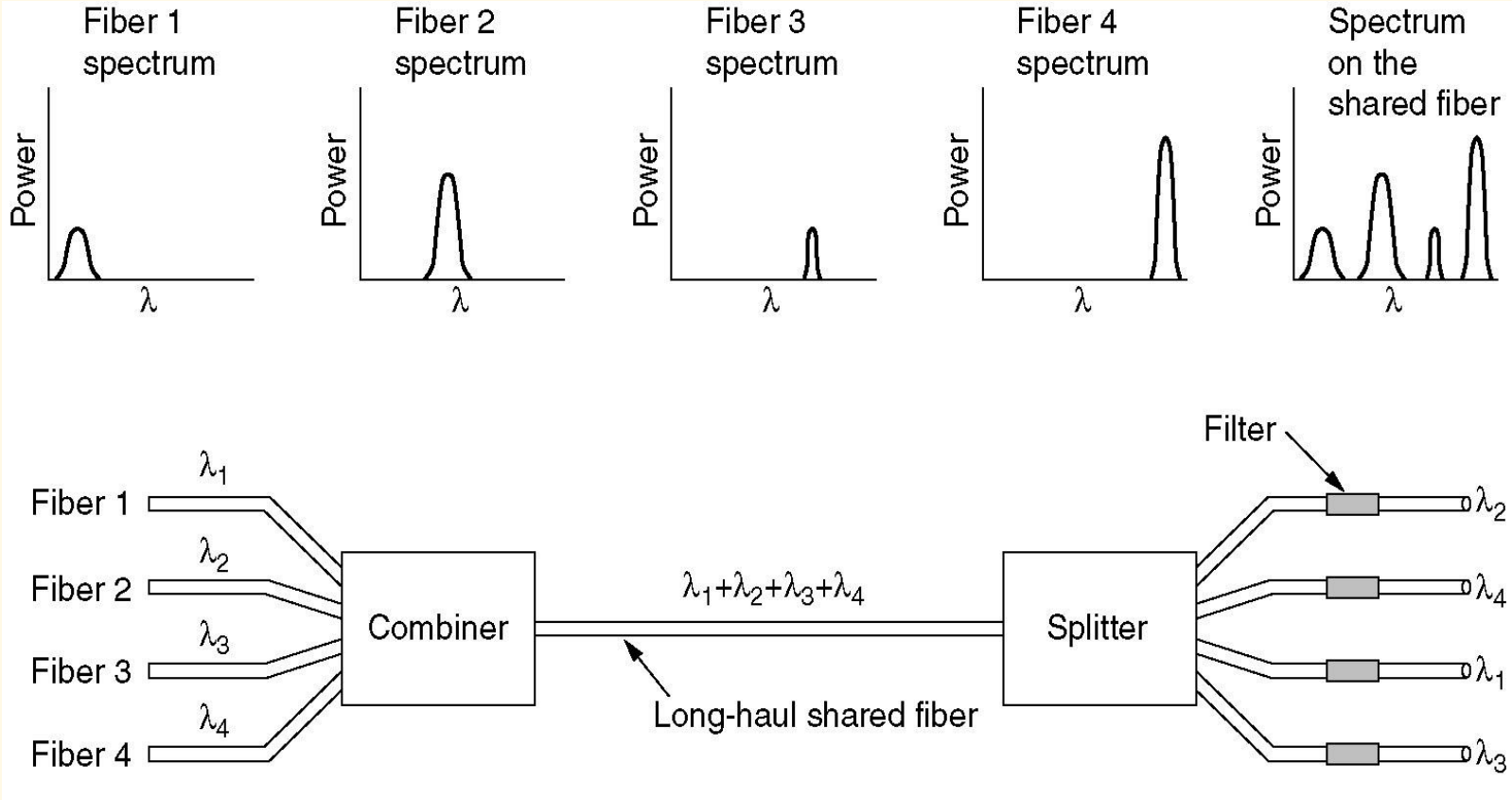


Figure 2-32.

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Physical Media: Twisted Pair

- **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.

Unshielded Twisted Pair (UTP)

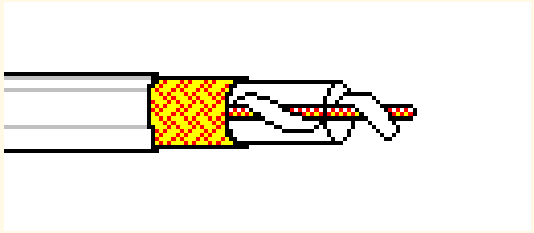
- two insulated copper wires
  - Category 3: traditional phone wires, 10 Mbps Ethernet
  - Category 5 : 100Mbps Ethernet

Category 5e is now standard!!

Physical Media: Coaxial Cable and Optical Fiber

Coaxial cable:

- two concentric copper conductors
- bidirectional
- baseband:
  - single channel on cable
  - legacy Ethernet
- broadband:
  - multiple channels on cable
  - HFC



Fiber optic cable:

- glass fiber carrying light pulses, each pulse a bit
- high-speed operation:
  - point-to-point transmission (e.g., 10's-100's Gps)
- low error rate: repeaters spaced far apart ; immune to electromagnetic noise.

