Computer Networks

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Chapter 1 Introduction

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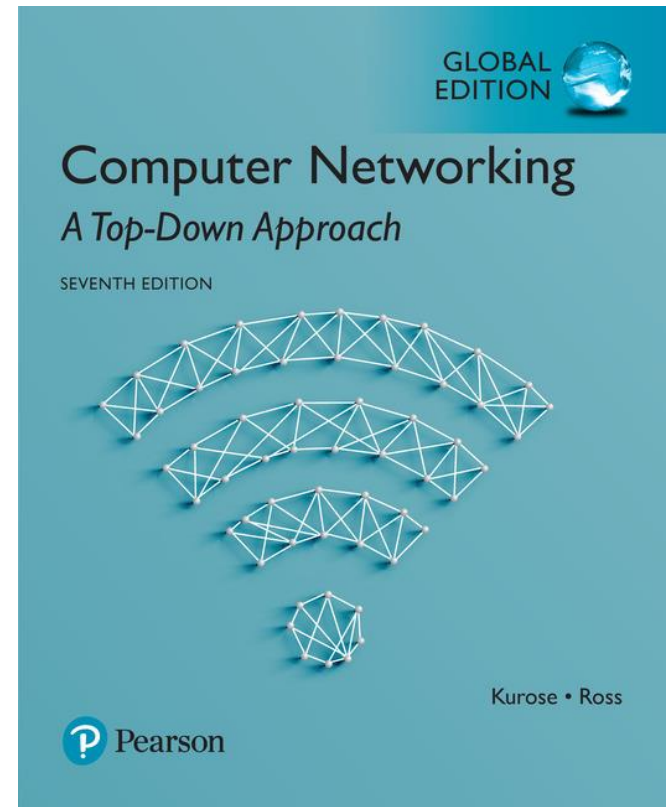
Computer Networking:

A Top Down Approach

7th Edition, Global Edition

Jim Kurose, Keith Ross

Pearson

2017

Chapter 1: Introduction

Our goal:

- ❑ get "feel" and terminology
- ❑ more depth, detail later in course
- ❑ approach:
  - ❍ use Internet as example

Chapter 1:

1.1 What is the Internet?

1.1 What's the Internet

❑ What are networks?

○ The interconnection of a set of devices capable to

○ Telephone network (PSTN), Internet, cable network, N-ISDN, B-ISDN, etc.

1.1.1 What's the Internet

- *hosts = end systems*
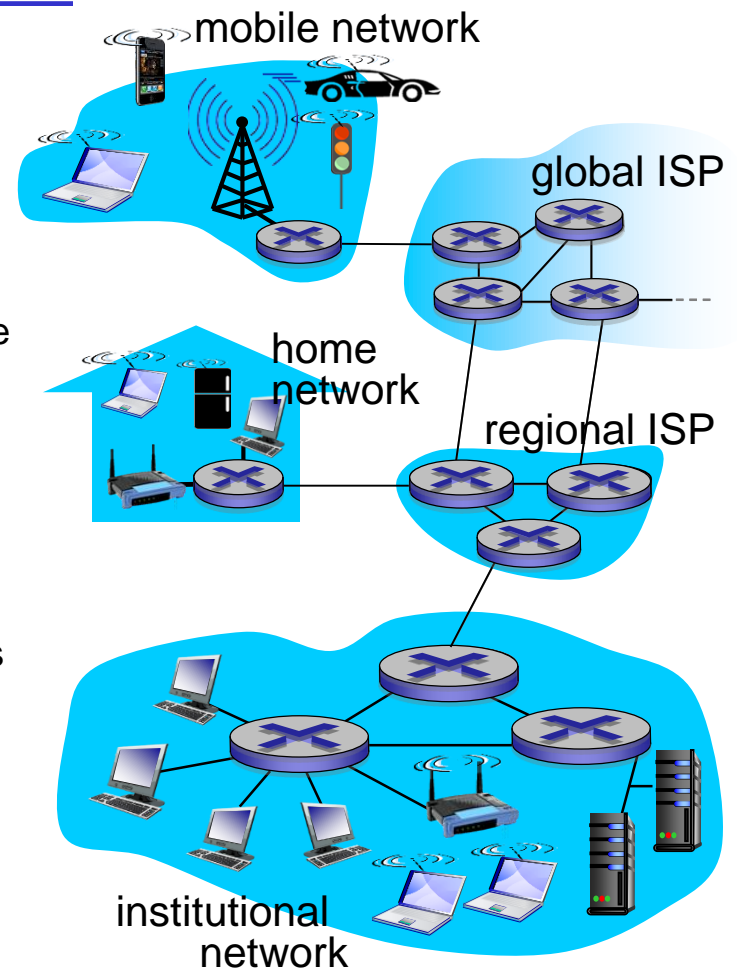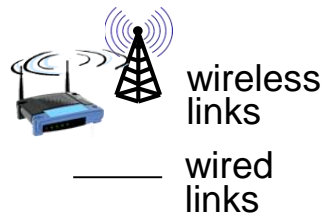 - running *network apps*

- communication links
  -
  - fiber, copper, radio, satellite
  - transmission rate vs. *bandwidth*

- *Routers (or switches)*
  - To forward packets (chunks of data)

PC

server

wireless laptop

smartphone

mobile network

global ISP

home network

regional ISP

institutional network

wireless links

wired links

router

1.1.1 What's the Internet

❑ *Internetwork (Internet)*
- ❍ *A network of networks*
- ❍ A set of independent networks interconnected
- ❍ loosely hierarchical

❑ *Internet vs. internet*
- ❍ *Protocols:*
- ❍ Internet standards
  - • RFC: Request for comments
  - • IETF: Internet Engineering Task Force

