Reti di Elaboratori

Corso di Laurea in Informatica
Università degli Studi di Roma "La Sapienza"
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Chapter 1: roadmap

A closer look at network structure:

❑ **network edge:**
applications and hosts

❑ **access networks, physical media:**
wired, wireless communication links

❑ **network core:**
  ❖ interconnected routers
  ❖ network of networks
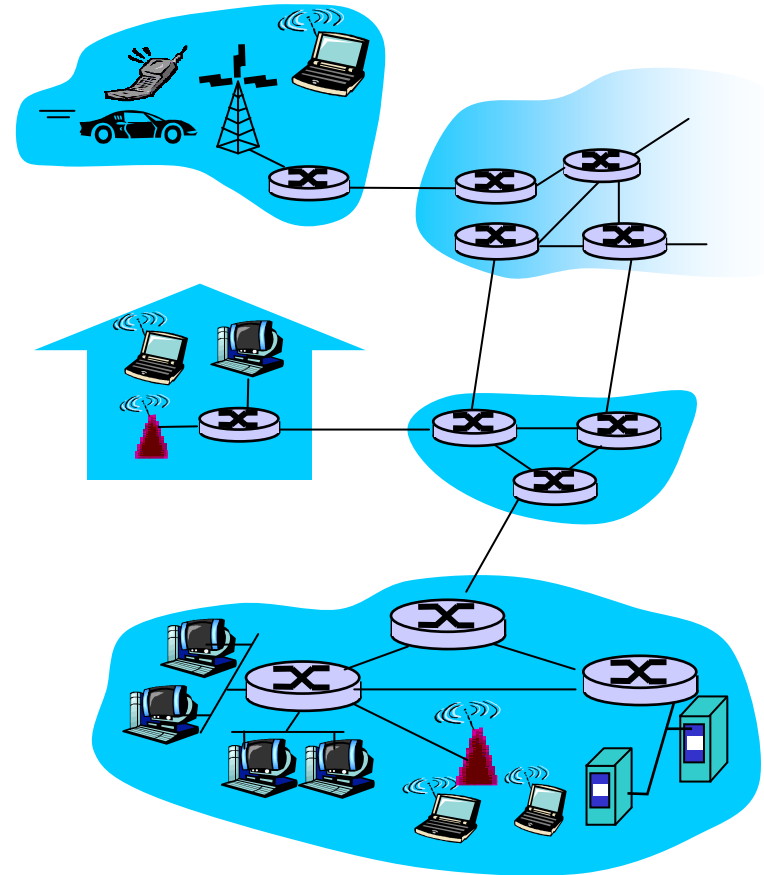
The network edge:

☐ **end systems (hosts):**
  - ○ run application programs
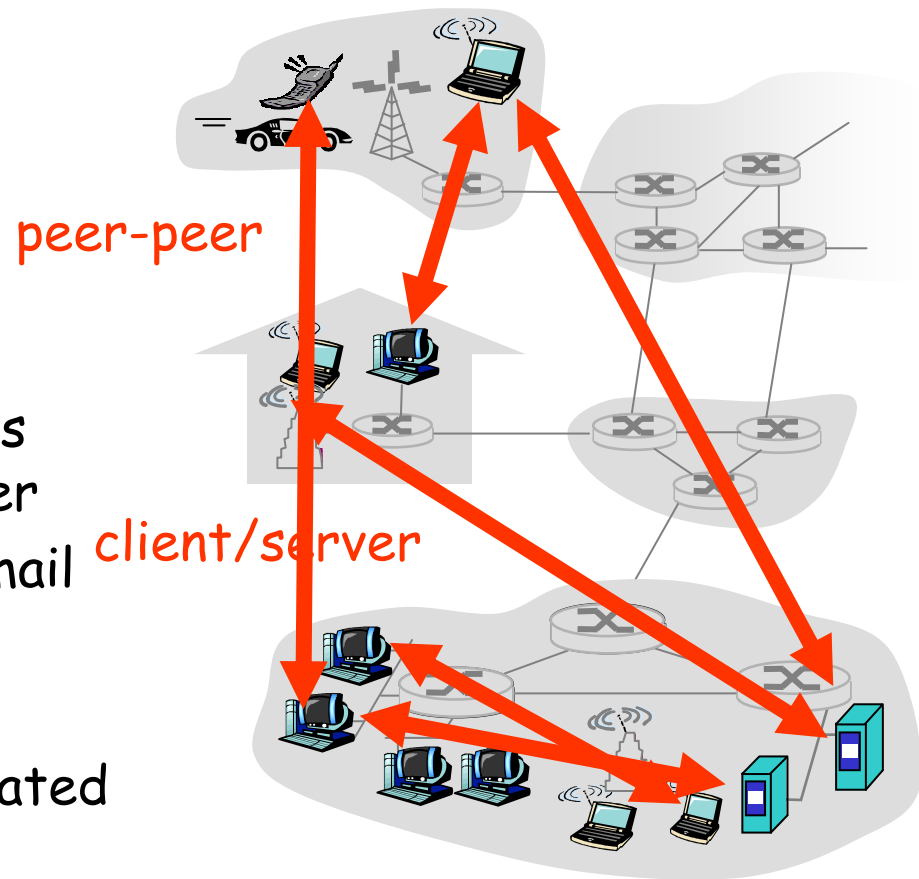 - ○ e.g. Web, email
  - ○ at "edge of network"

☐ **client/server model**
  - ❖ client host requests, receives service from always-on server
  - ❖ e.g. Web browser/server; email client/server

☐ **peer-peer model:**
  - ❖ minimal (or no) use of dedicated servers
  - ❖ e.g. Skype, BitTorrent

peer-peer

client/server

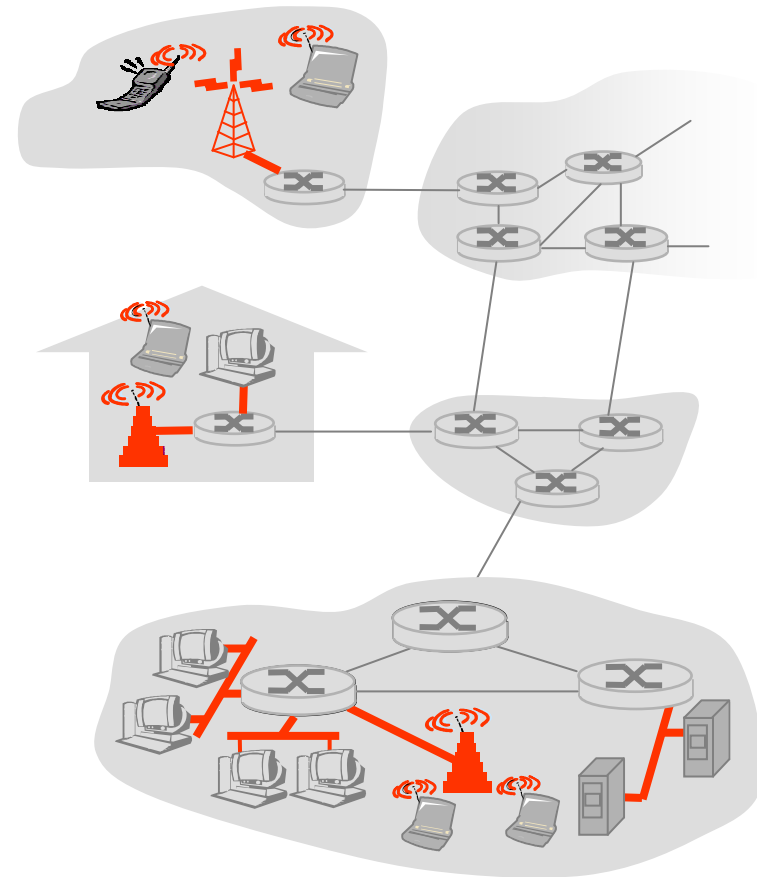# Access networks and physical media
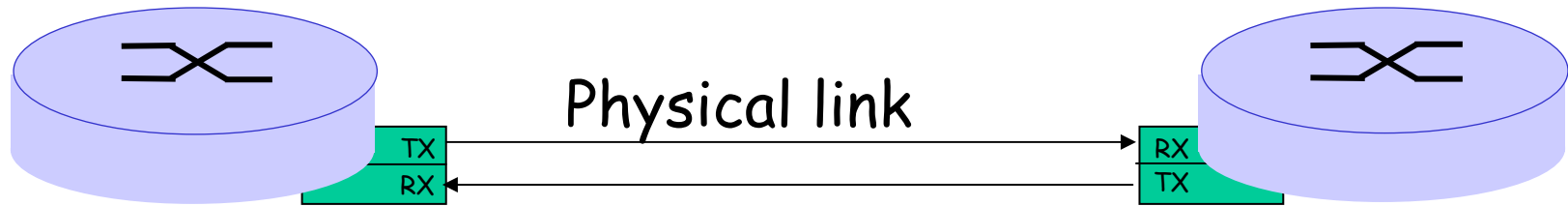
Q: How to connect end systems to edge router?

❑ residential access nets

❑ institutional access networks (school, company)

❑ mobile access networks

Keep in mind:

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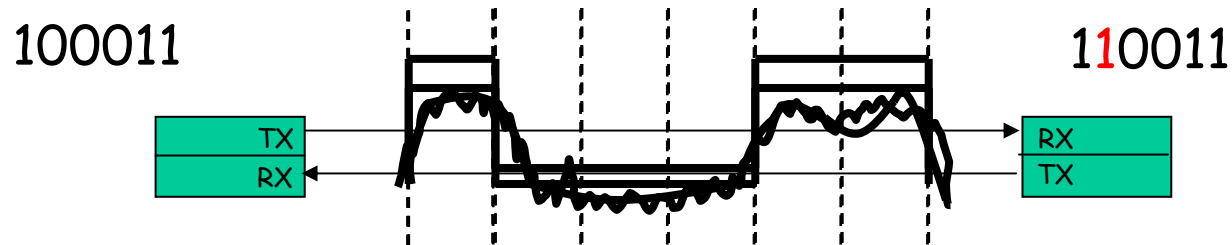
❑ shared or dedicated?