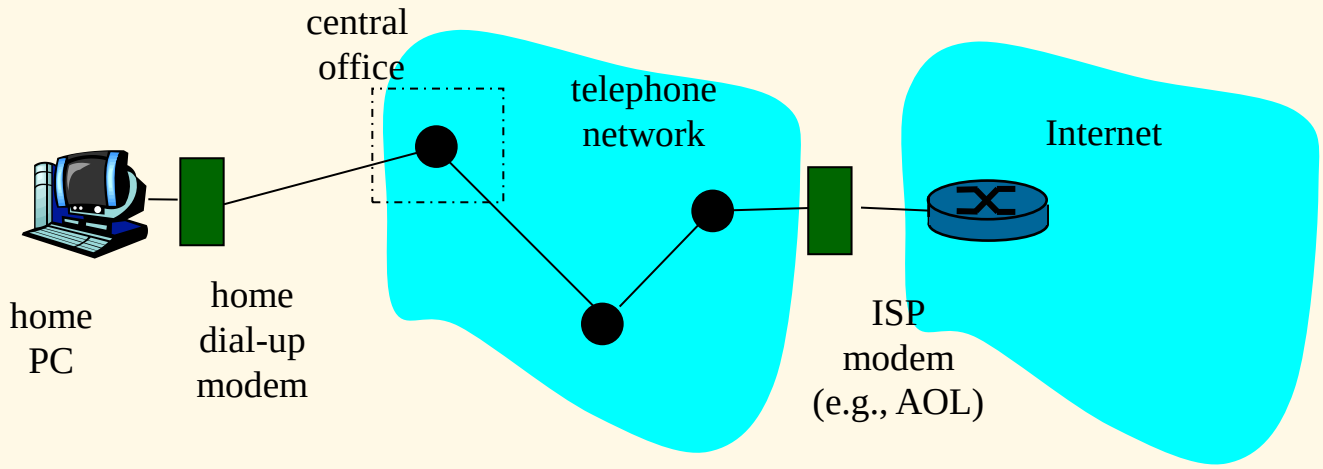
Physical Media: Radio Signals

- signal carried in electromagnetic spectrum.
- no physical "wire"
- bidirectional
- propagation environment effects:
  - reflection
  - obstruction by objects
  - interference

Radio link types:

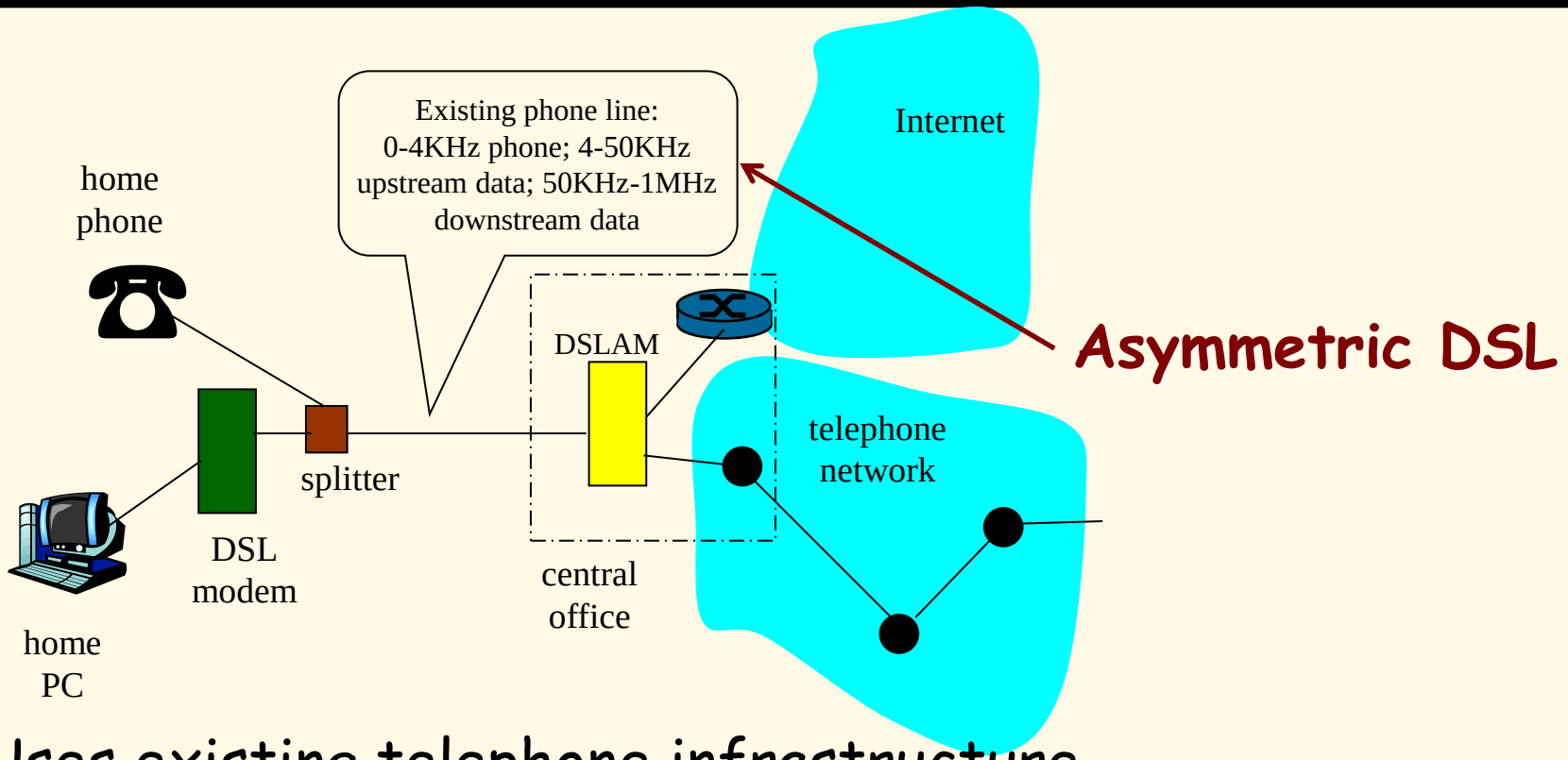
- terrestrial microwave
  - e.g. up to 45 Mbps channels
- LAN (e.g., Wifi)
  - 11Mbps, 54 Mbps
- wide-area (e.g., cellular)
  - 3G cellular: ~ 1 Mbps
- satellite
  - Kbps to 45Mbps channel (or multiple smaller channels)
  - 270 msec end-end delay
  - geosynchronous versus low altitude

Dial-up Modem



- Uses existing telephony infrastructure.
- Home is connected to central office (analog signals).
- up to 56Kbps direct access to router (often less)
- Can't surf and phone at same time: not "always on".