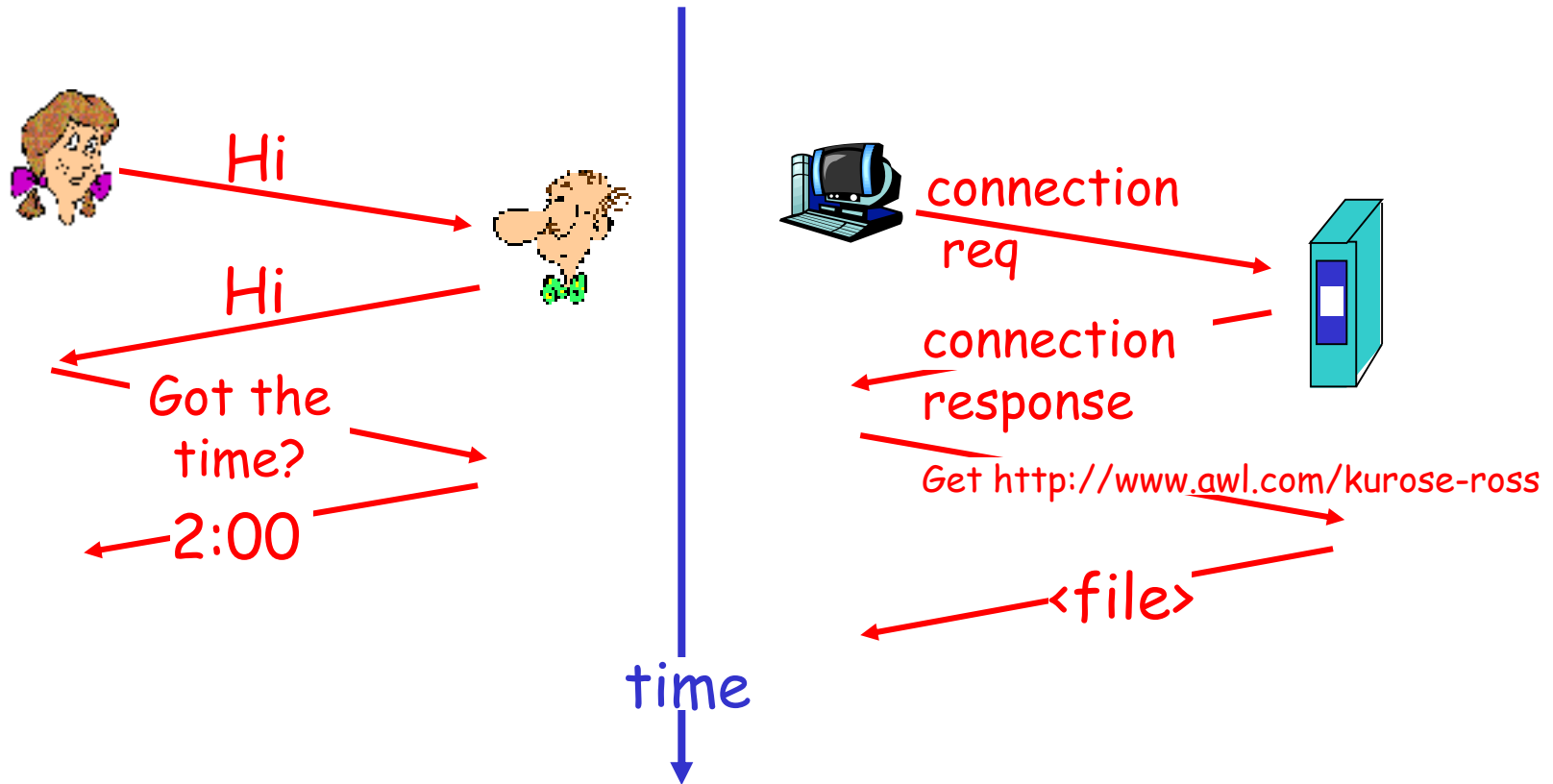**Router or gateway**
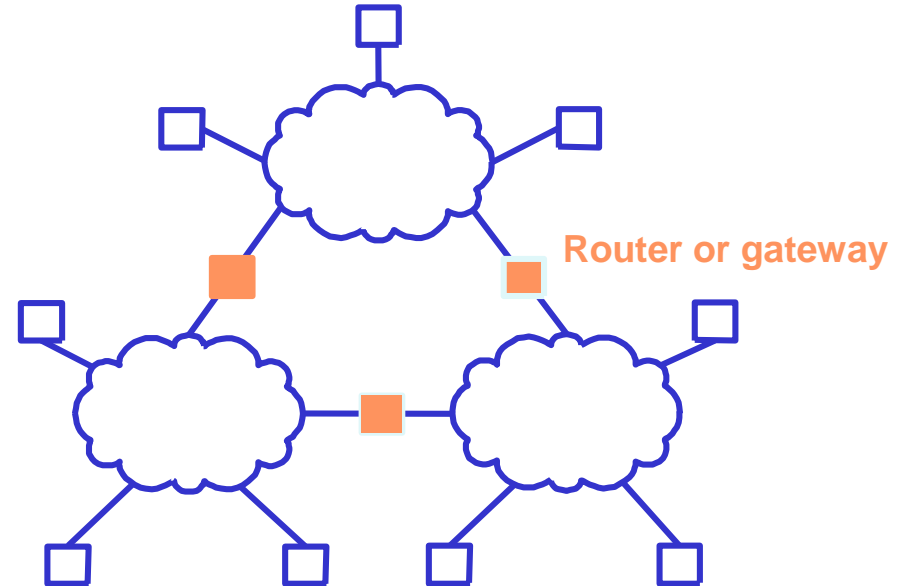
1.1.2 What's the Internet: a service view

❑ The Internet (communication *infrastructure*) enables distributed applications:
   ○ Web, email, games, e-commerce, file sharing

❑ The Internet provides two services to apps:
   ○ Connectionless unreliable
   ○ connection-oriented reliable

❑ The Internet can   support

1.1.3 What's a protocol?

❑ A *protocol* is the

                                     between
two or more entities should adhere.

   ○ *the format of messages*

   ○ *the order of messages exchanged*

   ○ *the actions taken on the transmission and/or receipt of a message or other event.*

1.1.3 What's a protocol?

a human protocol and a computer network protocol:

Hi

Hi

Got the time?

2:00

connection req

connection response

Get http://www.awl.com/kurose-ross

<file>

time

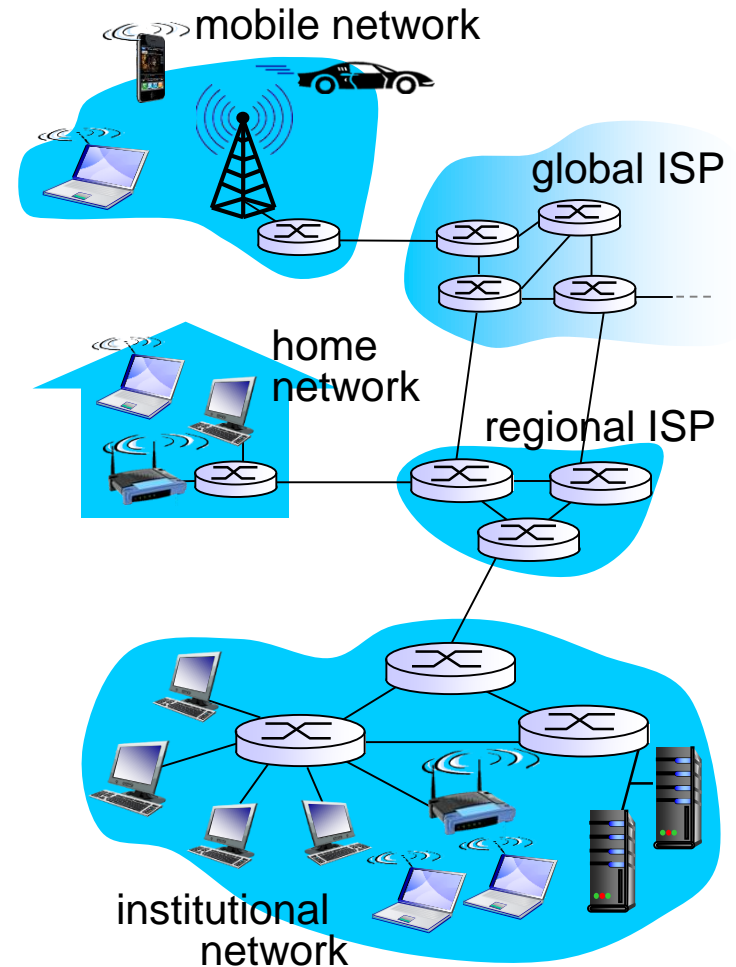# Chapter 1:

Network structure

❖ *network edge:*
  ▪ hosts: clients and servers
  ▪ servers often in data centers