Transmission across a physical link

Physical link

❑ **Bits:** propagate between transmitter and receiver
❑ **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

# Transmission across a physical link

□ **Bit sequence modulates a suitable waveform which is sent across the link**
  ○ How and which depends on the medium
□ **As the signal travels it experiences**
  ○ Attenuation (absorption)
  ○ Distortion (limited bandwidth (frequency))
  ○ Noise (interference, thermal noise)
  ○ Influenced by medium, bit rate and distance
□ **Received sequence may be incorrect!!!**

Codifica NRZ

❑ Codifica NRZ (Non Return to Zero)

Ogni bit ha associato un valore stabile per la sua intera durata (1: High; 0: Low)
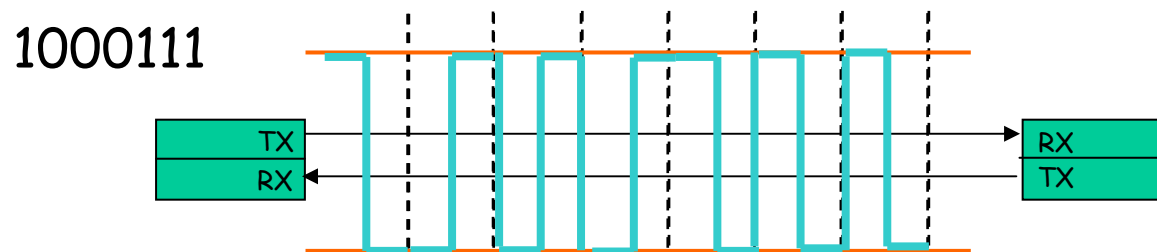
1000111
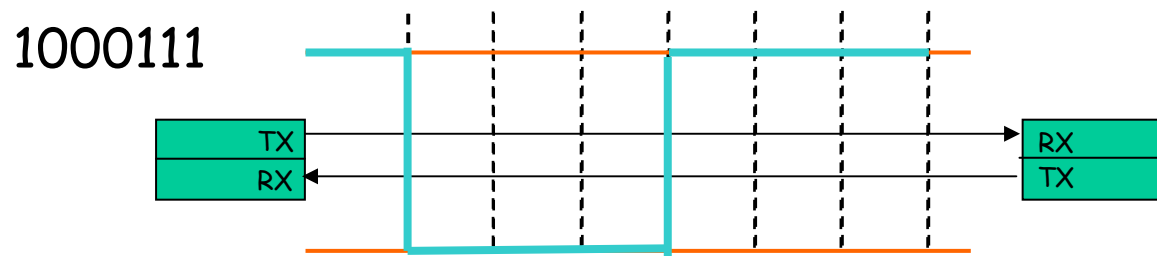
Problemi di sincronizzazione del ricevitore (nessuna transizione nel caso di sequenze di zeri o di uni)→ NRZ 5B6B o 4B5B

Codifica Manchester

❑ Codifica Manchester

Una transizione basso-alto (codifica dello zero) o alto-basso
(codifica del valore uno) in corrispondenza di ogni bit

1000111

| TX | RX |
| RX | TX |

Usato in Ethernet 10Mbps e Token Ring

Dial-up Modem

ISP=Internet Service Provider
Es. Telecom, Tiscali, Fastweb, Wind etc
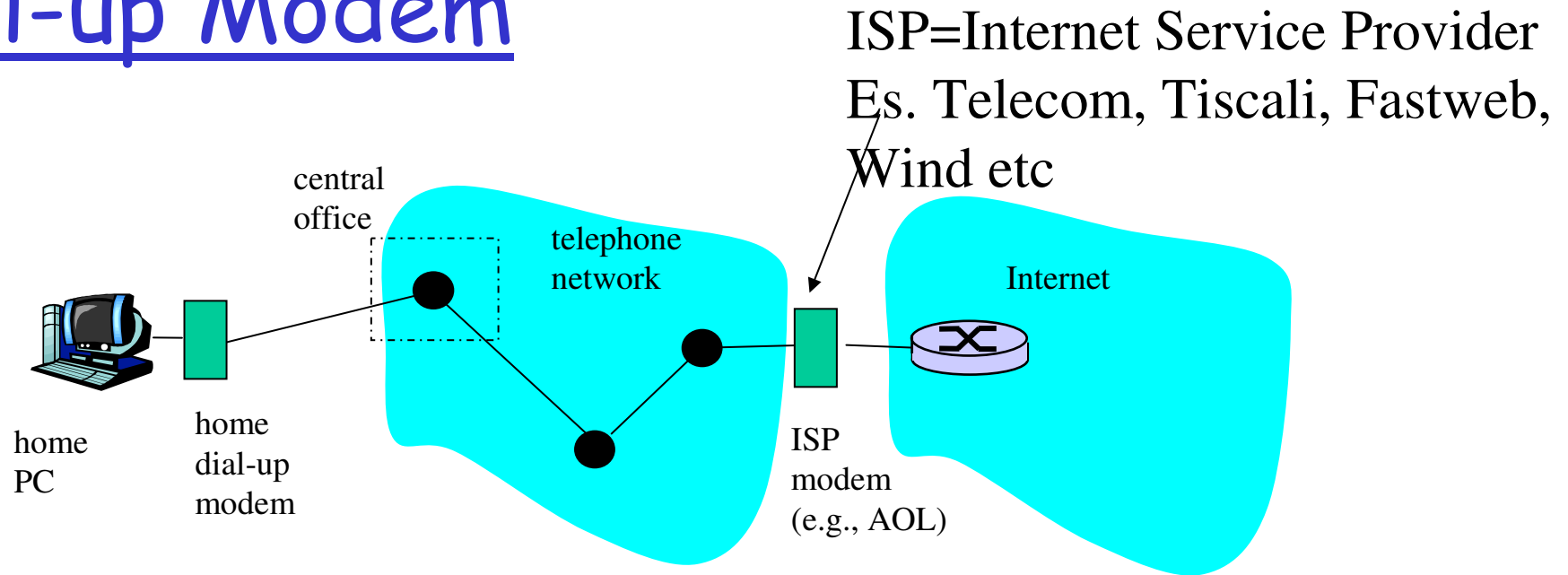
* ❖ Uses existing telephony infrastructure
  * ❖ Home is connected to central office
* ❖ up to 56Kbps direct access to router (often less)
* ❖ Can't surf and phone at same time: not "always on"

Digital Subscriber Line (DSL)
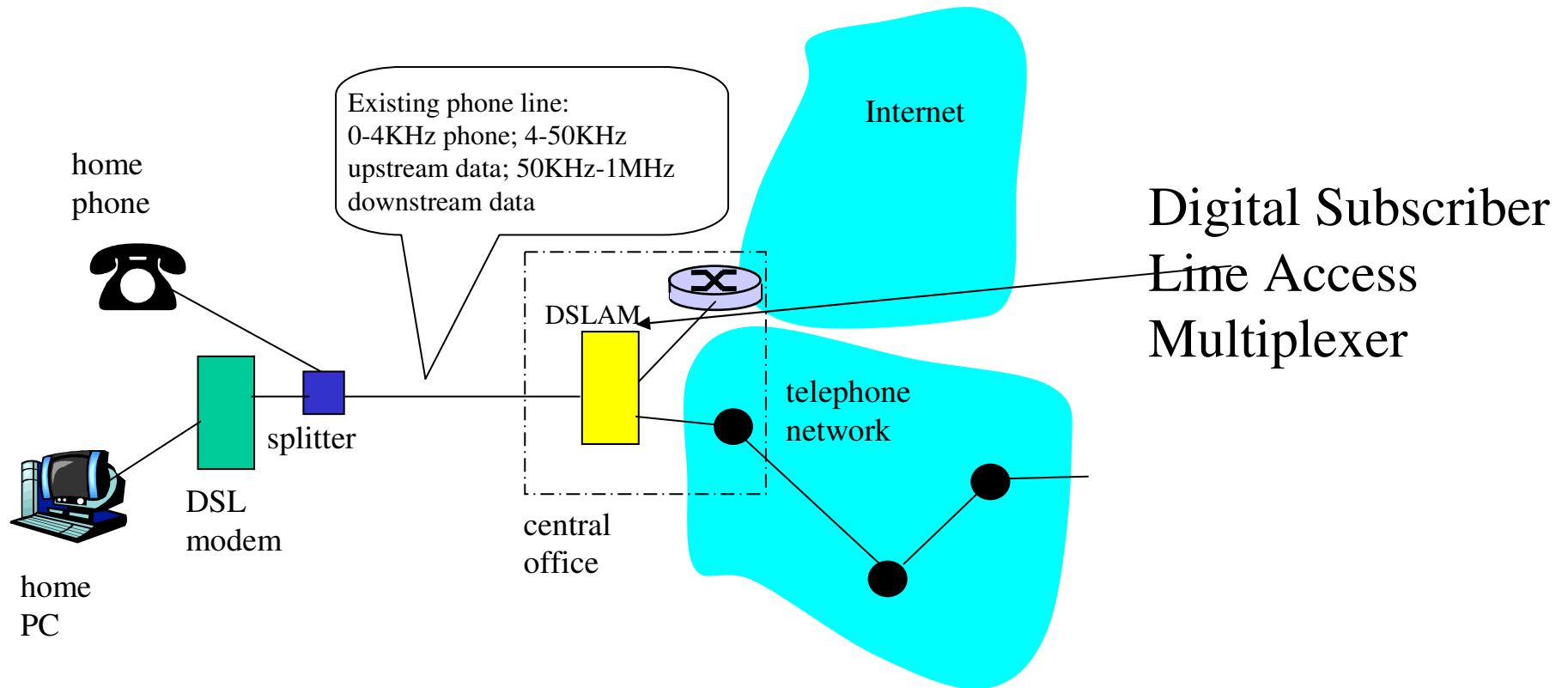
* ❖ Also uses existing telephone infrastruture
* ❖ up to 1 Mbps upstream (today typically < 256 kbps)
* ❖ up to 8 Mbps downstream (today typically < 1 Mbps)
* ❖ dedicated physical line to telephone central office

ADSL loops extender

❑ An **ADSL loop extender** or **ADSL repeater** is a device placed midway between the subscriber and central office by the telephone company to extend the distance and increase the channel capacity of their DSL connection.