Digital Subscriber Line (ADSL)



- Uses existing telephone infrastructure.
- up to 1 Mbps upstream (today typically < 256 kbps)
- up to 8 Mbps downstream (today typically < 1 Mbps)
- dedicated physical line to telephone central office

Residential Access: Cable Modems

- Does not use telephone infrastructure
  - Instead uses cable TV infrastructure.
- HFC: hybrid fiber coax
  - asymmetric: up to 30Mbps downstream, 2 Mbps upstream
- network of cable and fiber attaches homes to ISP router:
  - homes share access to router
  - unlike DSL, which has dedicated access.

Residential Access: Cable Modems

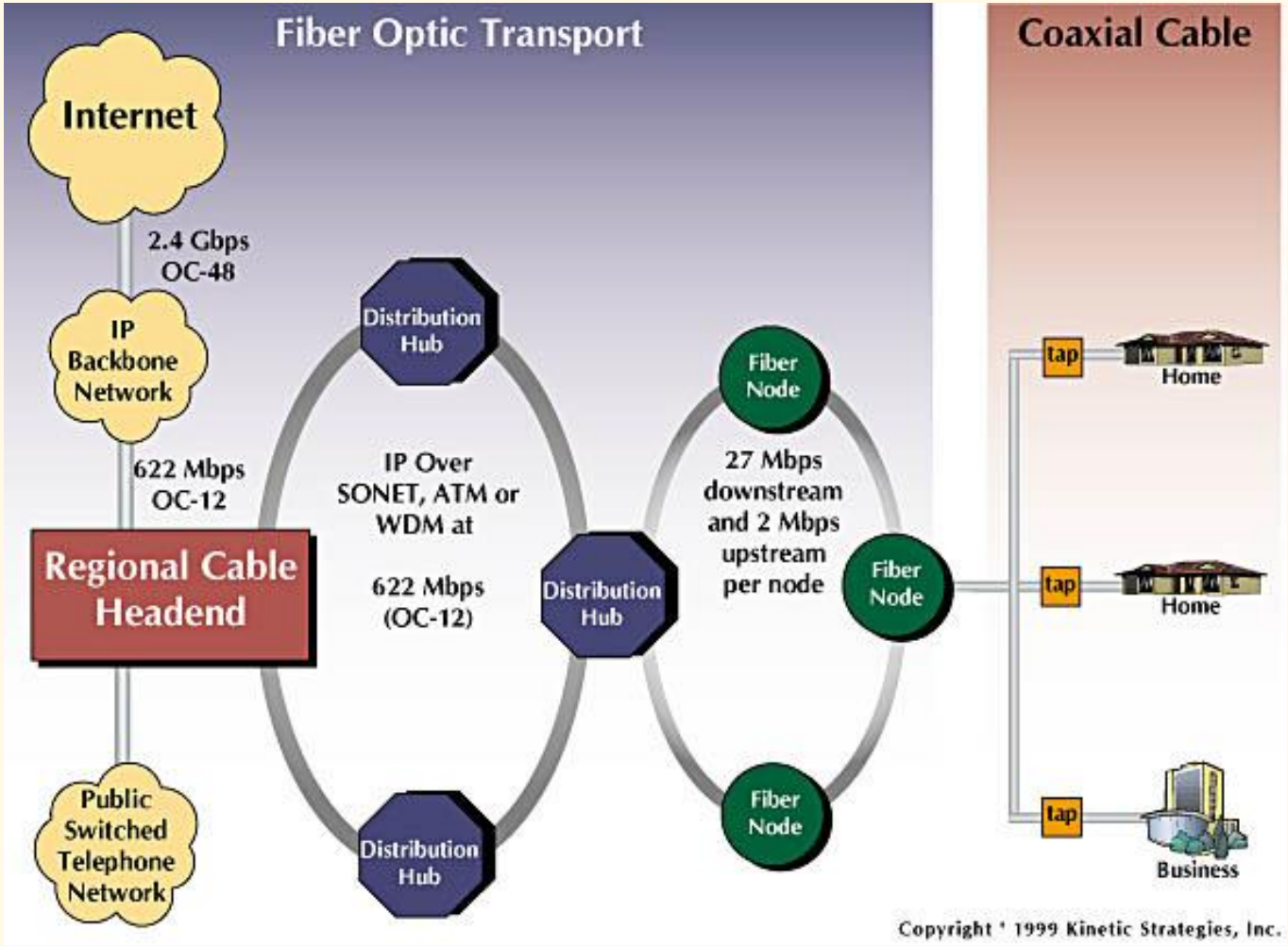
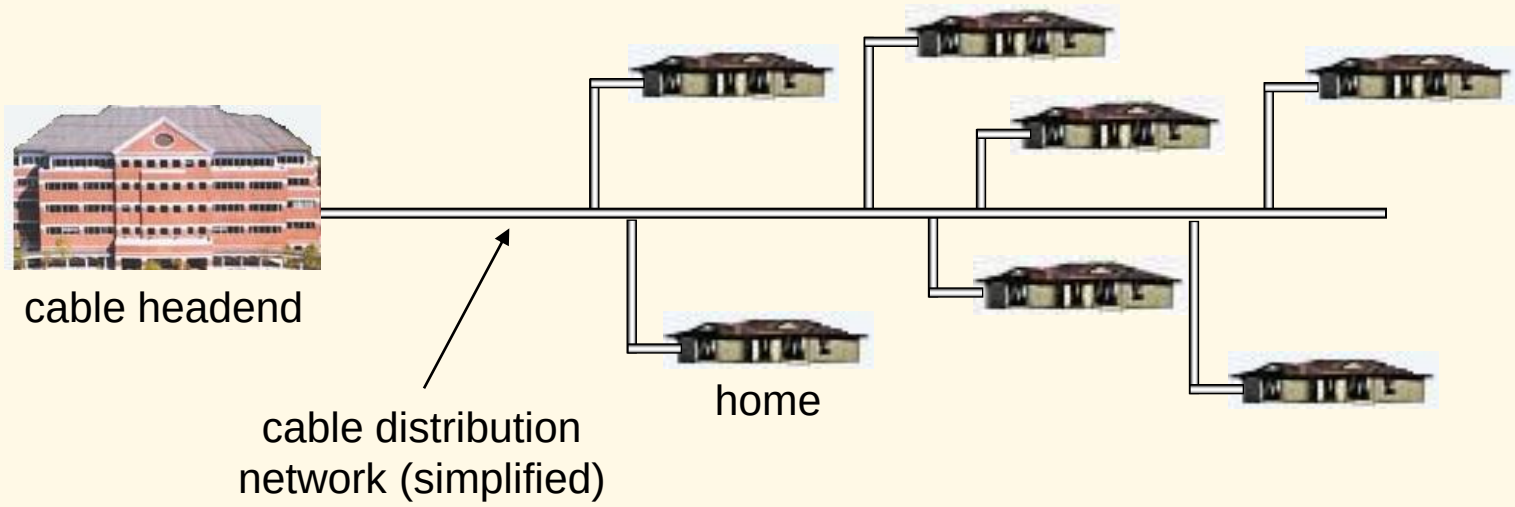


Diagram: http://www.cabledatacomnews.com/cmic/diagram.html

Cable Network Architecture: Overview

Typically 500 to 5,000 homes



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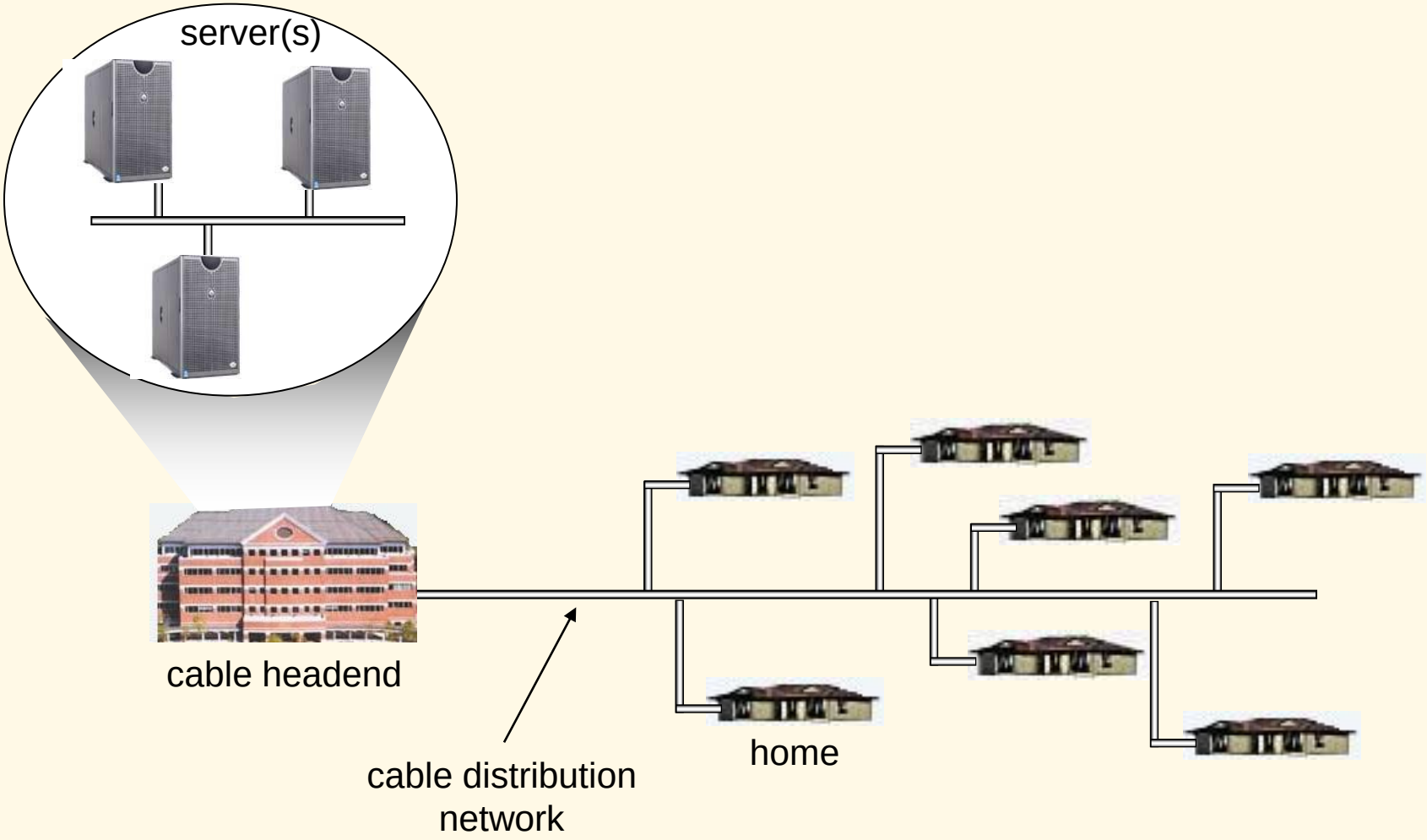
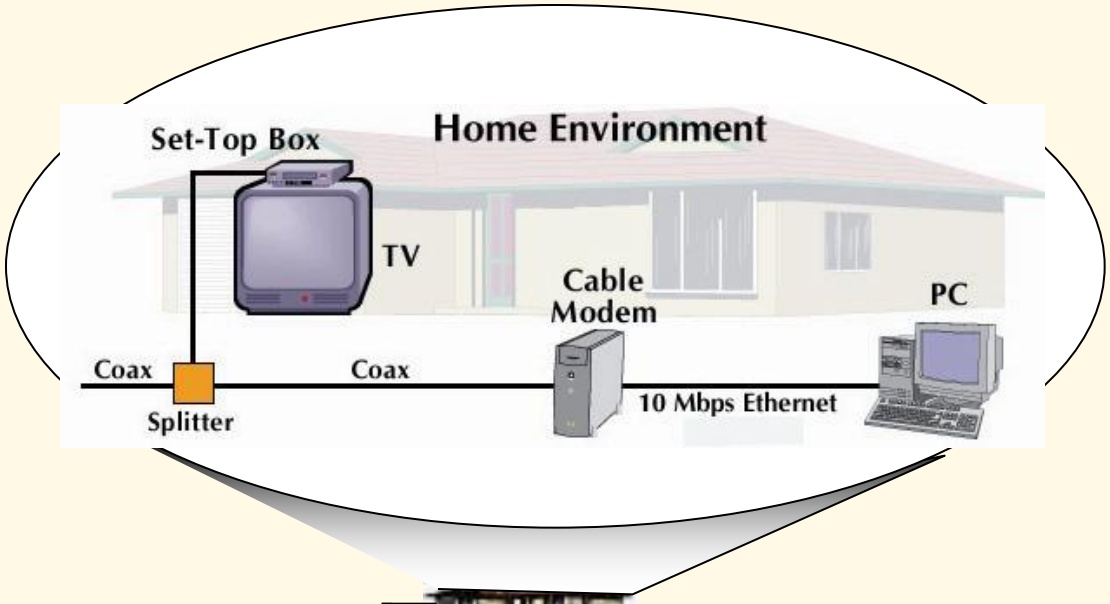
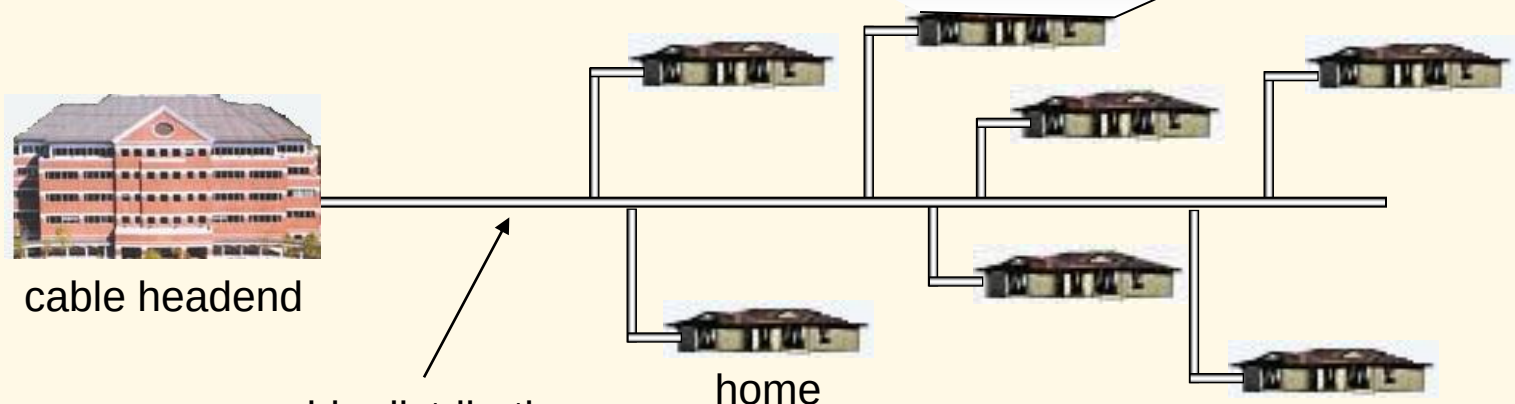


Cable Network Architecture: Overview



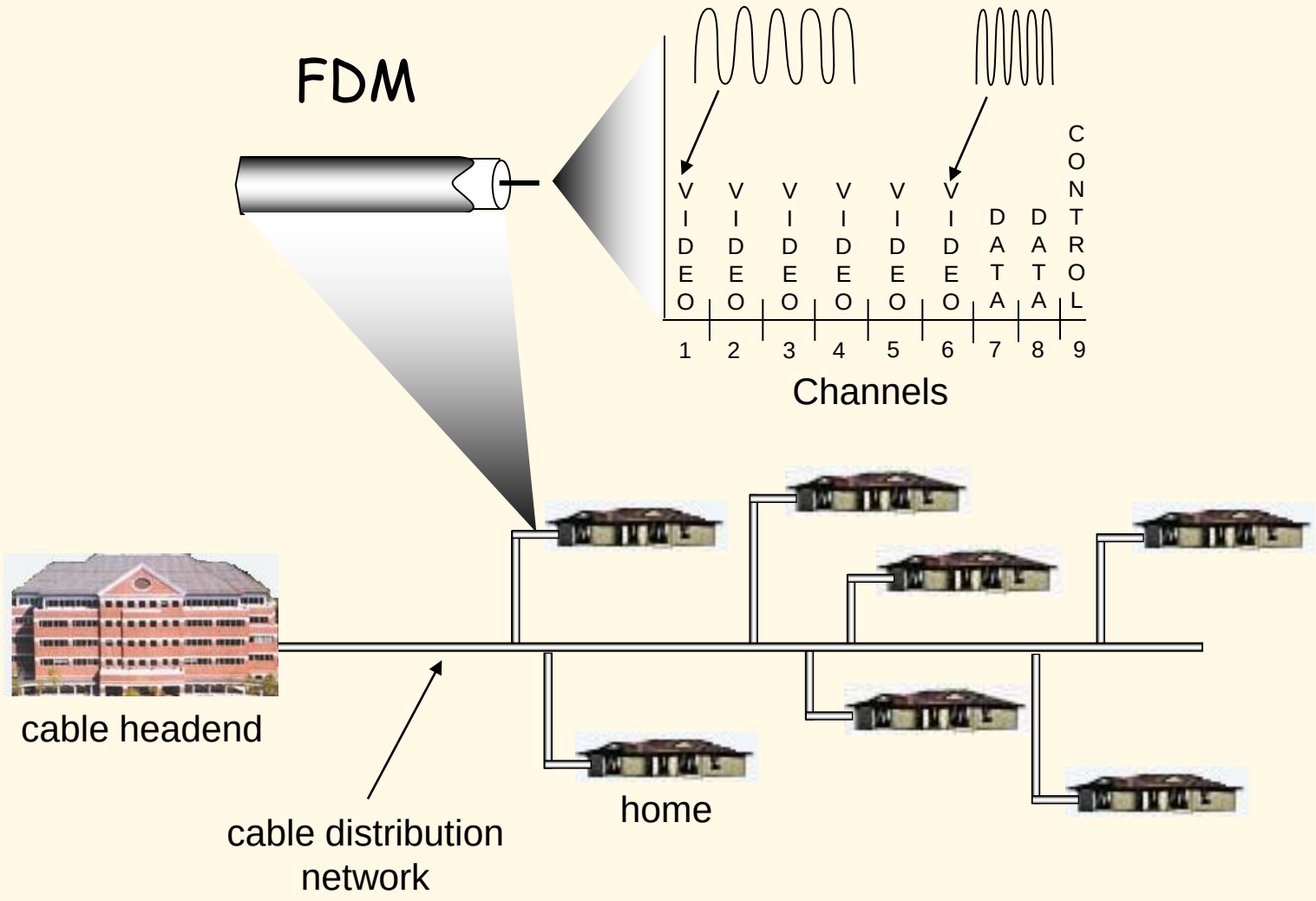


cable headend

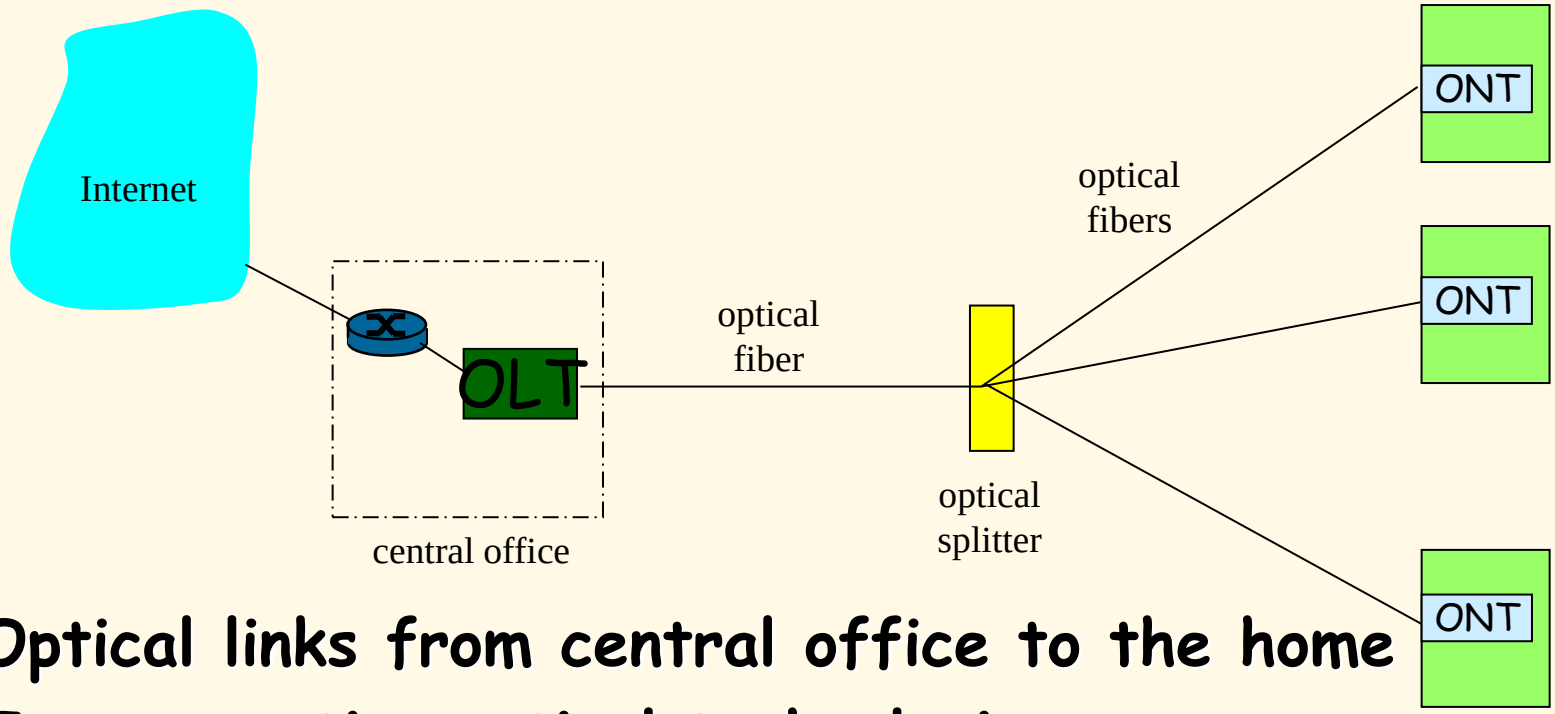
cable distribution network (simplified)