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

❖ *network core:*
 ▪ interconnected routers
  ▪ network of networks

mobile network

global ISP

home network

regional ISP

institutional network

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:
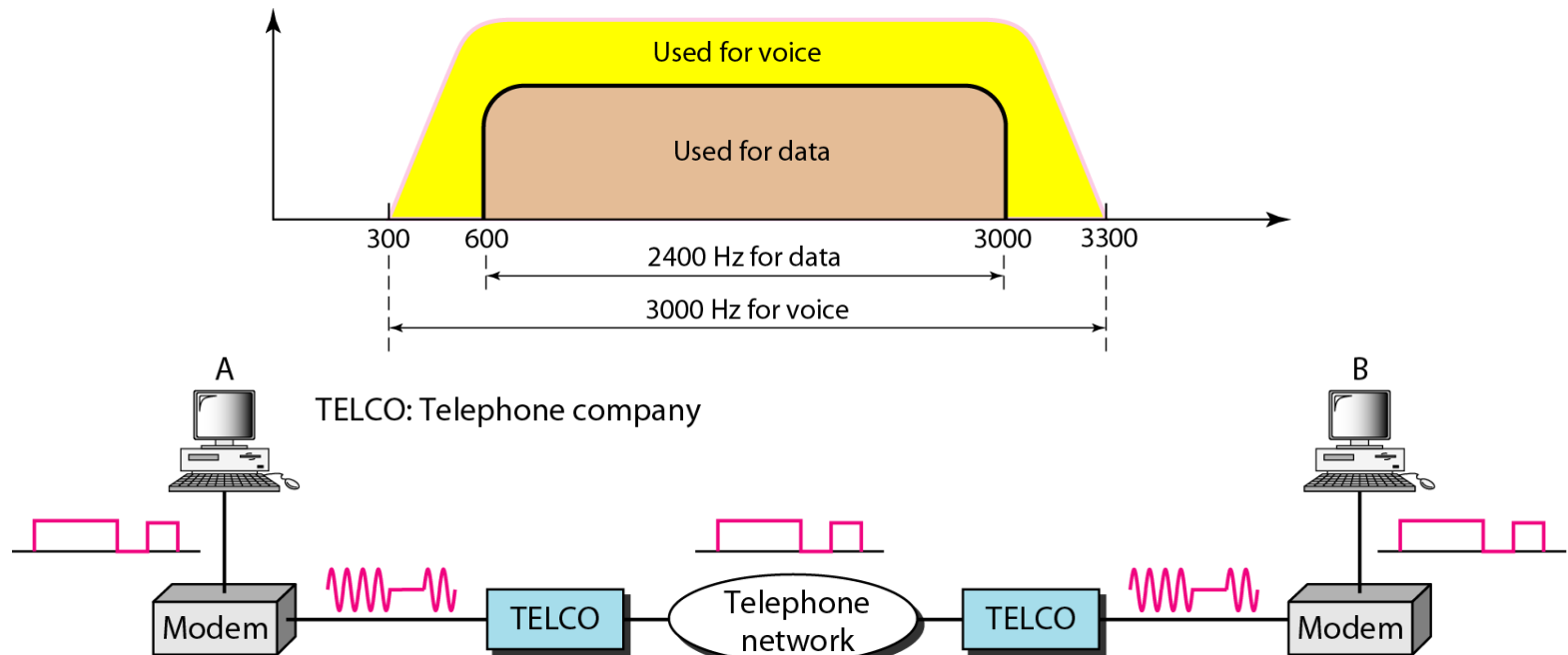
❖ bandwidth (bits per second) of access network?

❖ shared or dedicated?

mobile network

global ISP

home network

regional ISP

institutional network
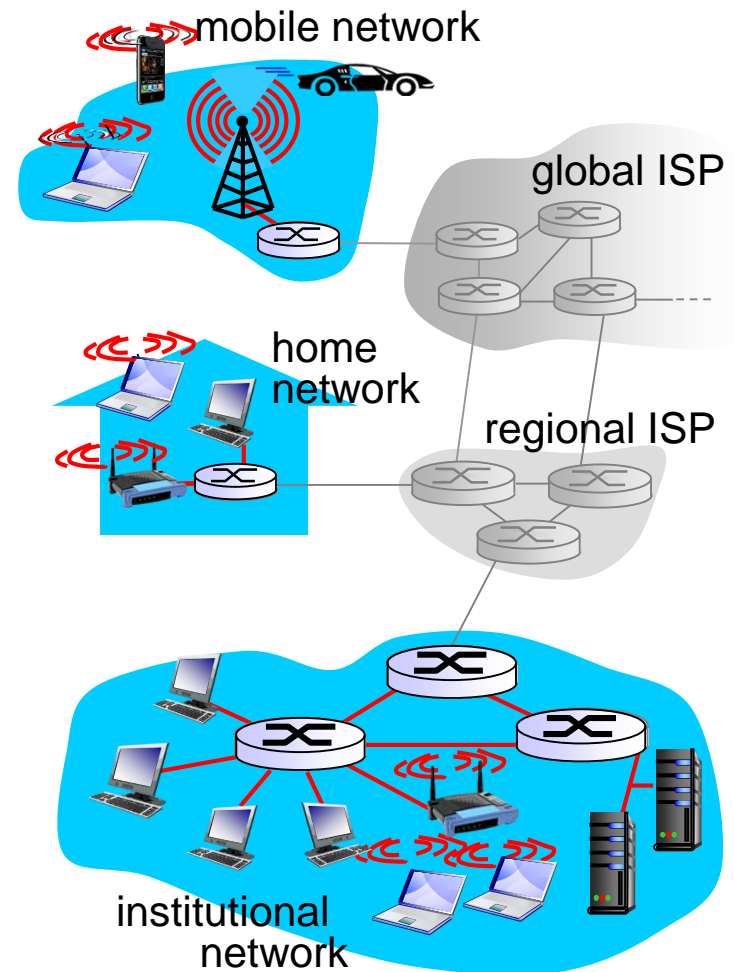
Home (residential) access net.

❑ **Dialup via modem**

- ○ up to 56Kbps direct access to router (often less)
- ○ Can't surf and phone at same time: can't be "always on"

Used for voice

Used for data

300   600   2400 Hz for data   3000   3300

3000 Hz for voice

A

TELCO: Telephone company

B

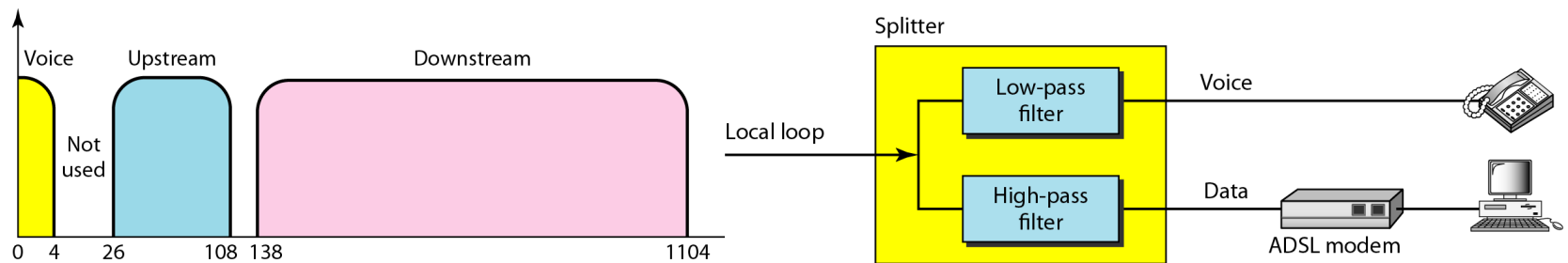Modem — TELCO — Telephone network — TELCO — Modem

Home access net.