❑ In some cases, service can now be established as far as 10 miles from the Central Office (factor of 2 improvement)

Residential access: cable modems

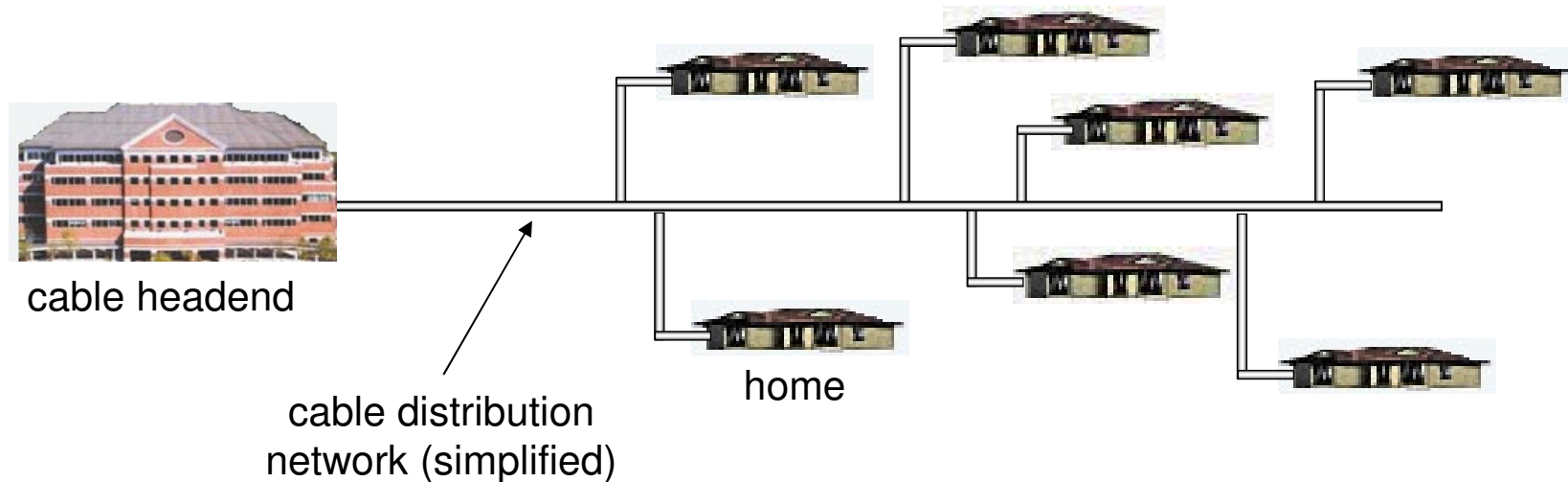- ❑ Does not use telephone infrastructure
    - ○ Instead uses cable TV infrastructure
- ❑ HFC: hybrid fiber coax
    - ○ asymmetric: up to 30Mbps downstream, 2 Mbps upstream
- ❑ network of cable and fiber attaches homes to ISP router
    - ○ homes share access to router
    - ○ unlike DSL, which has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

Residential access: cable modems

Diagram: http://www.cabledatacomnews.com/cmic/diagram.html
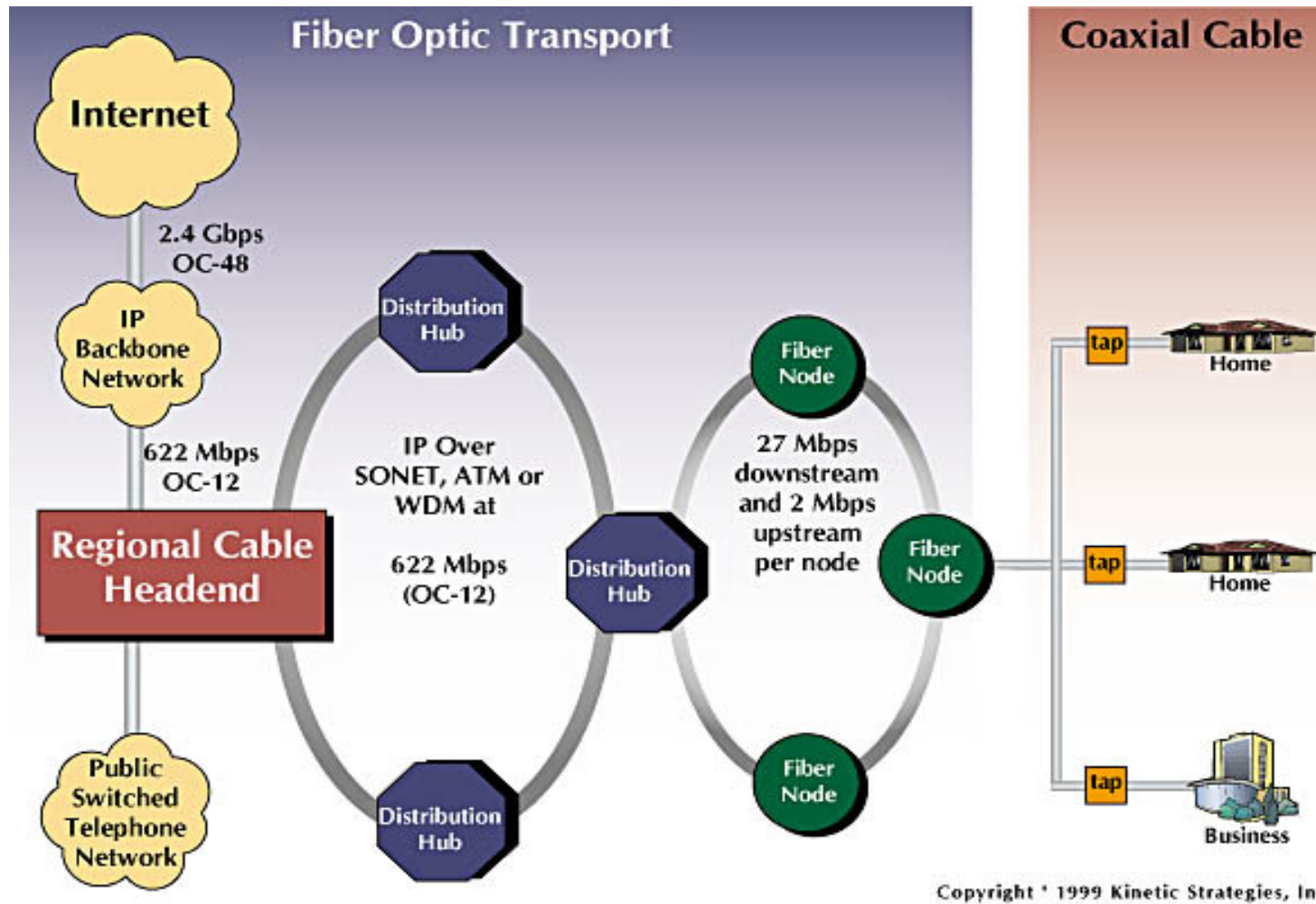
Cable Network Architecture: Overview

Typically 500 to 5,000 homes

cable headend

home

cable distribution
network (simplified)

Cable Network Architecture: Overview

server(s)