home

Cable Network Architecture: Overview

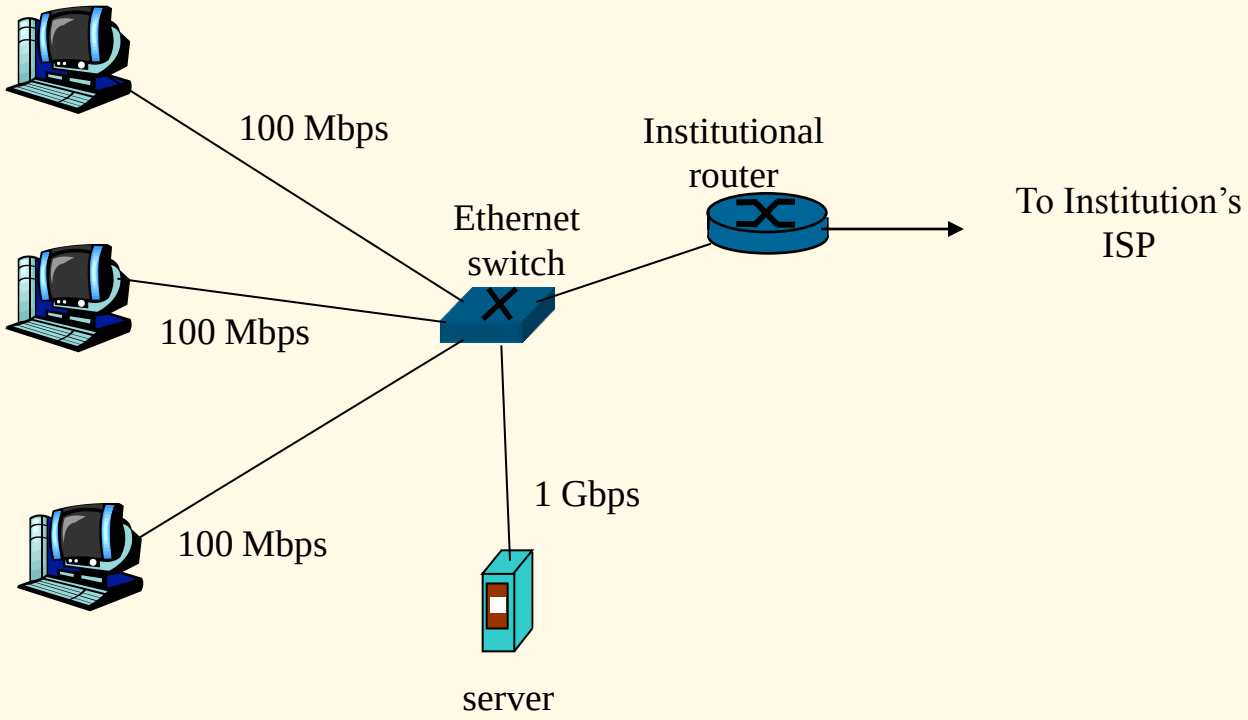


Fiber to the Home



- Optical links from central office to the home
- Two competing optical technologies:
  - Passive Optical network (PON)
  - Active Optical Network (AON)
- Higher Internet rates. Fiber also carries television and phone services.

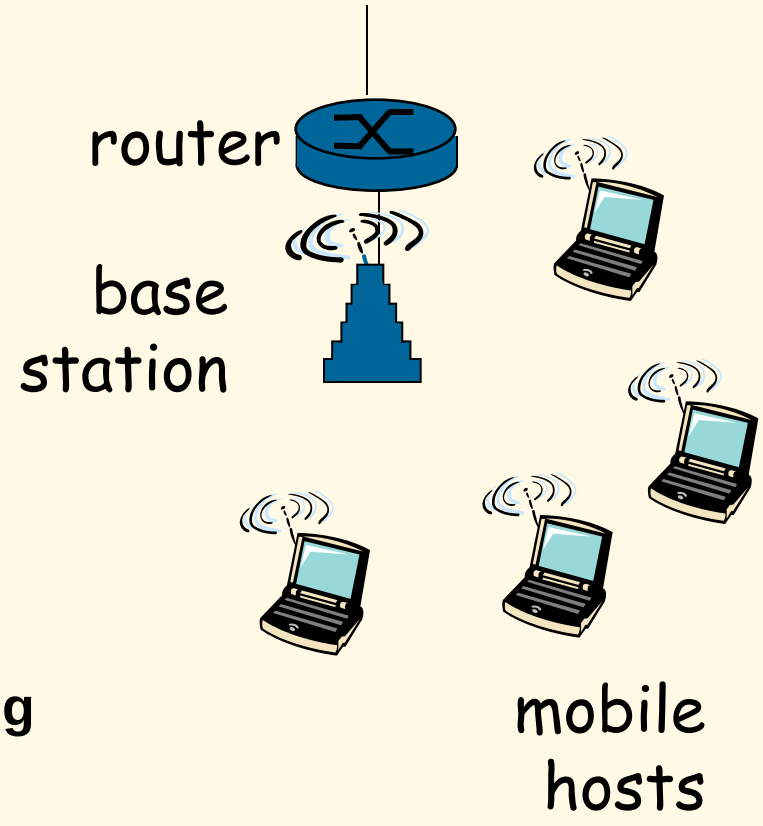
Ethernet Internet Access



- Typically used in companies, universities, etc
- 10 Mbs, 100Mbps, 1Gbps, 10Gbps Ethernet
- Today, end systems typically connect into Ethernet switch.

Wireless Access Networks

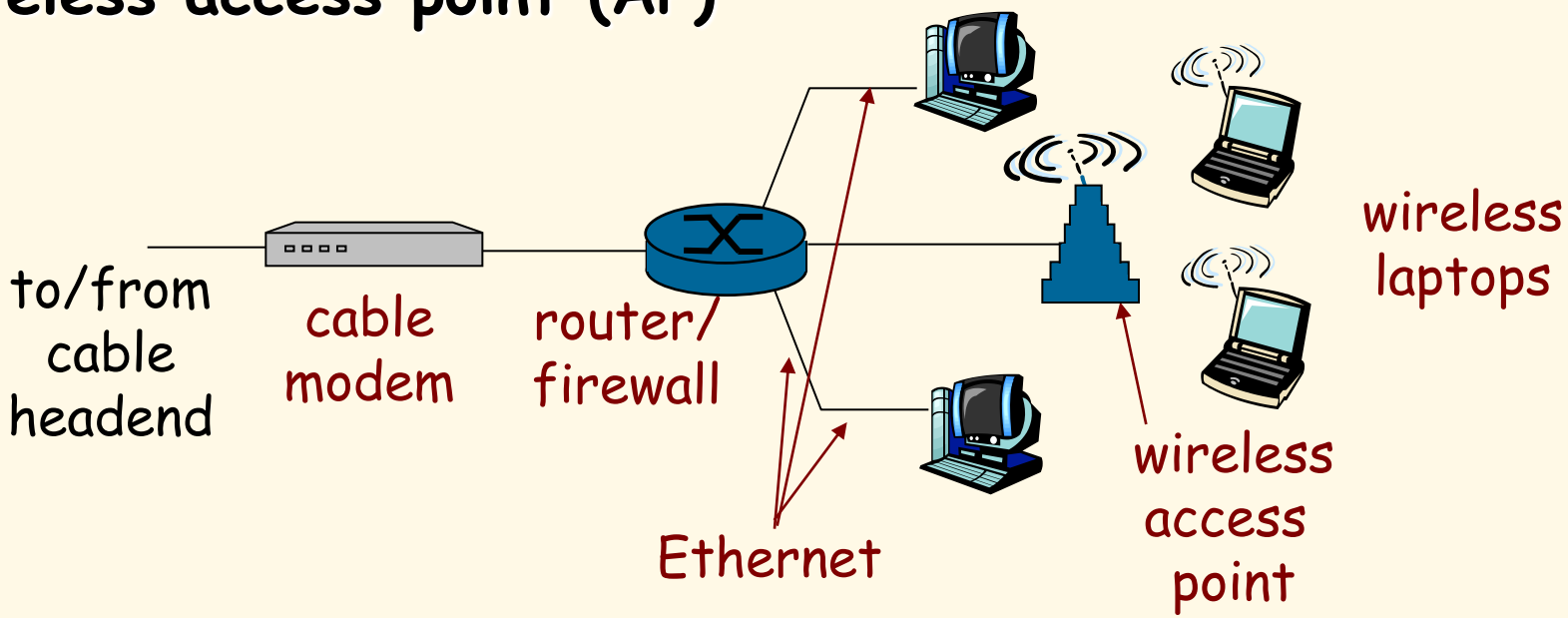
- Shared wireless access network connects end system to router
  - via base station aka "access point".
- Wireless LANs:
  - 802.11b/g/n (WiFi): 11, 54, 200 Mbps
- Wider-area Wireless Access
  - provided by telco operator
  - ~1Mbps over cellular system (EVDO, HSDPA) 3G and 4G coming
  - next up (?): WiMAX (10's Mbps) over wide area



Residential Networks

Typical Residential Network Components:

- DSL or cable modem
- router/firewall/NAT
- Ethernet
- wireless access point (AP)



Physical Layer Summary

- Definitions (analog versus digital)
- Multiplexing (FDM, TDM, statistical)
- Transmission Media (UTP, Coax, Fiber, Radio, Satellite)
- End System Choices (Dial-Up, ADSL, Cable,Ethernet, Wireless AP, Fiber-to-the Home)
- Residential Configurations