❏ DSL (Digital Subscriber Line)

  ○ A technology for supporting high-speed digital communication over the existing local loops

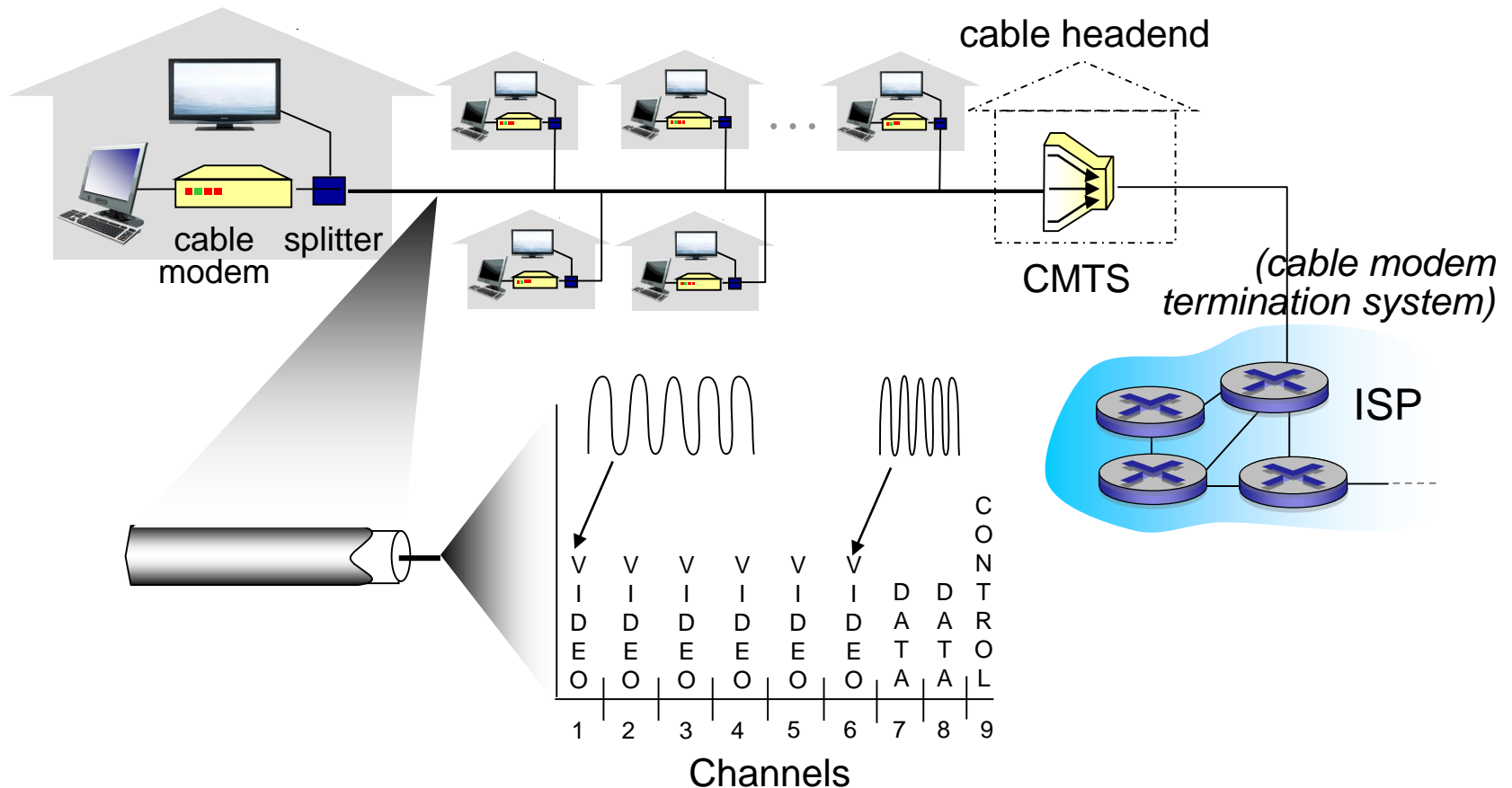 ○ Can use the Internet and the phone at the same time

central office

telephone network

DSL modem

splitter

DSLAM

ISP

voice, data transmitted at different frequencies over dedicated line to central office

DSL access multiplexer
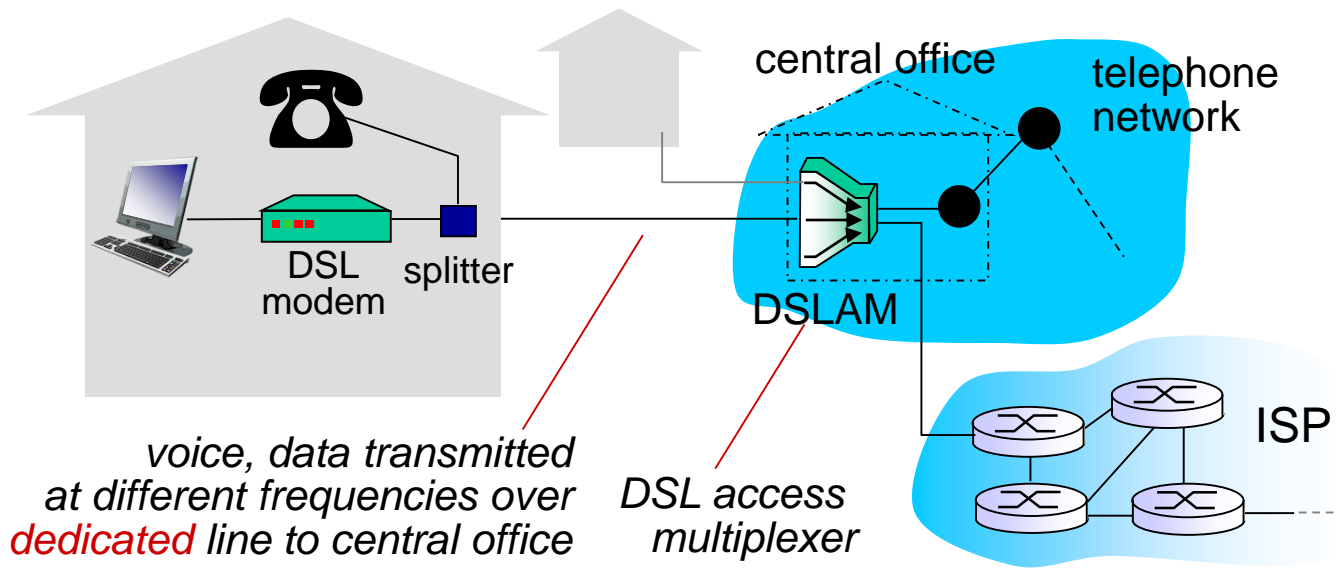
Home access net.