cable headend

cable distribution
network

home

Cable Network Architecture: Overview

cable headend
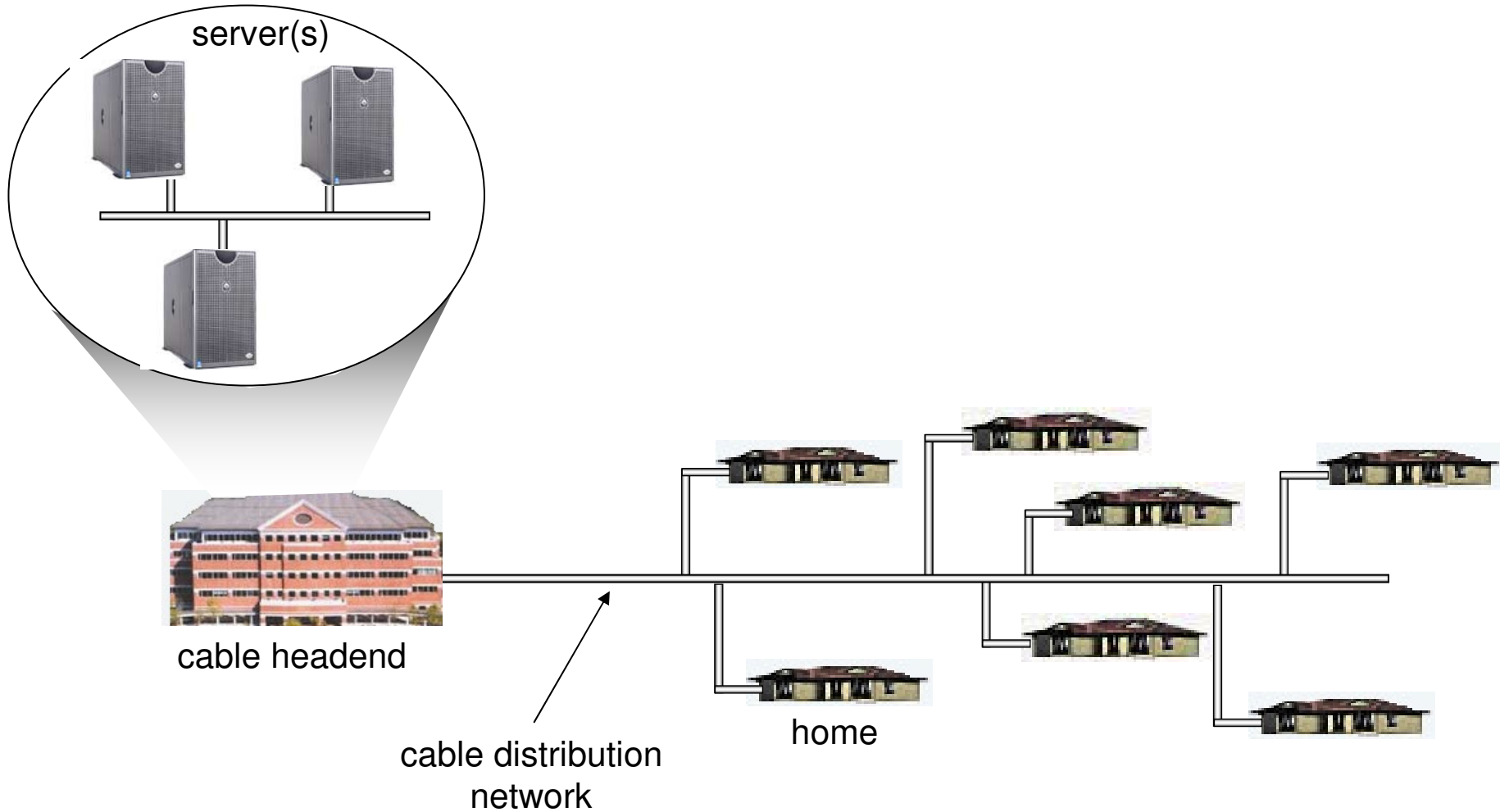
cable distribution
network (simplified)
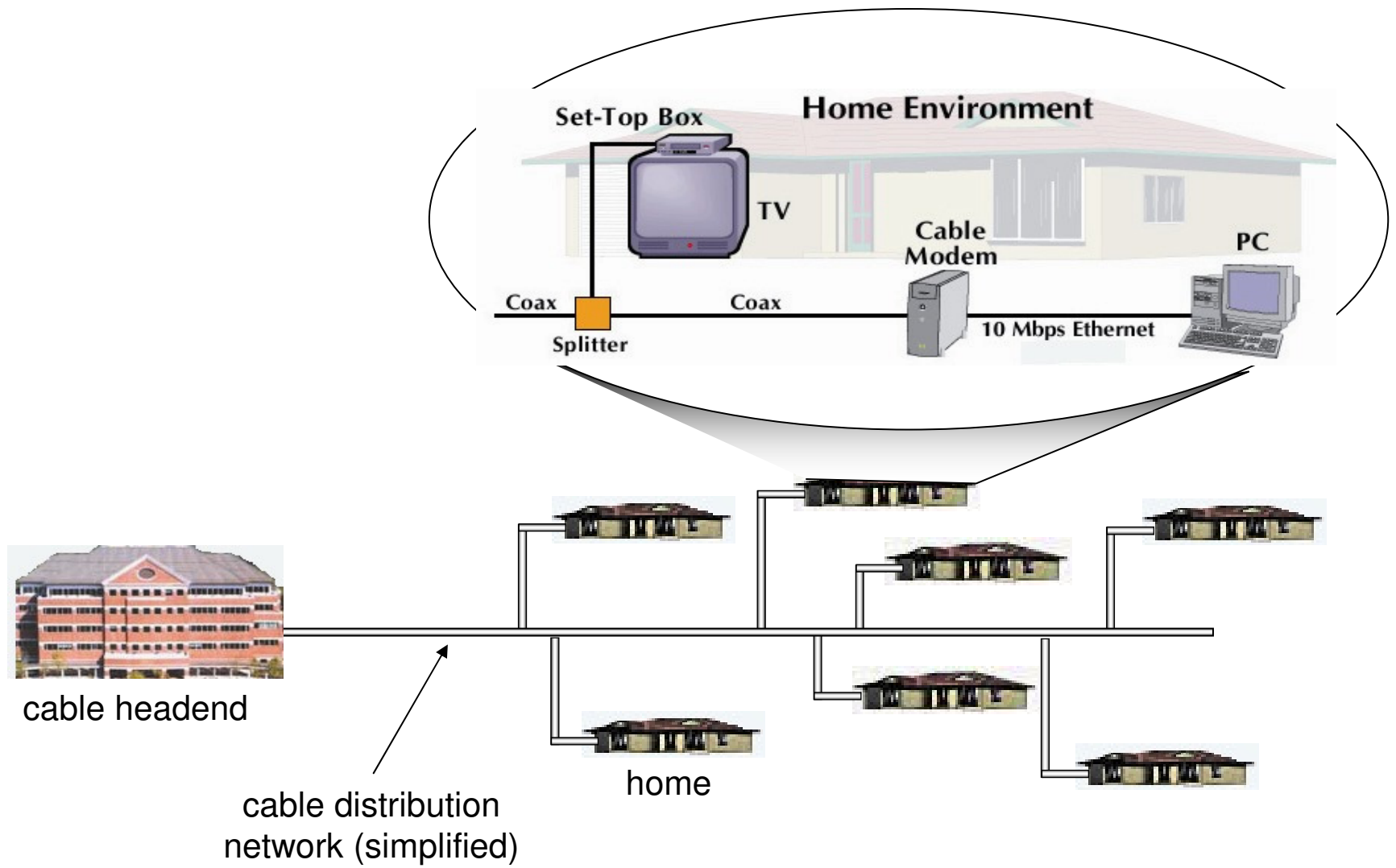
home

Cable Network Architecture: Overview

FDM (more shortly):

V I D E O	V I D E O	V I D E O	V I D E O	V I D E O	V I D E O	D A T A	D A T A	C O N T R O L
1	2	3	4	5	6	7	8	9

Channels
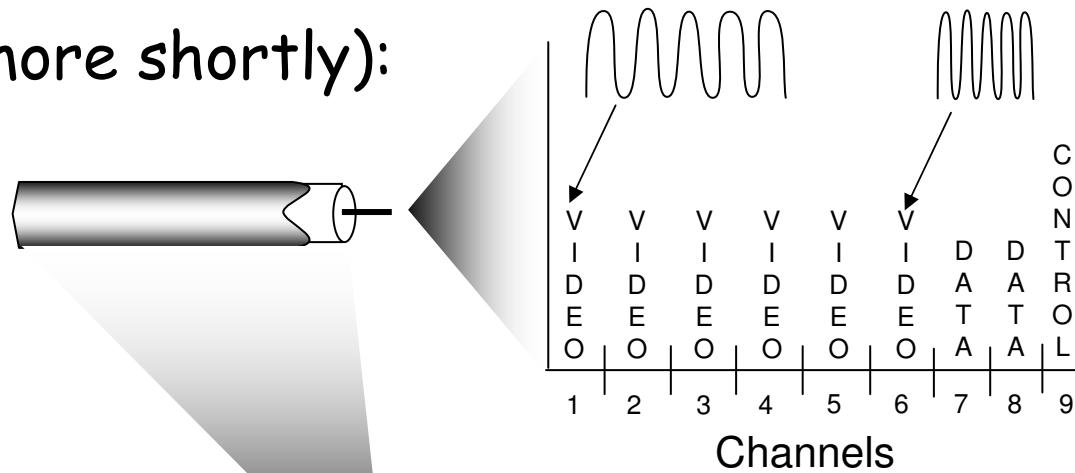
cable headend
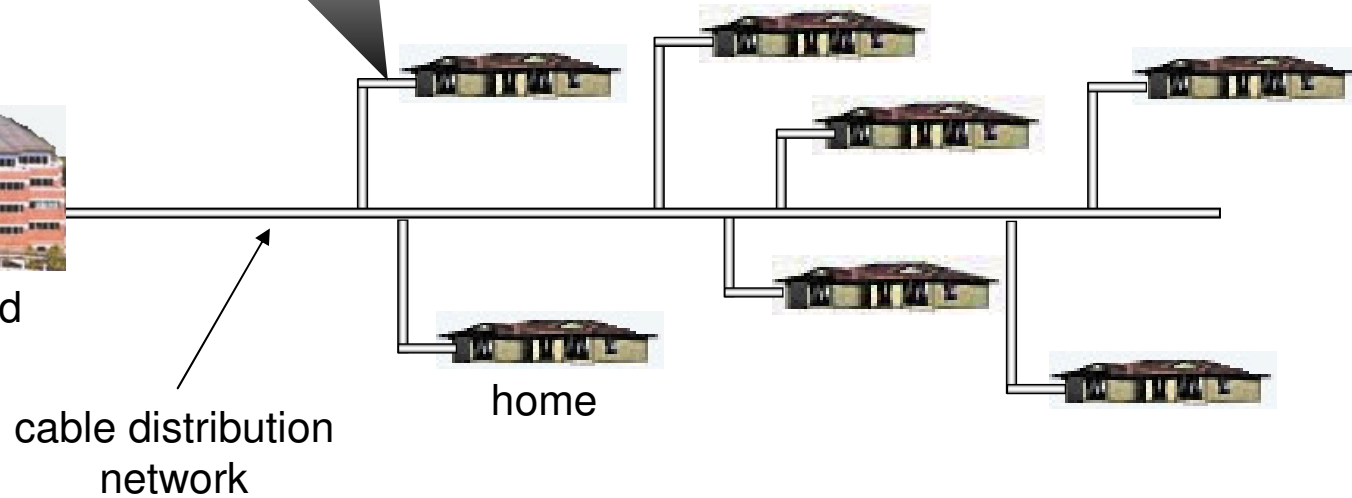
cable distribution network