❑ Ex. ADSL (Asymmetric DSL)

❑ DSL

Technology	Downstream Rate	Upstream Rate	Distance (ft)	Twisted Pairs	Line Code
ADSL	1.5–6.1 Mbps	16–640 kbps	12,000	1	DMT
ADSL Lite	1.5 Mbps	500 kbps	18,000	1	DMT
HDSL	1.5–2.0 Mbps	1.5–2.0 Mbps	12,000	2	2B1Q
SDSL	768 kbps	768 kbps	12,000	1	2B1Q
VDSL	25–55 Mbps	3.2 Mbps	3000–10,000	1	DMT

Home access net.: Cable

cable headend

cable modem   splitter

CMTS

(cable modem termination system)

ISP

VIDEO | VIDEO | VIDEO | VIDEO | VIDEO | VIDEO | DATA | DATA | CONTROL
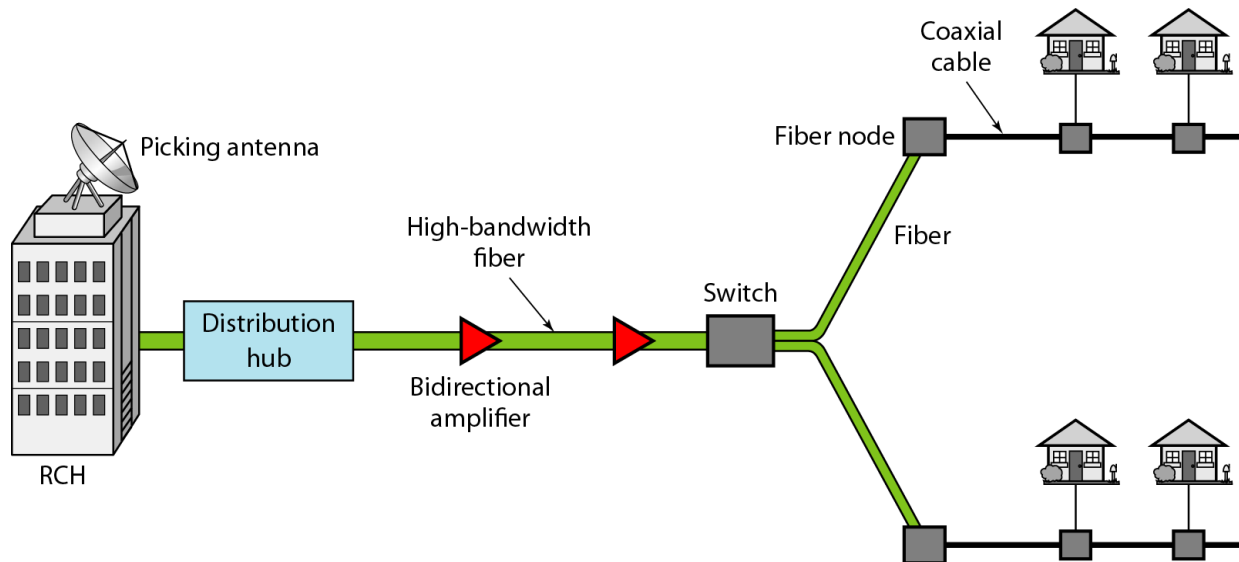1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9

Channels

frequency division multiplexing (FDM):
different channels transmitted in different frequency bands

Home access net.

❑ HFC: hybrid fiber coax

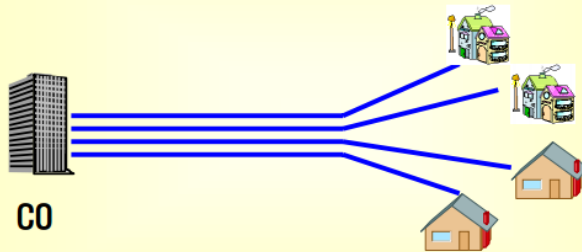 ❍ asymmetric: up to 30Mbps downstream,
     2 Mbps upstream

  ❍ network of cable and fiber attaches homes to ISP router

    • homes share access to router
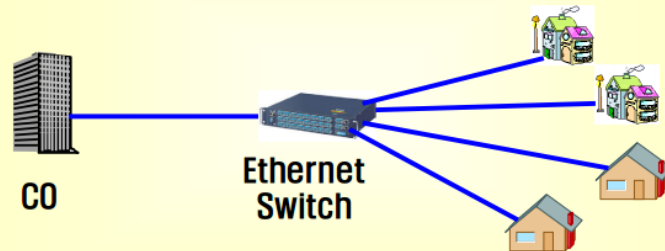
Home access net.

❏ FTTH (Fiber To The Home)
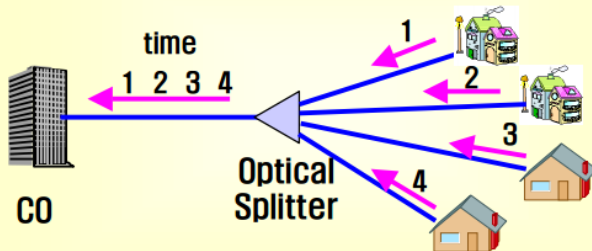
Home networks

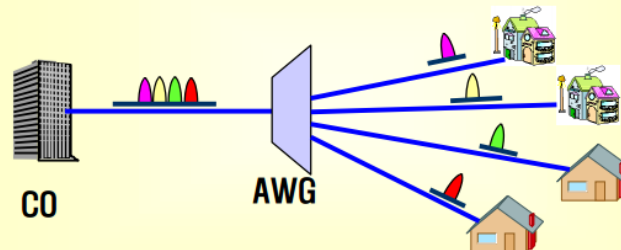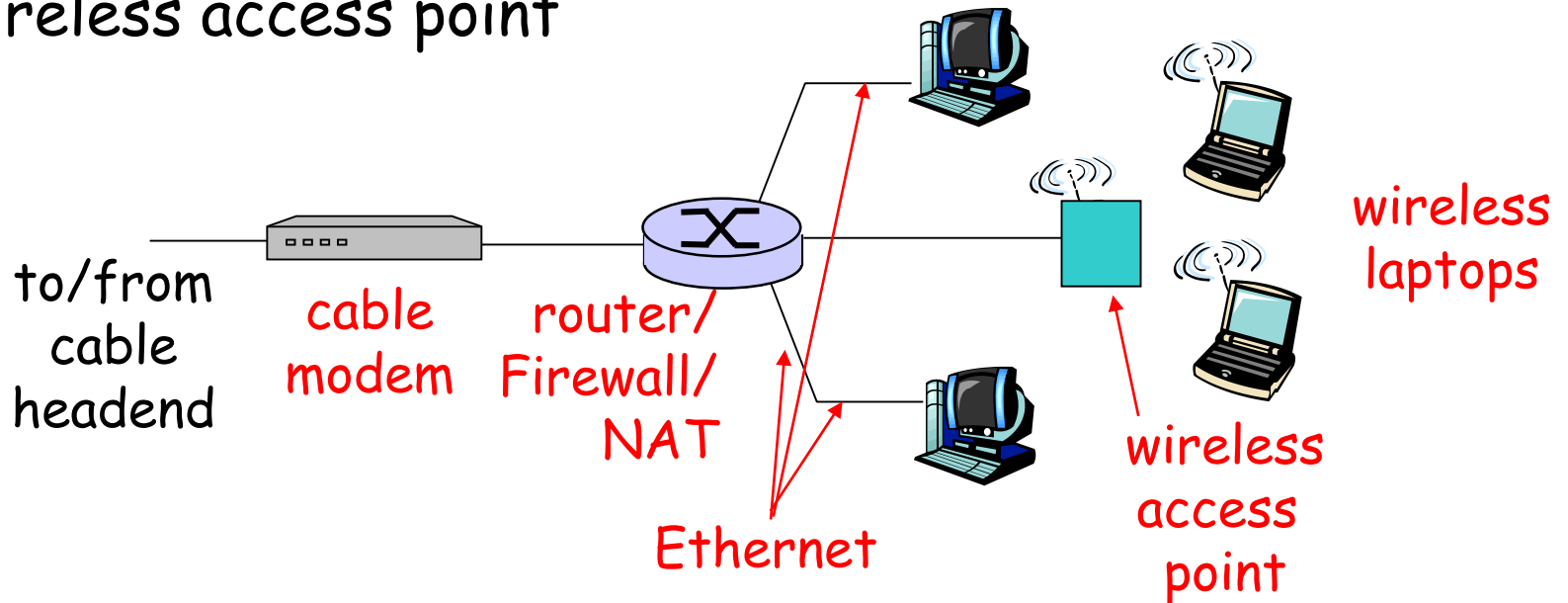Typical home network components:
- ❑ xDSL or cable modem
- ❑ router/firewall/NAT
- ❑ Ethernet
- ❑ wireless access point

to/from cable headend

cable modem

router/ Firewall/ NAT

Ethernet

wireless access point

wireless laptops

Enterprise access net.

institutional link to ISP (Internet)

institutional router

Ethernet switch

institutional mail, web servers
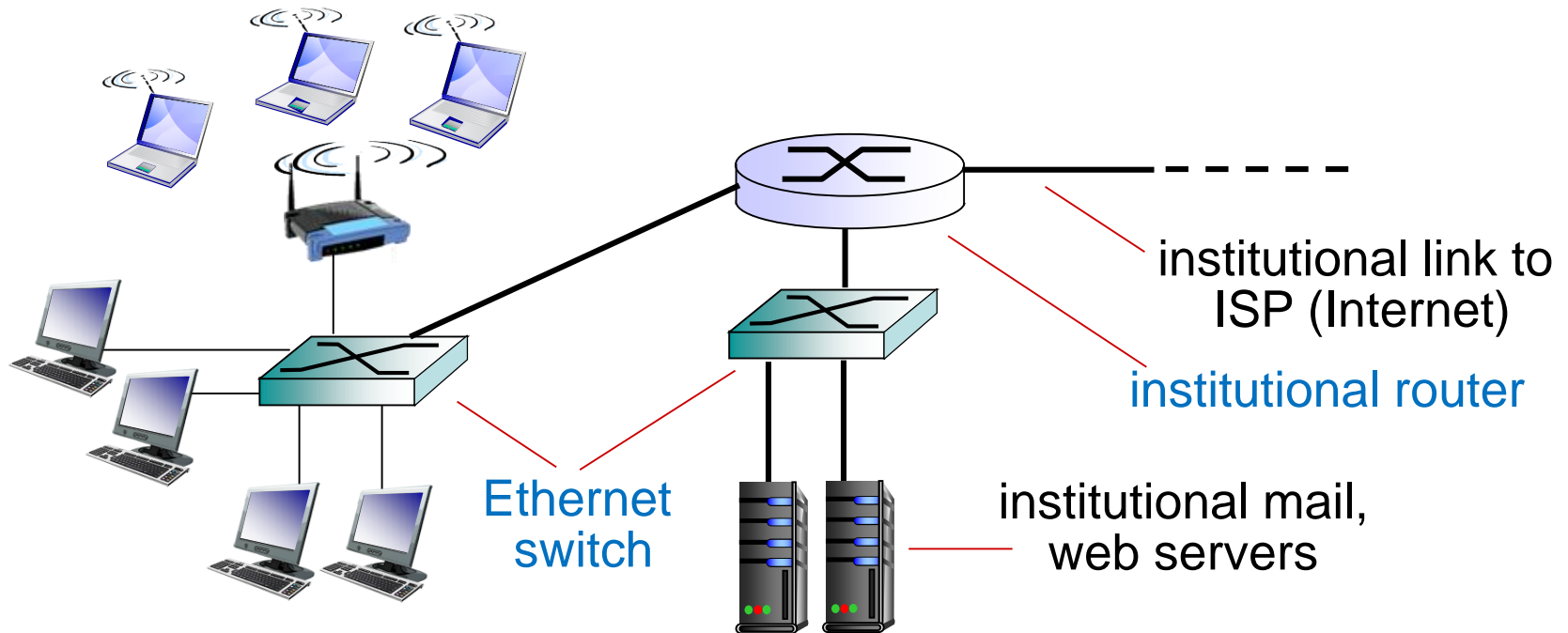
- ❖ company/univ local area network (LAN) connects end system to edge router 한 사람이 전적으로 사용가능
- ❖ today, end systems typically connect into Ethernet switch
  - ❖ 10 Mbps, 100Mbps, 1Gbps, 10Gbps transmission rates

Wireless access net.

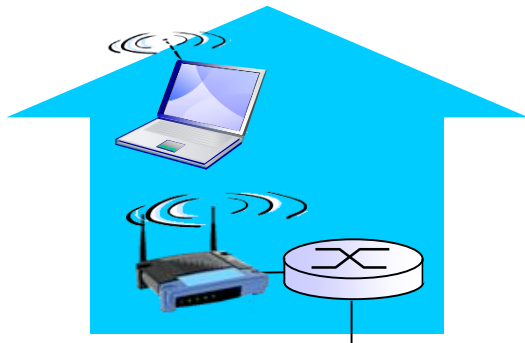❖ shared *wireless* access network connects end system to router
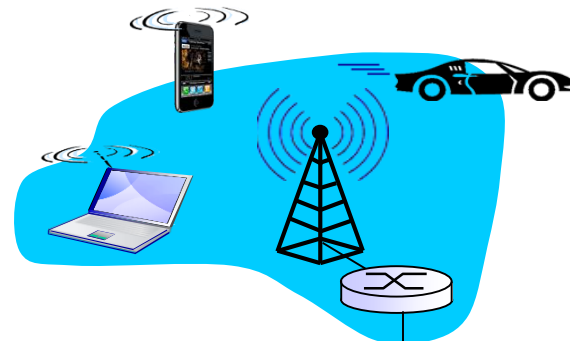 - via base station aka "access point"

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

to Internet

wide-area wireless access
  - provided by telco (cellular) operator, 10's km
  - between 1 and 10 Mbps
  - 3G, 4G: LTE