home

Fiber to the Home

Internet

Optical line termination

central office

optical fiber

optical fibers

optical splitter

OLT

ONT

ONT

ONT

Optical Network unit
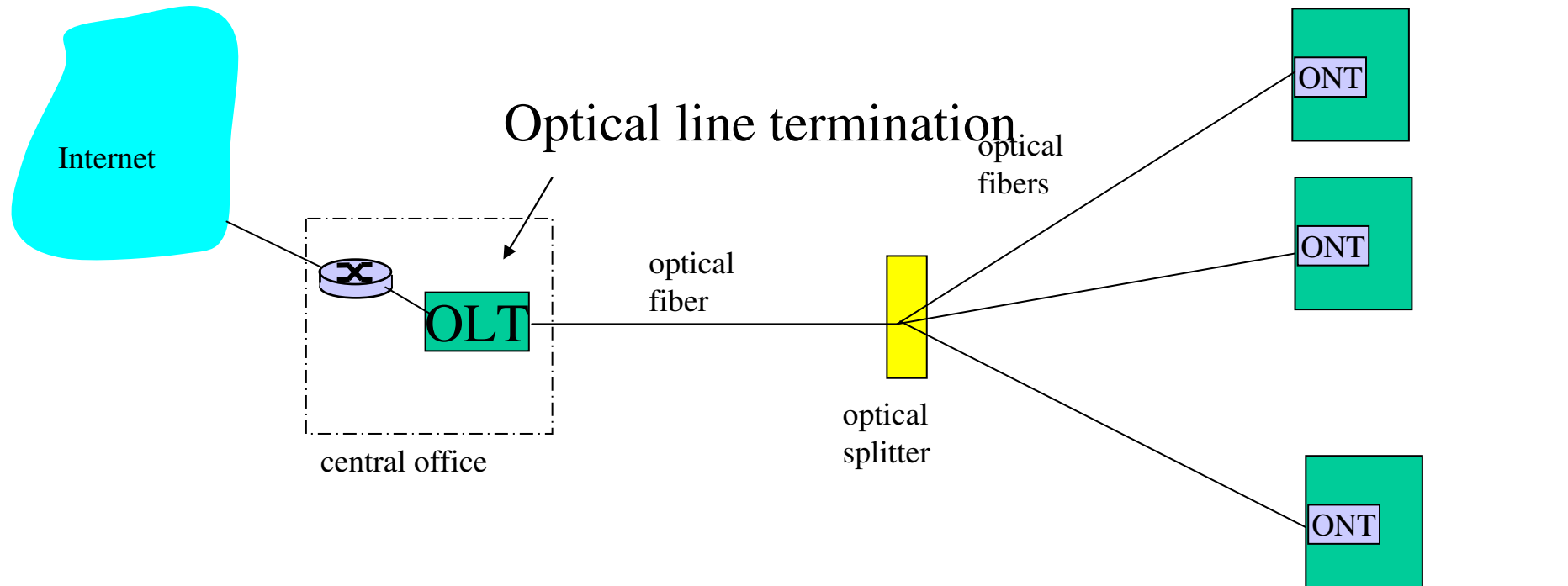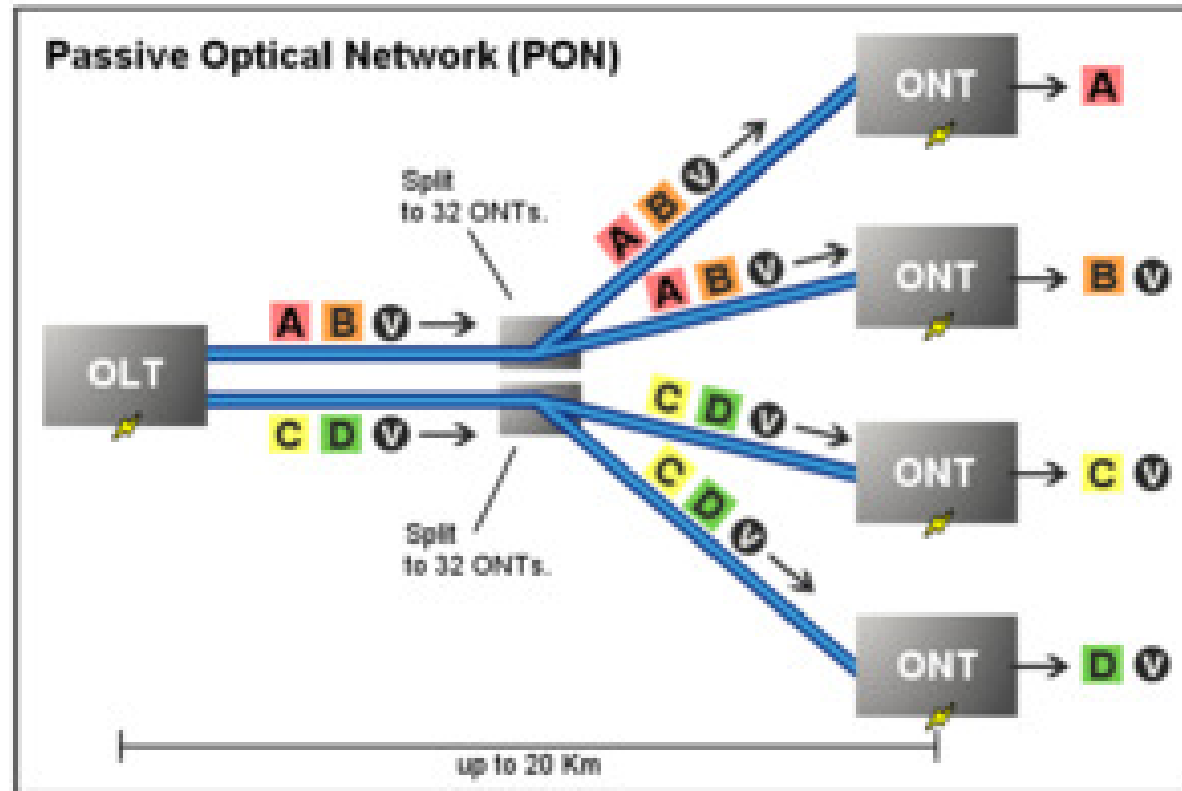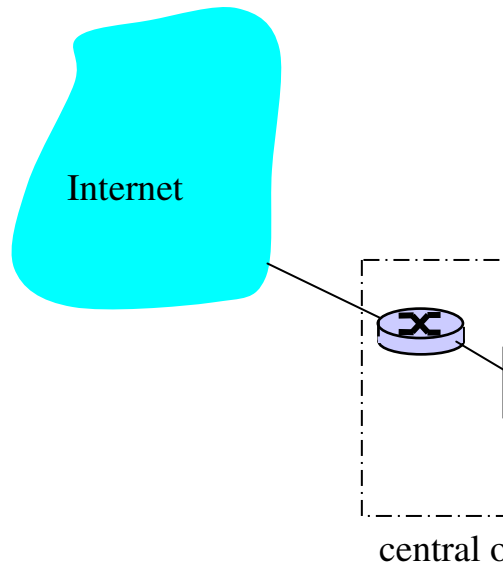
❑ Optical links from central office to the home
❑ Two competing optical technologies:
  ○ Passive Optical network (PON)
  ○ Active Optical Network (PAN)
❑ Much higher Internet rates; fiber also carries television and phone services

Fiber to the Home

Internet

central office

Passive Optical Network (PON)

Split to 32 ONTs.

OLT

Split to 32 ONTs.

ONT → A

ONT → B

ONT → C

ONT → D

up to 20 Km

Key: **A** - Data or voice for a single customer. - Video for multiple customers.

❑ Optical links from central office to the home ... cal

❑ Two competing optical technologies: Network unit
  ○ Passive Optical network (PON)
  ○ Active Optical Network (PAN)

❑ Much higher Internet rates; fiber also carries television and phone services

Active Optical Networks

❑ An active optical system uses electrically powered switching equipment, such as a router or a switch aggregator, to manage signal distribution and direct signals to specific customers.

❑ In such a system, a customer may have a dedicated fiber running to his or her house.
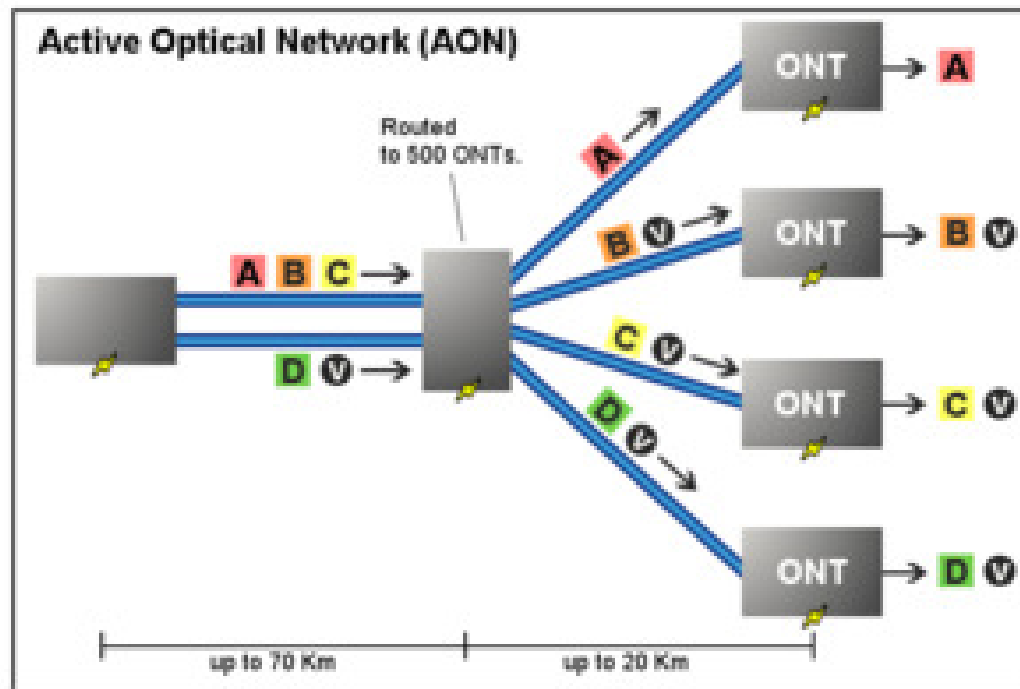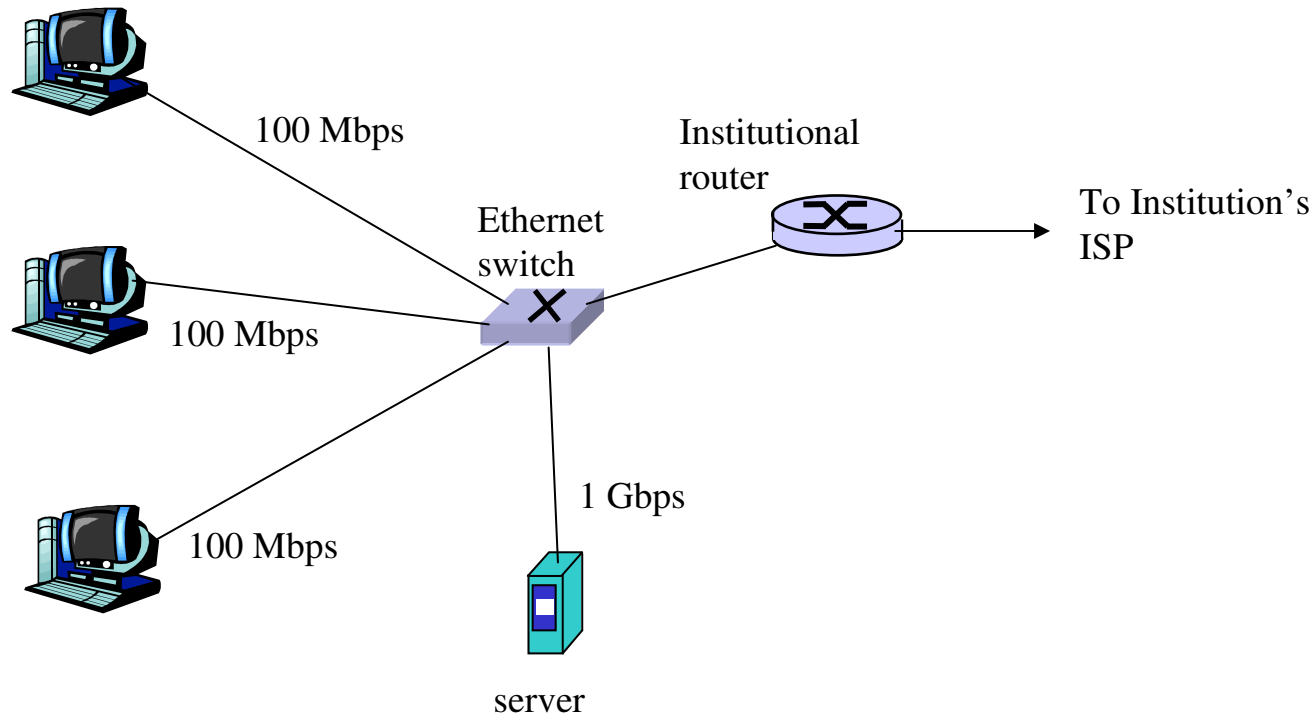
Active vs Passive Optical Networks

❑ Passive optical networks, or PONs, have some distinct advantages.

- ○ They're efficient, in that each fiber optic strand can serve up to 32 users

- ○ PONs have a low building cost relative to active optical networks along with lower maintenance costs. In active optical networks one aggregator is required every 48 subscribers.

❑ Passive optical networks also have some disadvantages.

- ○ They have less range than an active optical network.

- ○ PONs also make it difficult to isolate a failure when they occur.

- ○ Because the bandwidth in a PON is not dedicated to individual subscribers, data transmission speed may slow down during peak usage times.

Ethernet Internet access

100 Mbps

Institutional
router

To Institution's
ISP

Ethernet
switch

100 Mbps

100 Mbps

1 Gbps

server

❑ 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 (WiFi): 11 or 54 Mbps

❑ wider-area wireless access
  ○ provided by telco operator
  ○ ~1Mbps over cellular system (EVDO, HSDPA), LTE to come
  ○ next up (?): WiMAX (10's Mbps) over wide area

router

base station

mobile hosts
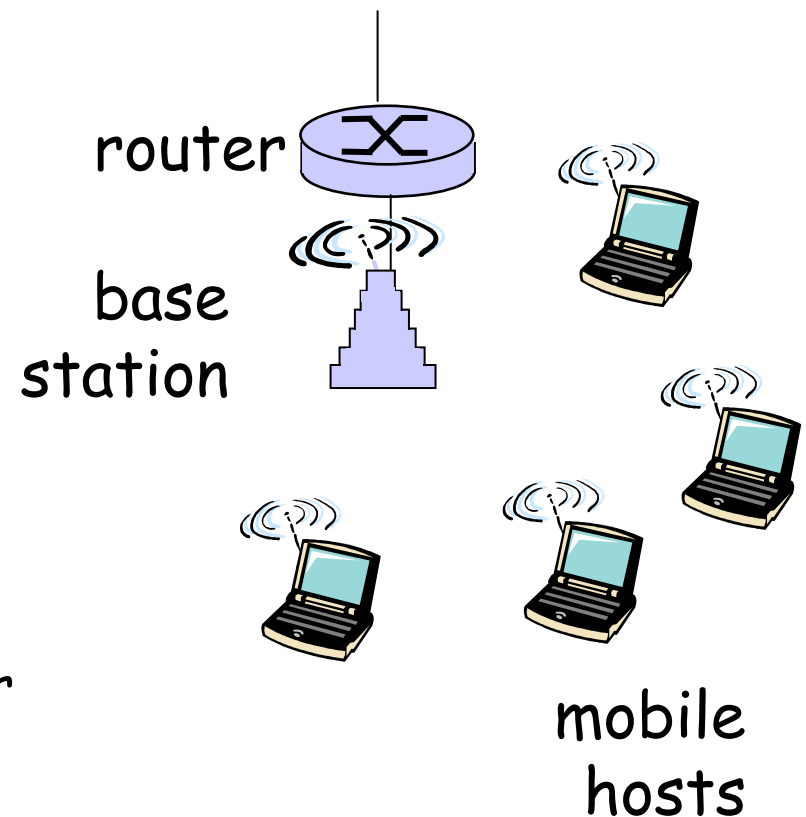
Home networks

Typical home network components:
- ❑ DSL or cable modem
- ❑ router/firewall/NAT
- ❑ Ethernet
- ❑ wireless access point

to/from cable headend

cable modem

router/ firewall
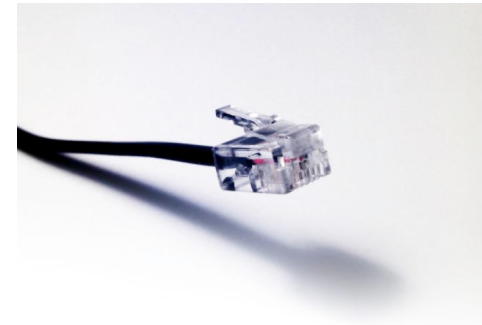
Ethernet

wireless access point

wireless laptops
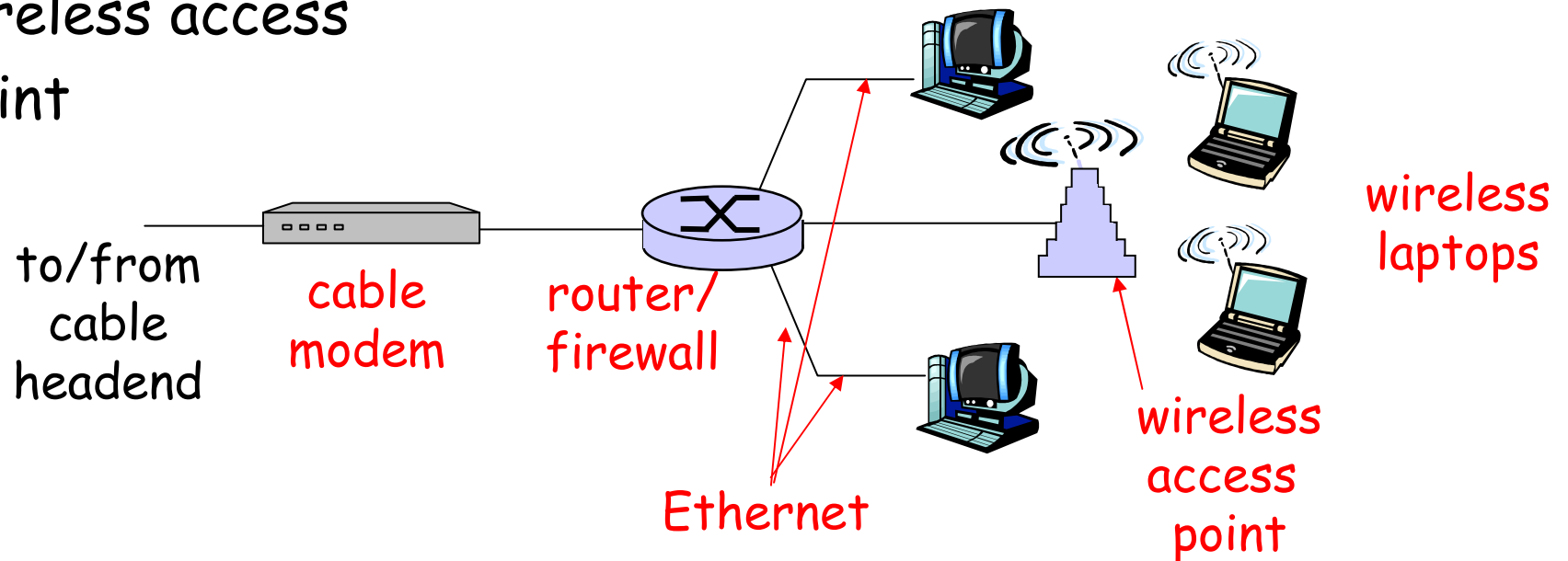
Physical Media

❑ **Bit:** propagates between transmitter/rcvr 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
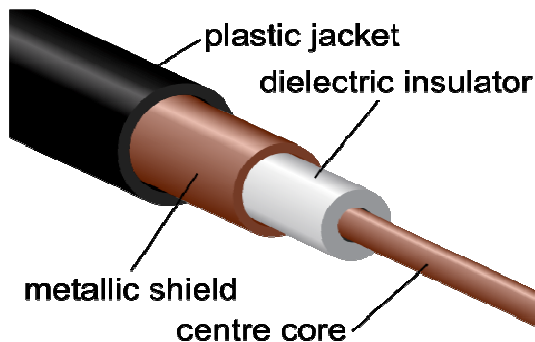   ○ Category 3: traditional phone wires, 10 Mbps Ethernet

   ○ Category 5: 100Mbps Ethernet
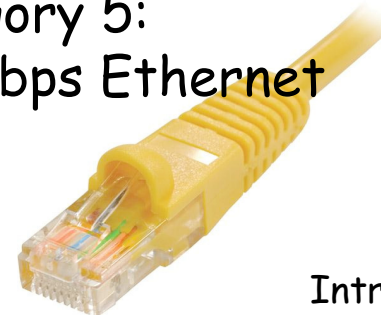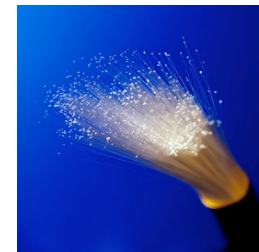
Physical Media: coax, fiber

Coaxial cable:

❑ two concentric copper conductors

❑ bidirectional

❑ baseband:
  ○ single channel on cable
  ○ legacy Ethernet

❑ broadband:
  ○ multiple channels on cable
  ○ HFC

plastic jacket
dielectric insulator
metallic shield
centre core

Fiber optic cable:

❑ glass fiber carrying light pulses, each pulse a bit

❑ high-speed operation:
  ❖ high-speed 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

- 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
    - (500 Km dalla superficie terrestre, servono costellazioni di satelliti)

Chapter 1: roadmap

The Network Core

- mesh of interconnected routers
- *the* fundamental question: how is data transferred through net?
  - circuit switching: dedicated circuit per call: telephone net
  - packet-switching: data sent thru net in discrete "chunks"
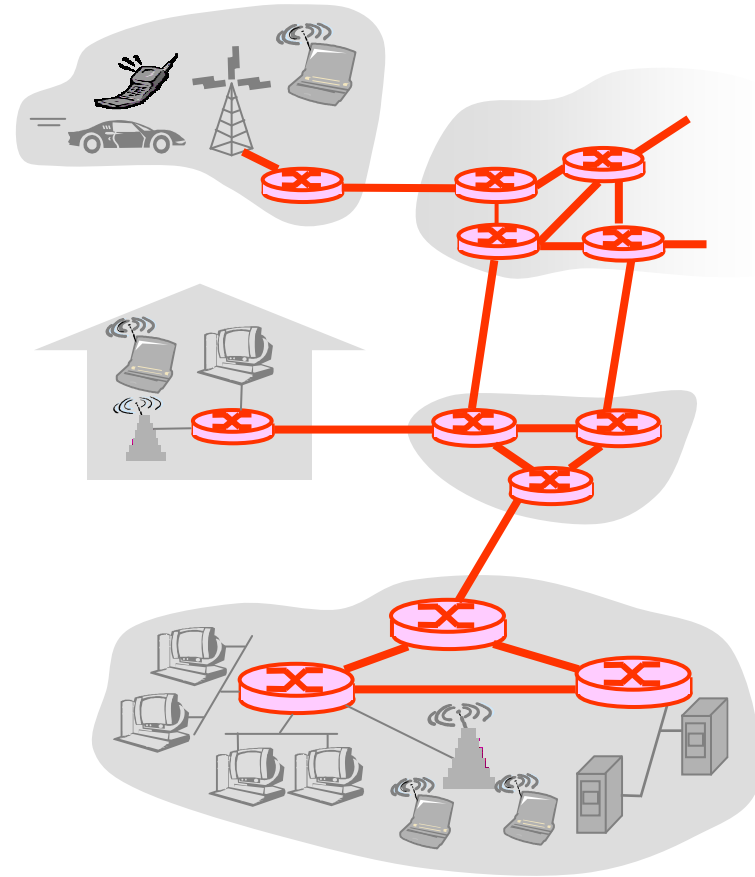
Network Core: Circuit Switching

End-end resources reserved for "call"

- link bandwidth, switch capacity
- dedicated resources: no sharing
- circuit-like (guaranteed) performance
- call setup required
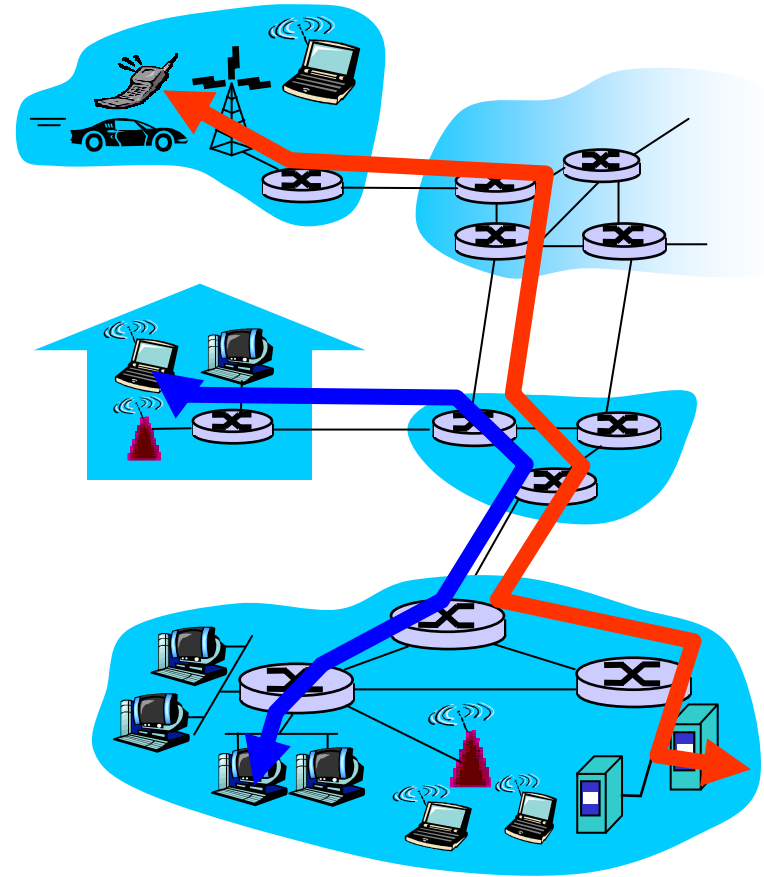
Network Core: Circuit Switching

network resources (e.g., bandwidth) divided into "pieces"

❑ pieces allocated to calls

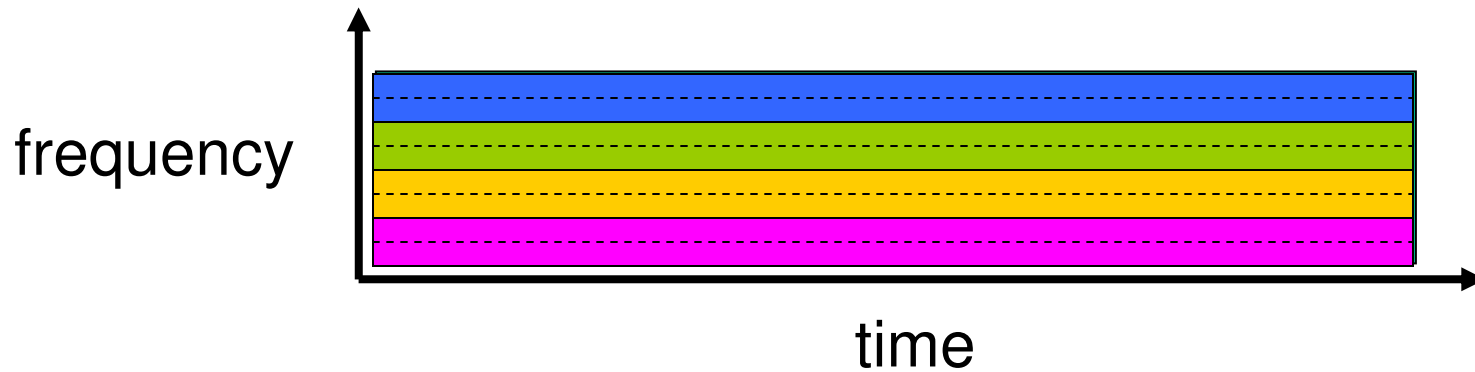❑ resource piece *idle* if not used by owning call *(no sharing)*

❑ dividing link bandwidth into "pieces"
  ❖ frequency division
  ❖ time division

Circuit Switching: FDM and TDM
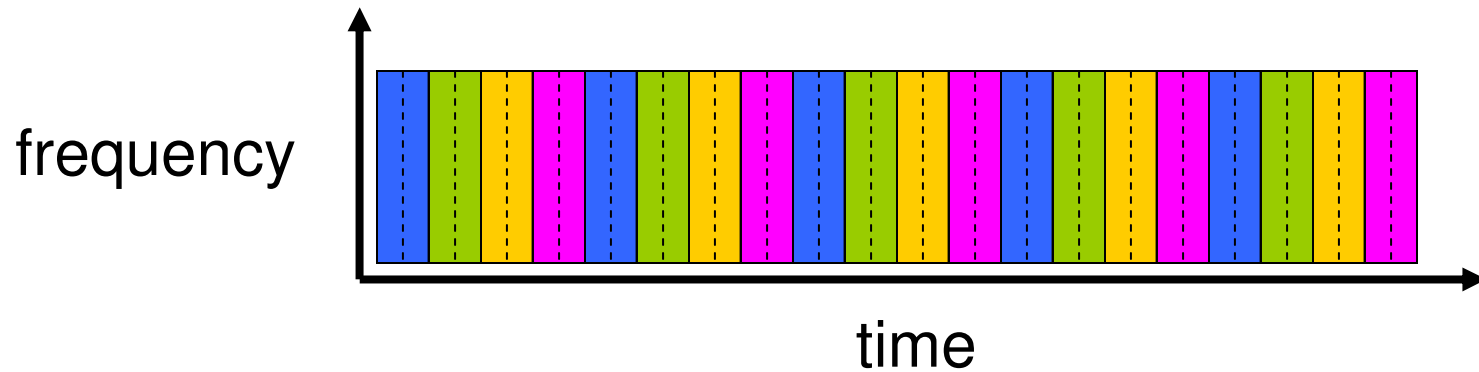
FDM

Example:

4 users

frequency

time

TDM

frequency

time

Numerical example

❑ How long does it take to send a file of 640,000 bits from host A to host B over a circuit-switched network?

  ○ All links are 1.536 Mbps
  ○ Each link uses TDM with 24 slots/sec
  ○ 500 msec to establish end-to-end circuit

Let's work it out!

..Numerical example

❑ Each circuit has a transmission rate of (1,536Mbps)/24=64Kbps
❑ 640000/64000=10s
❑ Plus the circuit establishment→10,5s

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

❑ resources used *as needed*

~~Bandwidth division into "pieces"~~
~~Dedicated allocation~~
~~Resource reservation~~

resource contention:

❑ aggregate resource demand can exceed amount available

❑ congestion: packets queue, wait for link use

❑ store and forward: packets move one hop at a time

  ○ Node receives complete packet before forwarding

# Packet Switching: Statistical Multiplexing
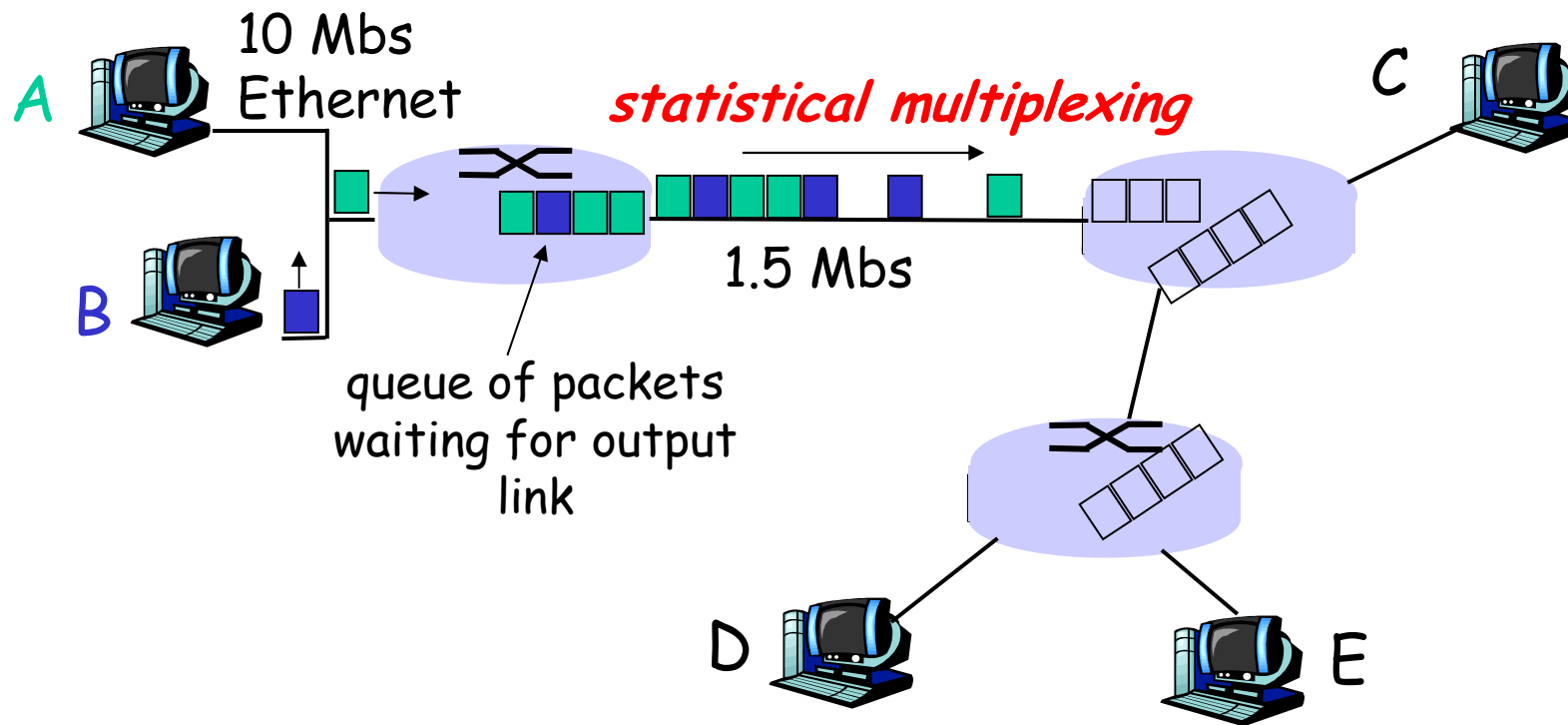
Sequence of A & B packets does not have fixed pattern
➔ *statistical multiplexing*.

In TDM each host gets same slot in revolving TDM frame.

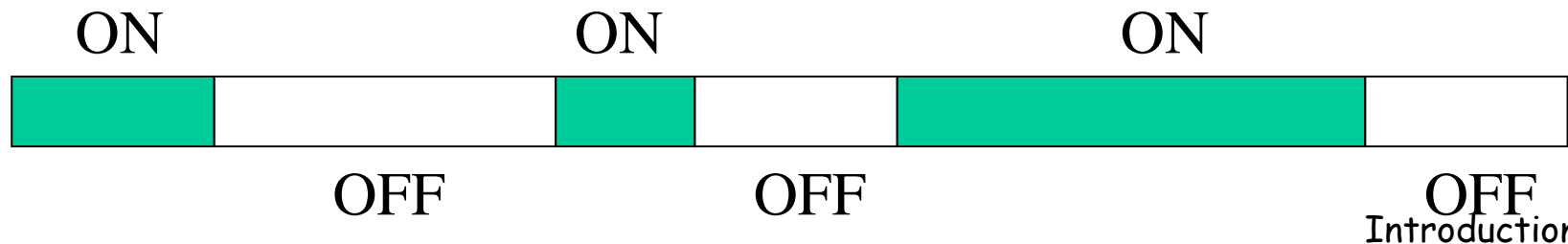# Packet switching versus circuit switching

Packet switching allows more users to use network!

❑ 1 Mbit link

❑ each user:
  ○ 100 kbps when "active"
  ○ active 10% of time

N users

❑ circuit-switching:
  ○ 10 users

❑ packet switching:
  ○ with 35 users, probability
    > 10 active less than .0004

1 Mbps link
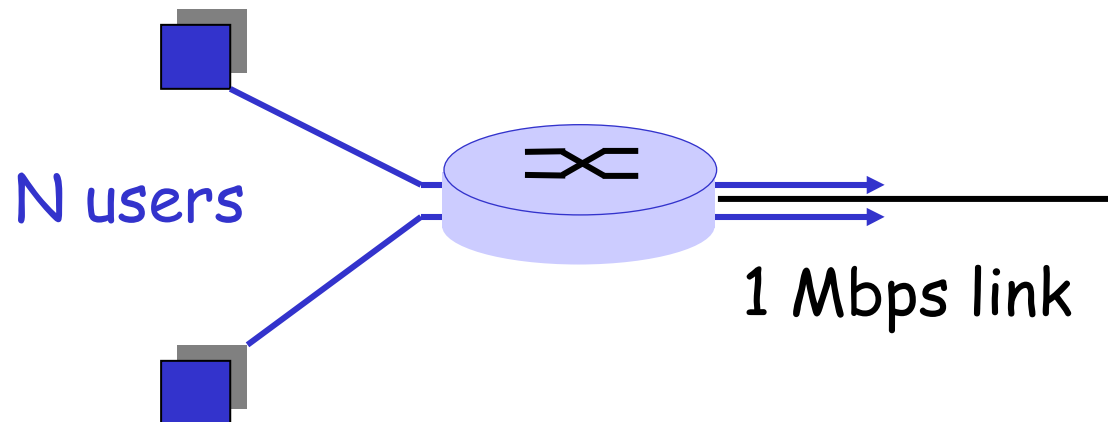
Source types

- Constant Bit Rate (e.g. encoded voice without silence suppression→ voice packets have fixed size and are trasmitted periodically. Required bit rate: 64Kbps)

- Variable Bit Rate (e.g. Video encoding, voice with silence suppression, file downloading etc.)
  - The bit rate varies with time
  - Source behavior characterized by min/max transmission rate, and average bit rate. Source burstiness = max bit rate/ average bit rate.
  - Example: CBR ON/OFF

ON   ON   ON

OFF   OFF   OFF

Packet switching versus circuit switching

Is packet switching a "slam dunk winner?"

❑ Great for bursty data
  ○ resource sharing
  ○ simpler, no call setup
❑ Excessive congestion: packet delay and loss
  ○ protocols needed for reliable data transfer,
    congestion control