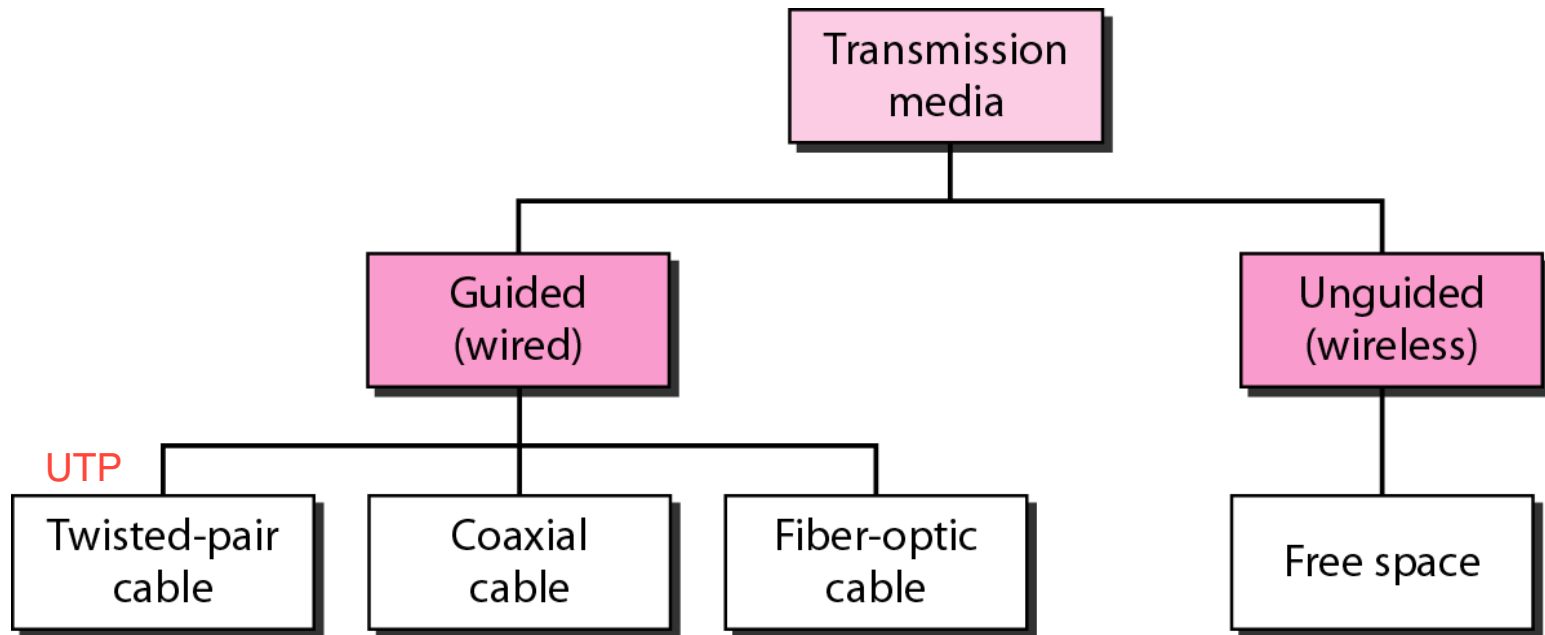*to Internet*

1.2.2 Physical Media

❑ **Classes of Physical Media**
  ○ **guided media:**
    • signals propagate in solid media: copper, fiber, coax
  ○ **unguided media:**
    • signals propagate freely, e.g., radio

```
                    ┌──────────────┐
                    │ Transmission │
                    │    media     │
                    └──────────────┘
                 ┌──────────┴──────────┐
           ┌──────────┐          ┌──────────┐
           │  Guided  │          │ Unguided │
           │  (wired) │          │(wireless)│
           └──────────┘          └──────────┘
      ┌────────┼────────┐              │
UTP┌────────┐┌────────┐┌──────────┐┌──────────┐
   │Twisted-││Coaxial ││Fiber-    ││Free space│
   │pair    ││cable   ││optic     ││          │
   │cable   ││        ││cable     ││          │
   └────────┘└────────┘└──────────┘└──────────┘
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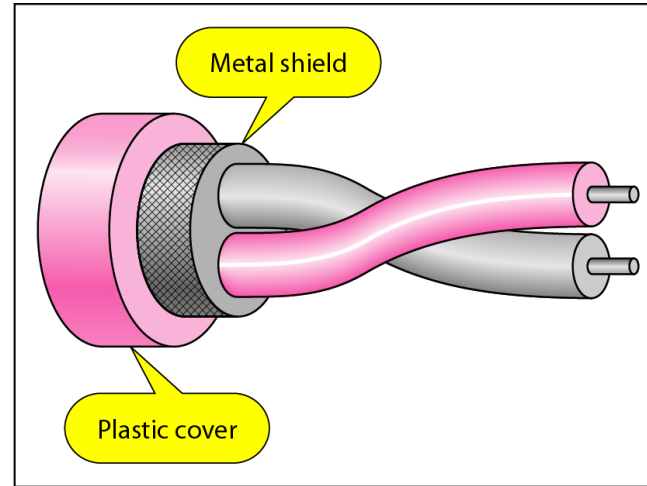
Physical Media: Twisted Pair (TP)

❑ **UTP and STP**
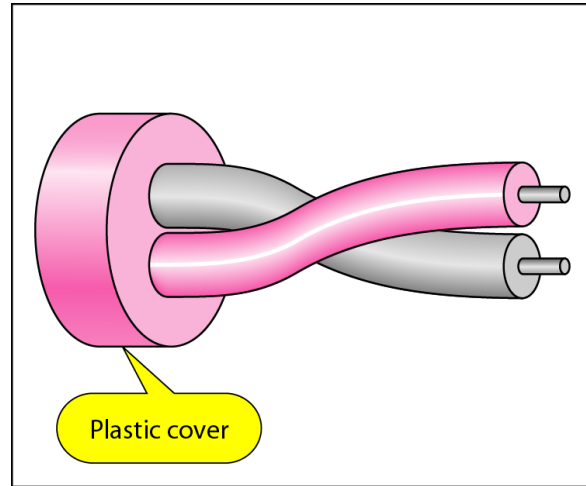
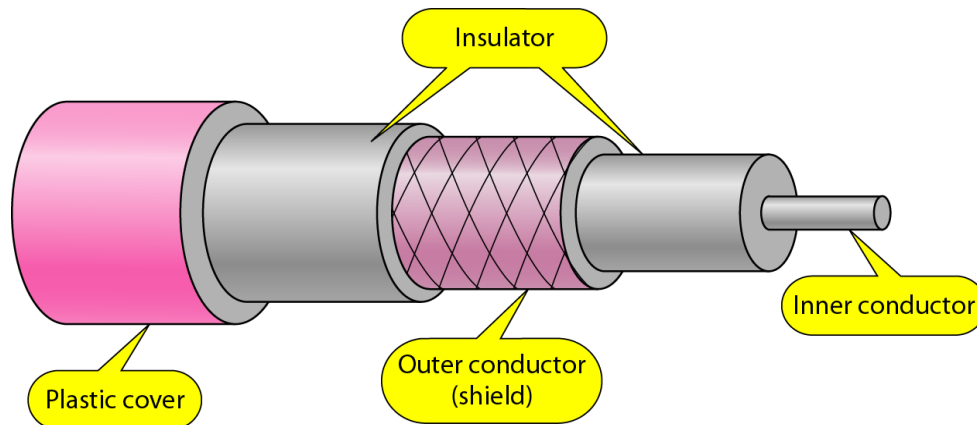a. UTP   b. STP

❑ **UTP**

   ○ Category 3: traditional phone wires, 10 Mbps Ethernet

   ○ Category 5: 100Mbps Ethernet

      • Category 5e: 1 Gbps

   ○ Category 6: 10 Gbps

# Physical Media: coaxial cable

❑ two concentric copper conductors

❑ baseband:

  ❍ single channel on cable

  ❍ legacy Ethernet

❑ broadband:

  ❍ multiple channel on cable

  ❍ HFC

Insulator

Inner conductor

Plastic cover

Outer conductor
(shield)
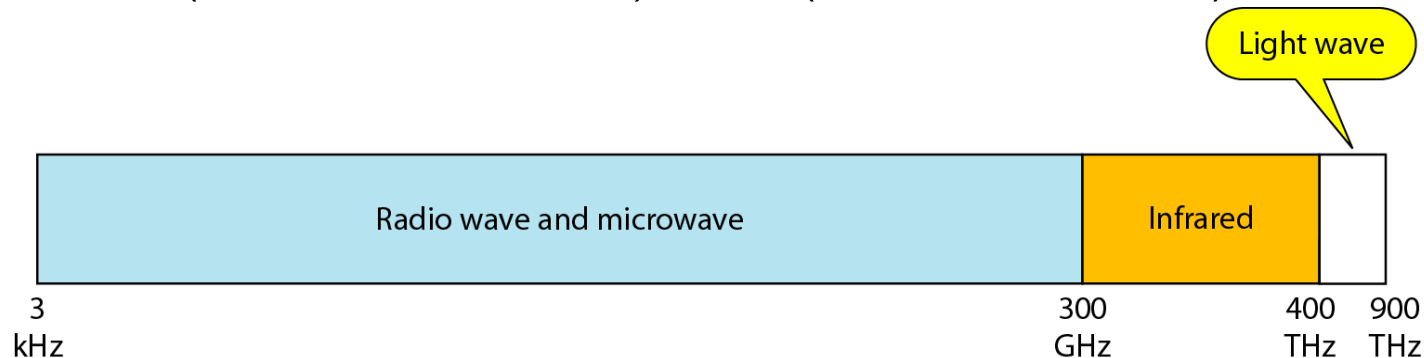
Physical Media: fiber

Fiber optic cable:

- Glass fiber carrying light pulses, each pulse a bit
- Ultra-high bandwidth (up to 50 Tbps);
- Low error rate
  - Not susceptible to electromagnetic interference;
- Secure, wire-tapping near impossible.
- Very low attenuation
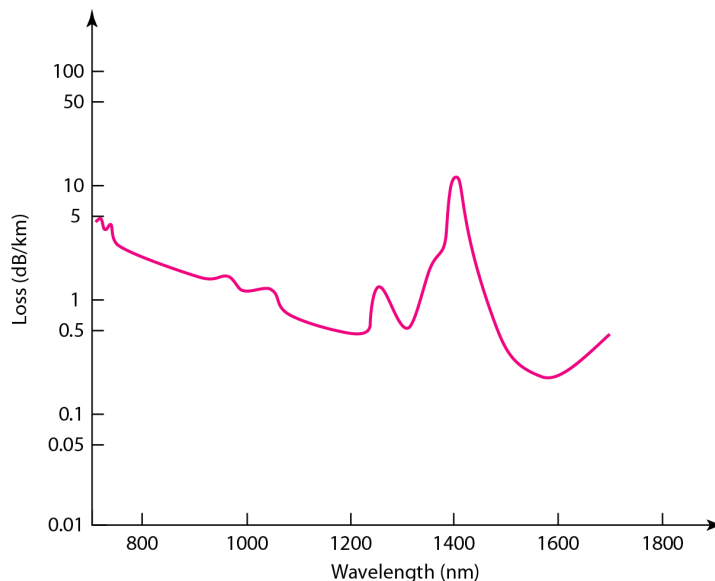
Physical media: radio

❑ Regulated by ITU-R (WARC) <—> ISM band(규제가 없음)
　　　　규제를 잘 해야됨
❑ noisier (more bit error) than wire transmission

　❍ Reflection, interference, obstruction by objects

❑ Frequency spectrum

　❍ VLF(3~30 kHz),　　　　　　　　LF(30~300kHz),

　❍ MF(300~3000kHz;AM),　　　　　HF(3~30MHz;HAM),

　❍ VHF(30~300MHz;TV, FM), UHF(300~3000MHz;TV)

Light wave

Radio wave and microwave	Infrared	
3 kHz	300 GHz	400 THz　900 THz

Physical media: radio

Typical Radio link types:

❑ **LAN** (IEEE802.11 e.g., Wifi)
   ○ 11 Mbps, 54Mbps, …

❑ **wide-area** (e.g., cellular)
   ○ e.g. 3G, 4G

❑ **satellite**   Propagation delay 큼
   ○ Kbps to 45Mbps channel
   ○ 270 msec (from ground station through satellite back to ground)
   ○ geosynchronous versus low-earth orbiting (LEO)

❑ Terrestrial microwave

Send packets

Sending function in a host

- 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, aka *link capacity, aka link bandwidth*

two packets,
L bits each

2 1

R: link transmission rate

host
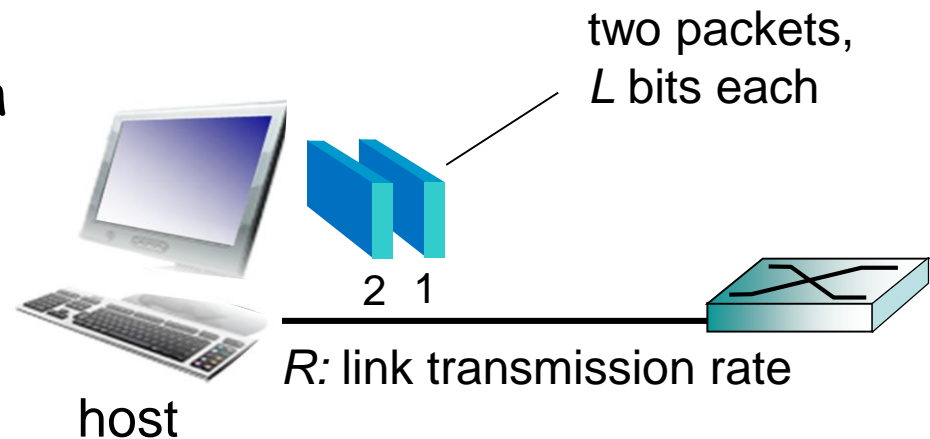
packet transmission delay	=	time needed to transmit *L*-bit packet into link	=	————

Physical media: Basic theorems

❑ **Nyquist Theorem**
  - expresses the maximum data rate for a **noiseless** channel
  - maximum rate = 2B symbols/sec   (B=bandwidth [Hz])

$$= 2B \log_2 V \text{ bits/sec}$$

         (V=the number of discrete levels of each symbol)

❑ **Shannon Theorem**
  - the maximum bit rate of a random **noisy** channel
    : channel capacity
  - max. bit rate = $B \log_2 (1+ S/N)$ bits/sec

         (S/N : signal-to-noise ratio)

Physical media: Basic theorems

Q) If a binary signal is sent over a 3-kHz channel whose signal-to-noise ratio is 20dB, what is the maximum achievable data rate?

Sol)

   - By Nyquist theorem:

   - By Shannon theorem: