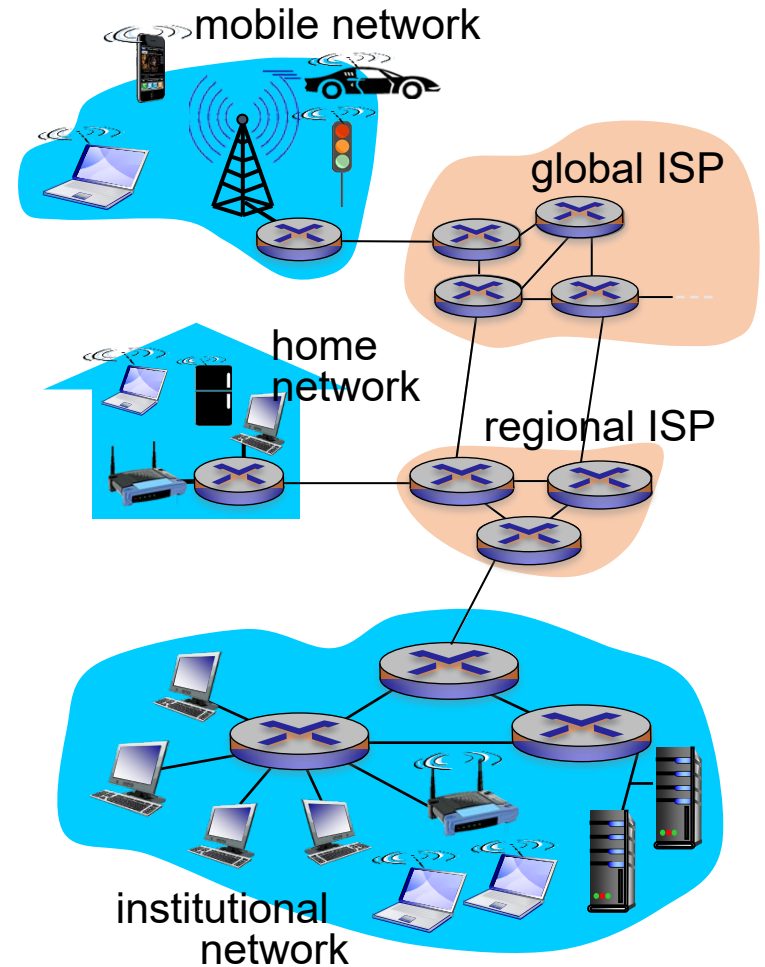# Computer Networks

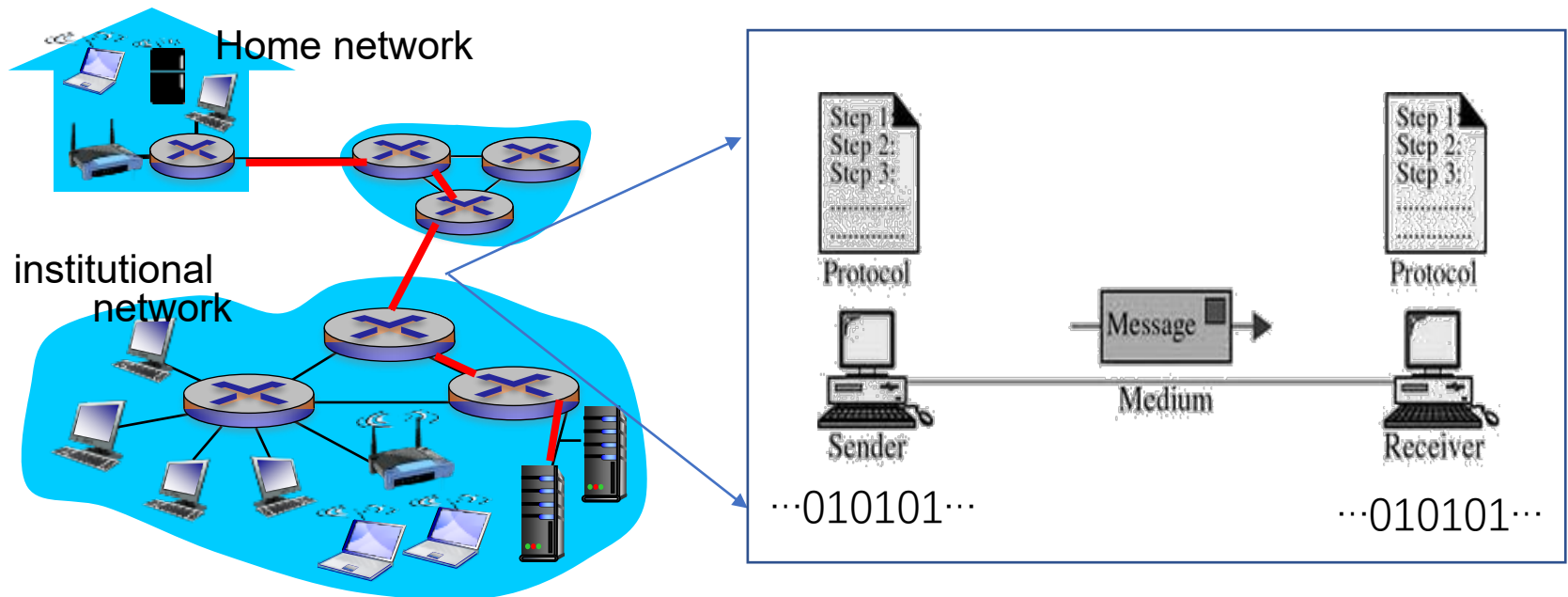Lecturer: ZHANG Ying

Fall semester 2022

Chapter 1: Introduction

Network Edge

- Devices
  - end systems/hosts
- Access network:
  - end systems to edge router
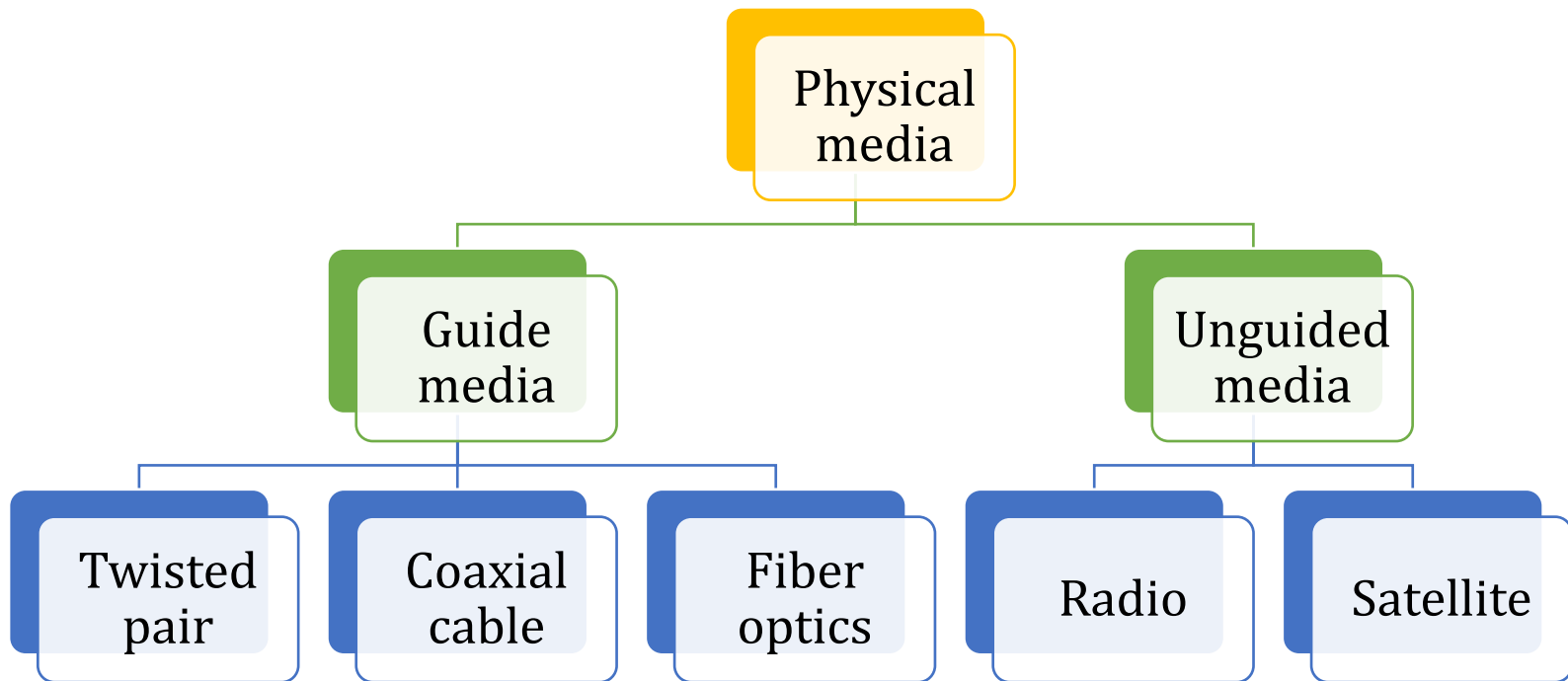- Physical media
  - Guided media
  - Unguided media

mobile network

global ISP

home network

regional ISP

institutional network

Physical media – the journey of a "bit"

Home network

institutional network

Protocol

Step 1
Step 2
Step 3

Protocol

Step 1
Step 2
Step 3

Message

Medium

Sender

Receiver

···010101···   ···010101···

- Bits travels through multiple sender-receiver pairs from source to destination.
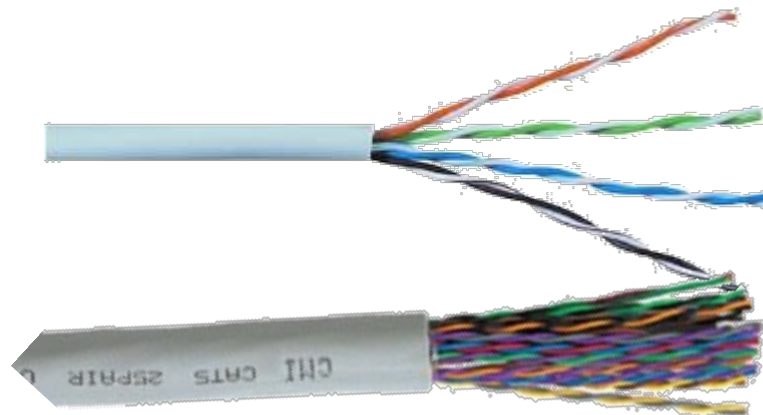- Each pair via own physical media
- Various medias may exist.

Physical media
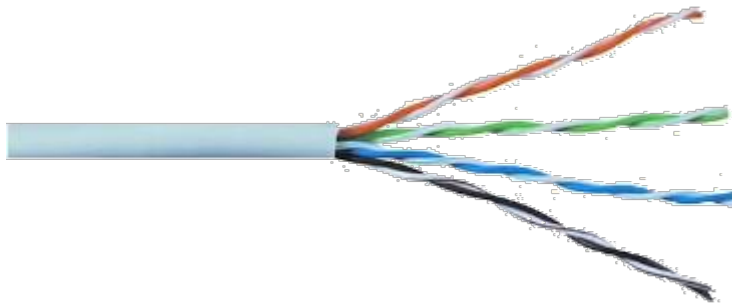
- physical link: lies between transmitter & receiver

Twisted-Pair Copper Wire

- most commonly-used physical media
- support both digital & analog signal

Unshielded twisted pair cable/ UTP

Twisted-pair:
protect the signal from interference

Color-coded plastic insulation:
electrically isolated wires from each other and identifies each pair

Outer jacket:
protect the copper wire from physical damage
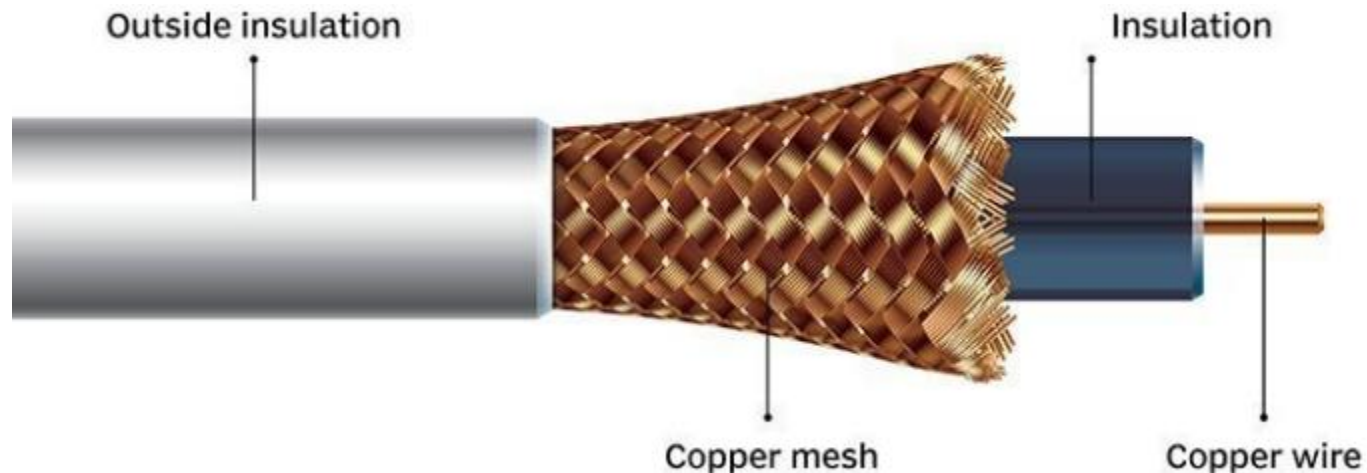
Category 3 UTP & Category 5 UTP

(a) Category 3 UTP.

(b) Category 5 UTP.

Coaxial-Cable

- Special insulation and shielding to well block the signal interference.
- coaxial cable can have higher bit rates than twisted pair.

Outside insulation
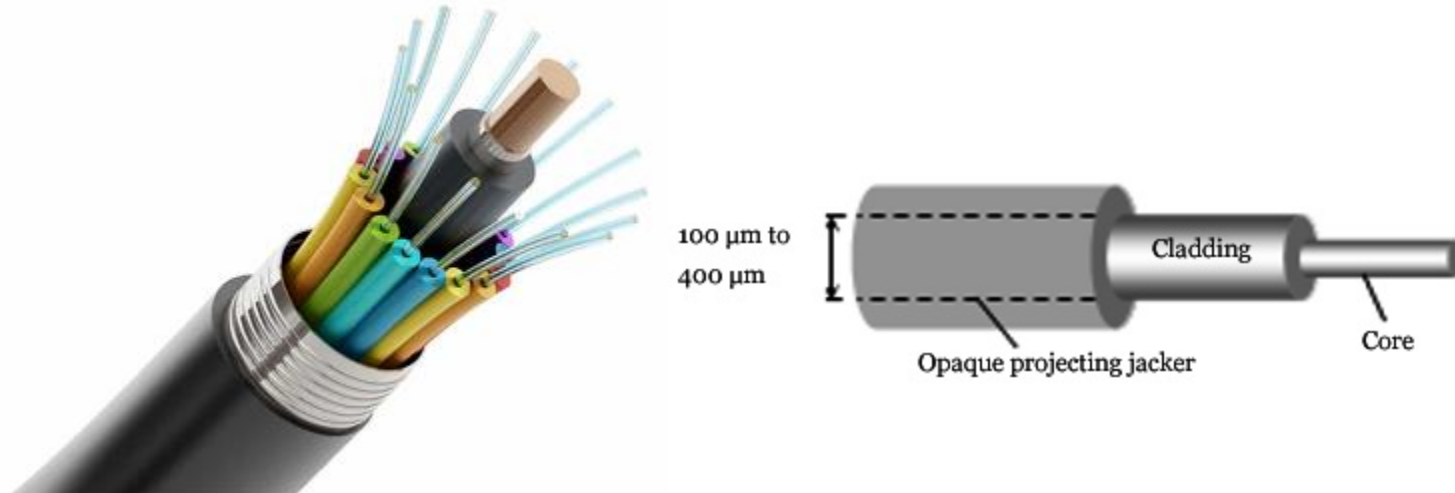
Insulation

Copper mesh

Copper wire

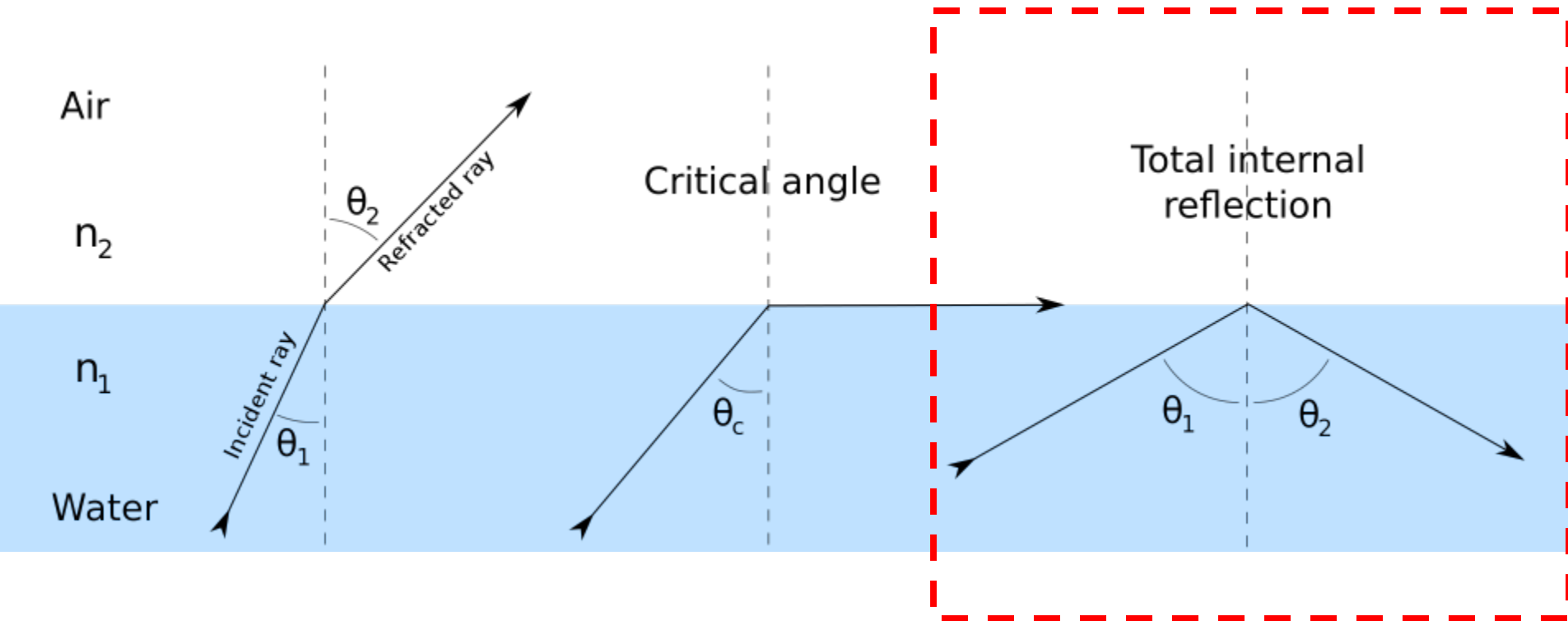# baseband & broadband coaxial cable

Two common categories
- 50-ohm cable/baseband
  - LAN
  - digital transmission
- 75-ohm cable/broadband
  - cable television systems
  - analog transmission

Fiber Optics

- optical fiber: light pulse represents a bit
- low signal attenuation up to 100 kilometers - Preferred long distance transmission media
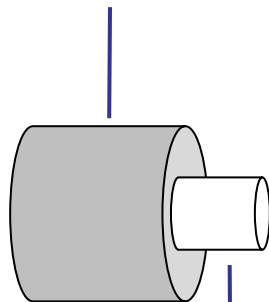- But with high cost

100 μm to 400 μm

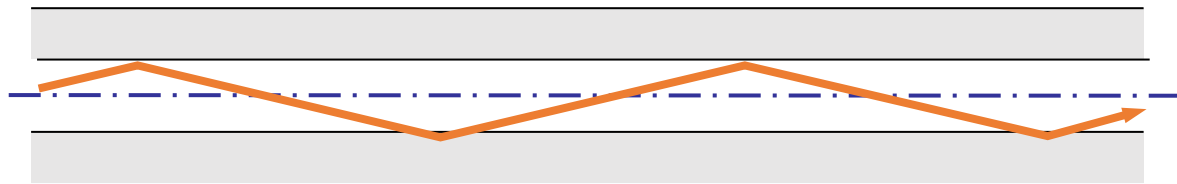Cladding

Opaque projecting jacker

Core

Working of Optical Fiber

Air

n_2

θ_2

Refracted ray

n_1

Incident ray

θ_1

Water

Critical angle

θ_c

Total internal reflection

θ_1 θ_2

Working of Optical Fiber

(cladding)

Light travel through the fiber

**Denser medium
(core)**

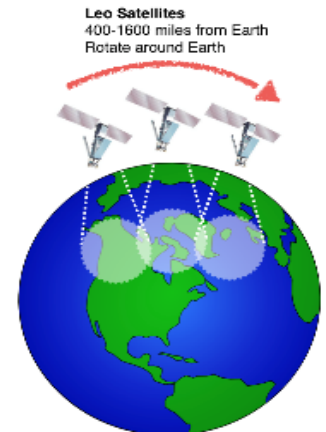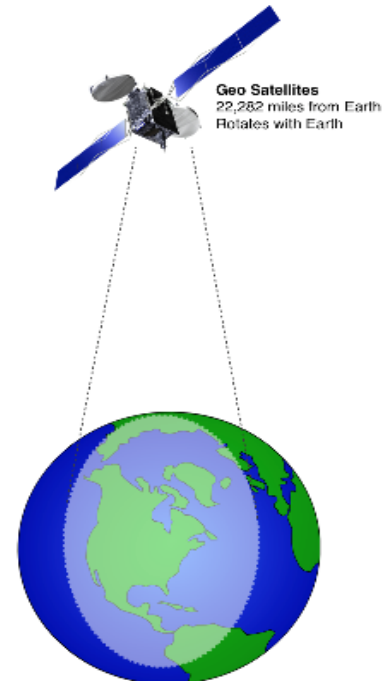**Travels by total
internal reflection**

Terrestrial Radio

- carry signal carried in electromagnetic spectrum
- no physical "wire"
- LAN (e.g., WiFi)
  - 54 Mbps
- wide-area (e.g., cellular)
  - 4G cellular: ~ 10 Mbps

Satellite Radio Channels

- **satellite**
  - Bandwidth
  - end-end delay
  - Geostationary vs
    Low altitude satellite

Geo Satellites
22,282 miles from Earth
Rotates with Earth

Leo Satellites
400-1600 miles from Earth
Rotate around Earth

Outline

Network core

- Network core/ backbone network is the mesh of routers that interconnect the Internet's end-systems
- Build via:
  - Circuit switching
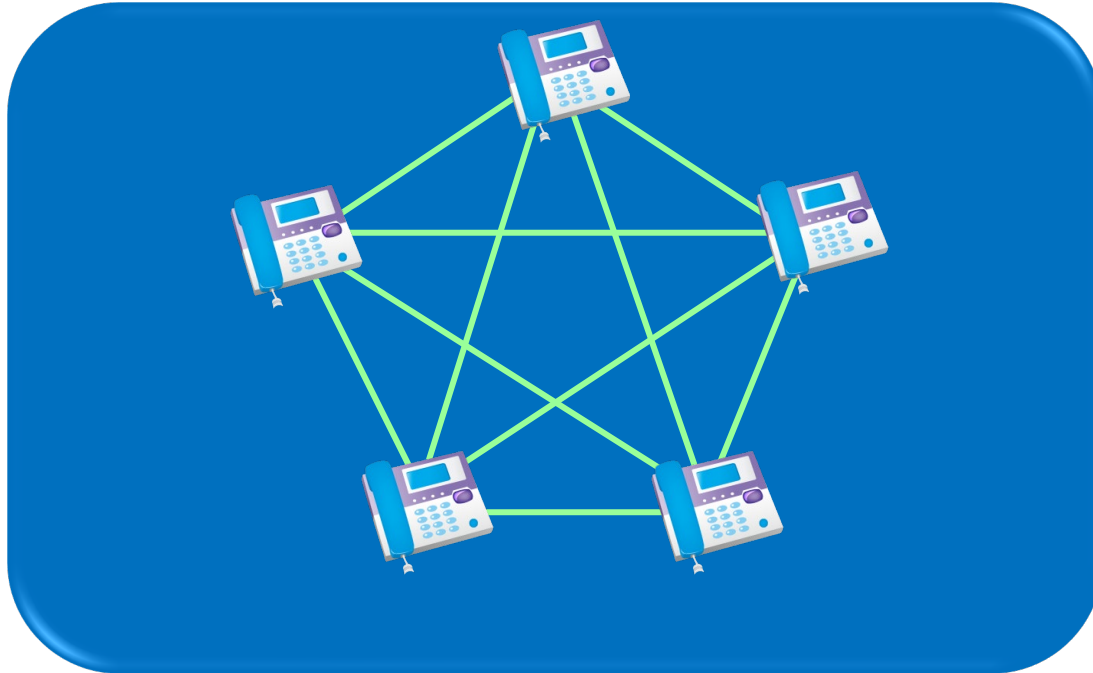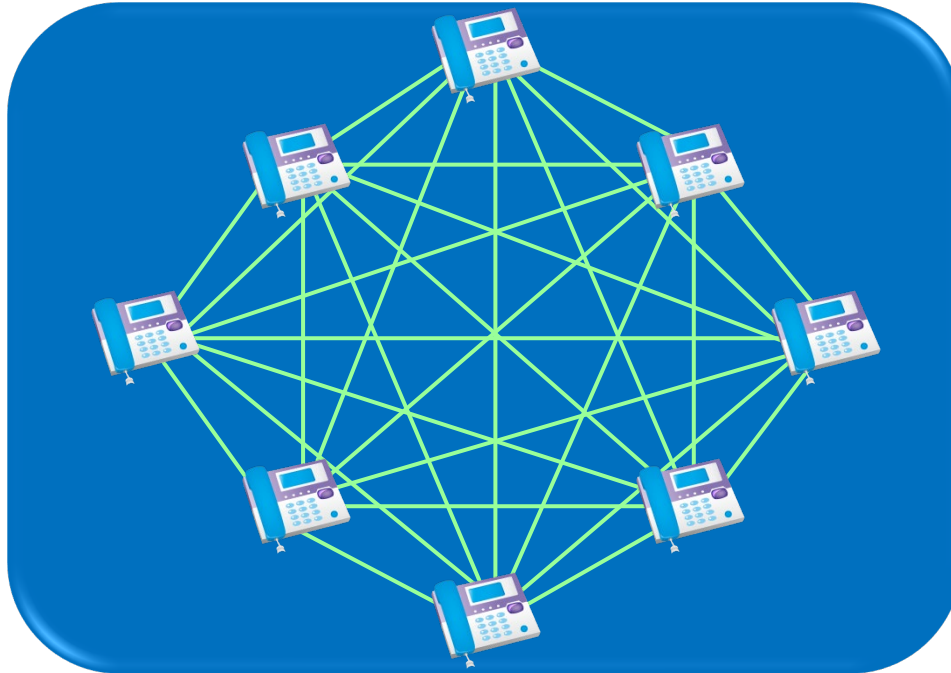 - Packet switching
  - (message switching)

mobile network

global ISP

home network

regional ISP

institutional network
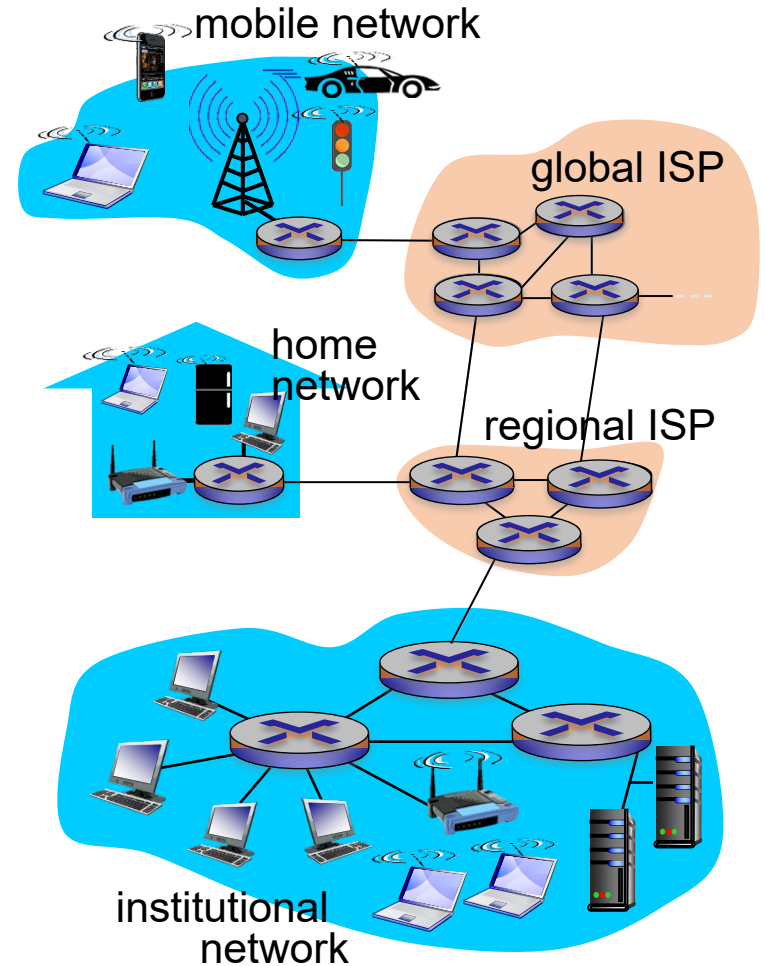
How to connect two phones?

Use a single telephone cable to connect 2 phones

How to connect 5 phones?

10 cables to connect 5 phones
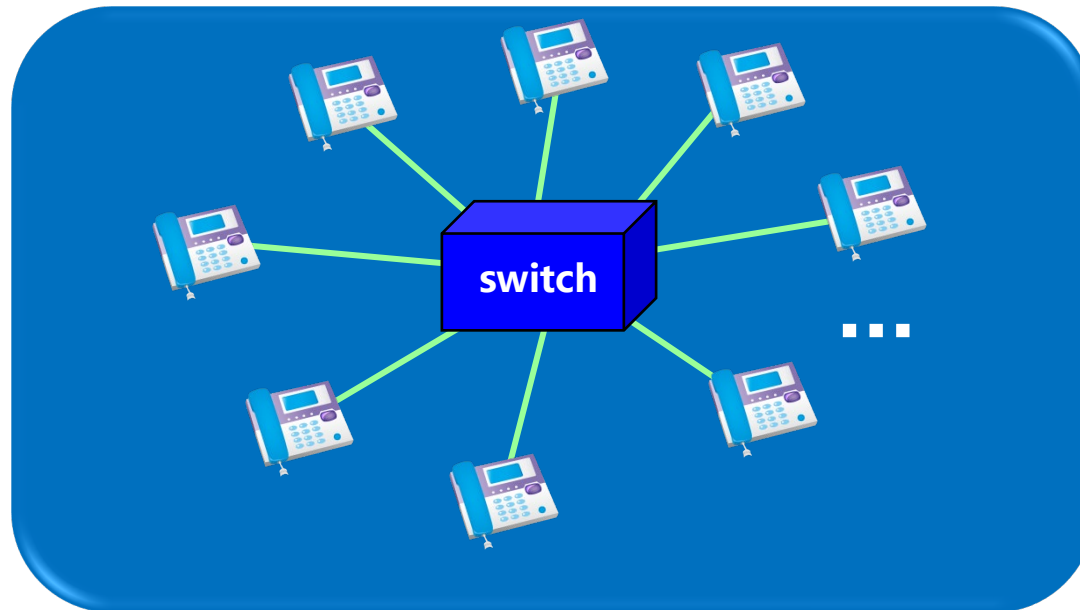
How to connect N phones?

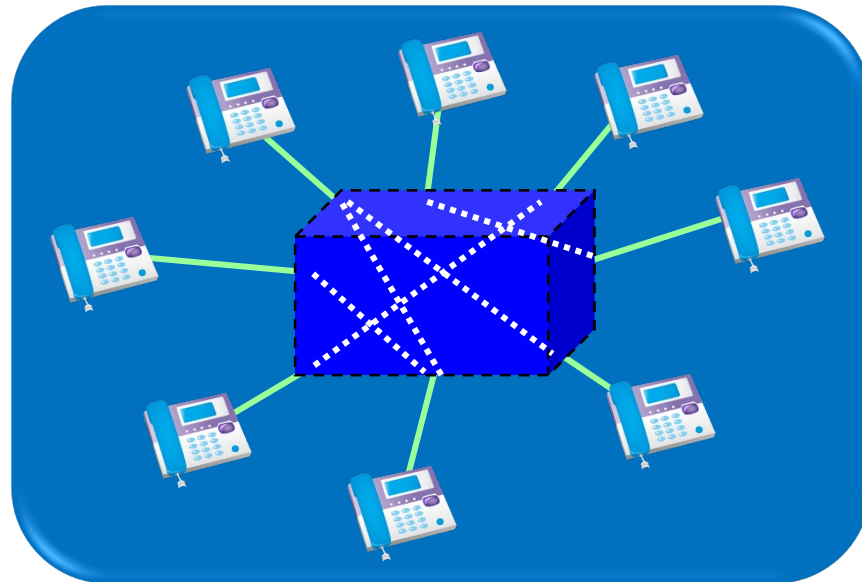*N*(*N* −1)/2 **cables to connect N phones**

A huge number!

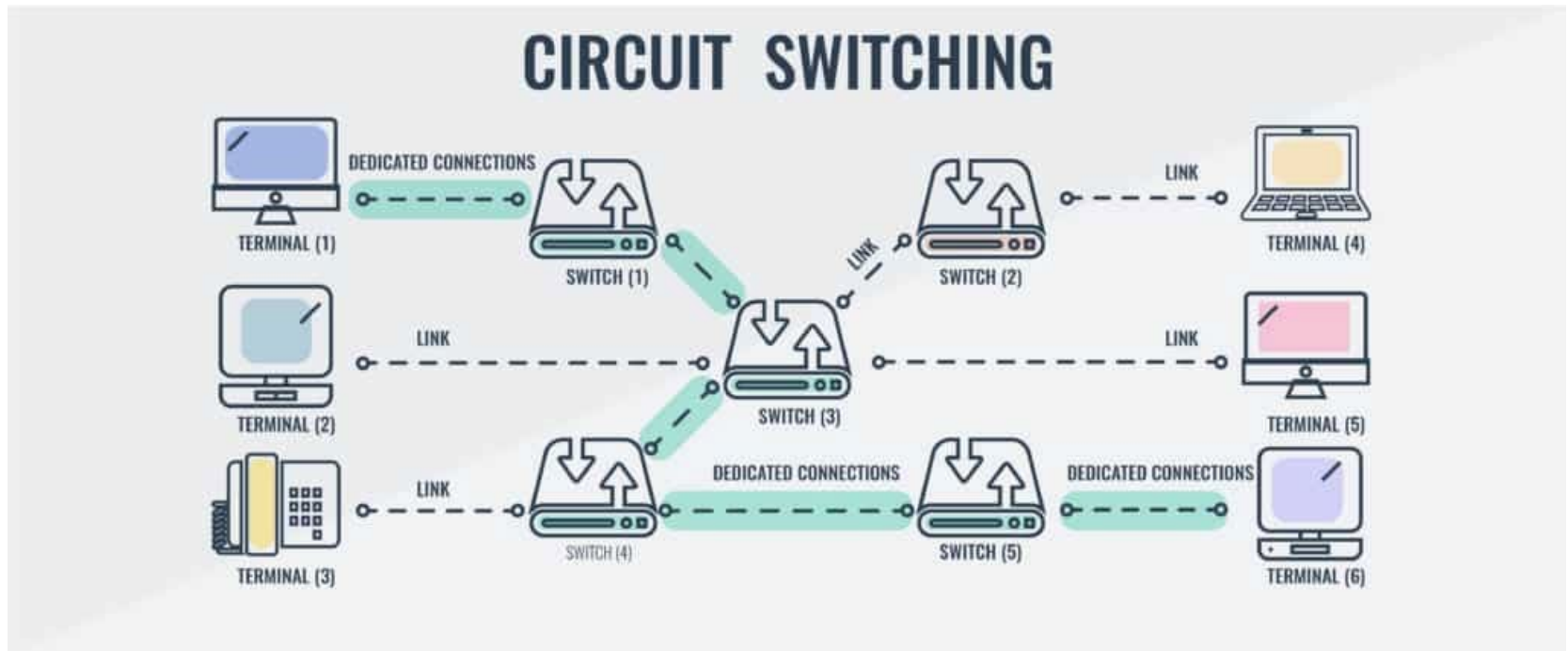# How to connect N phones efficiently?

Use a switch! – this is named as "circuit switching"

About switching

- Switching: transfer one phone line to another so that they are connected
- allocate the resources of the transmission line

Circuit switching – a quick view

□ *Circuit switching establishes a dedicated channel or circuit before users can speak to each other on a call.*

□ *A channel used in circuit switching is kept reserved at all times and is used once the two users communicate*

23

Circuit switching: connection-oriented networks

- Circuit switching is connection-oriented
- Three phases
  - ① Establish circuit from end-to-end
  - ② Transfer/communicate
  - ③ Disconnect/close circuit
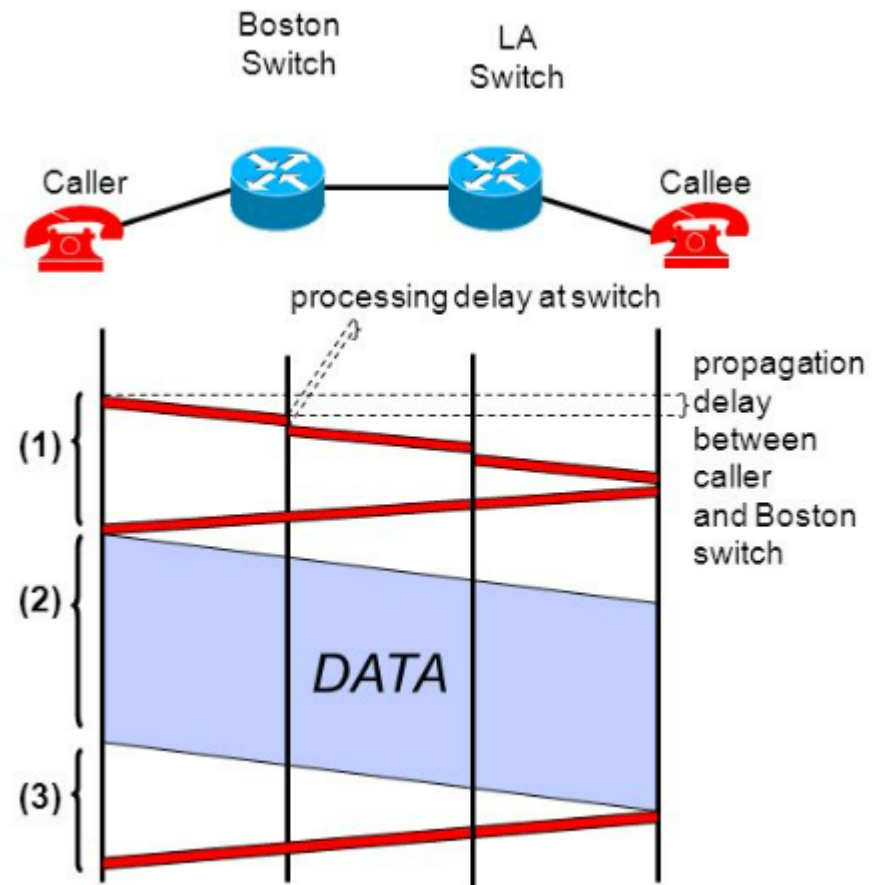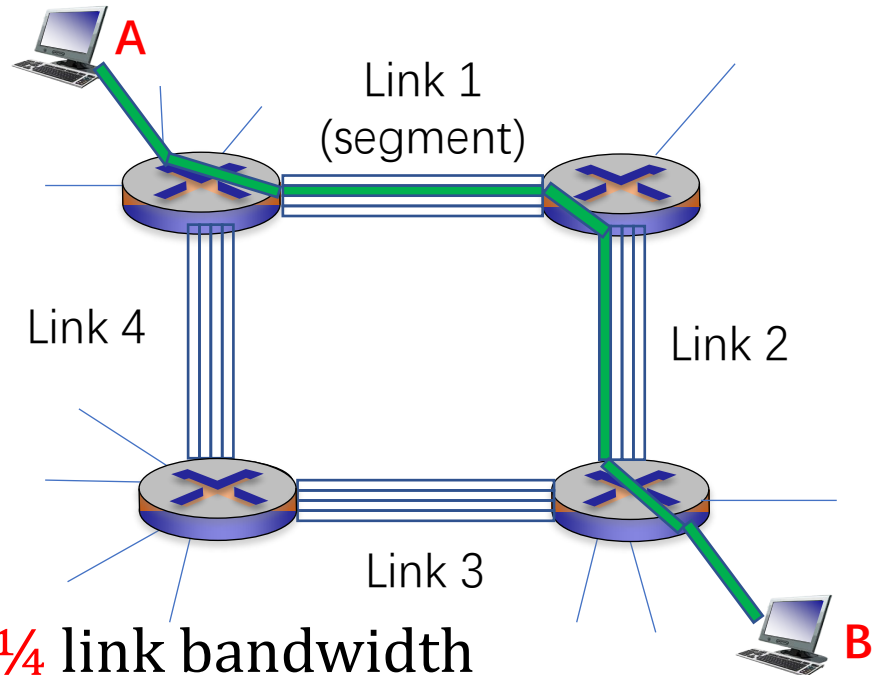
Circuit switching

- end-end resources allocated to, reserved for "call" between source & destination:

Example： each link/segment has four circuits. A wants to send to B via 2nd circuit on link-1 & 4th circuit on link-2

Link： 1Mbps = 1000 kbps
1/4Mbps = 250kbps

A

Link 1 (segment)

Link 4

Link 2

Link 3

B

☐ Each circuit get 250kbps, ¼ link bandwidth
☐ circuit segment wasted if not used by call (no sharing)

How to create multiple circuits on a link?

- Multiplexing: a method combines multiple analog or digital signals into one signal over a shared medium.

(a) Without multiplexing

(b) With multiplexing

Circuit switching: FDM

Example: 4 users ▪▪▪▪

frequency

time
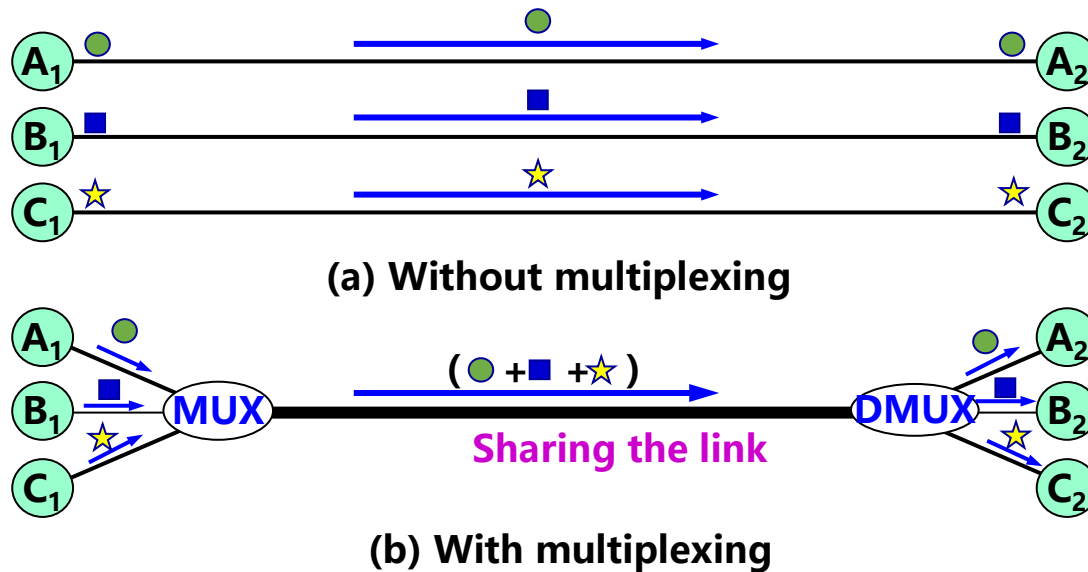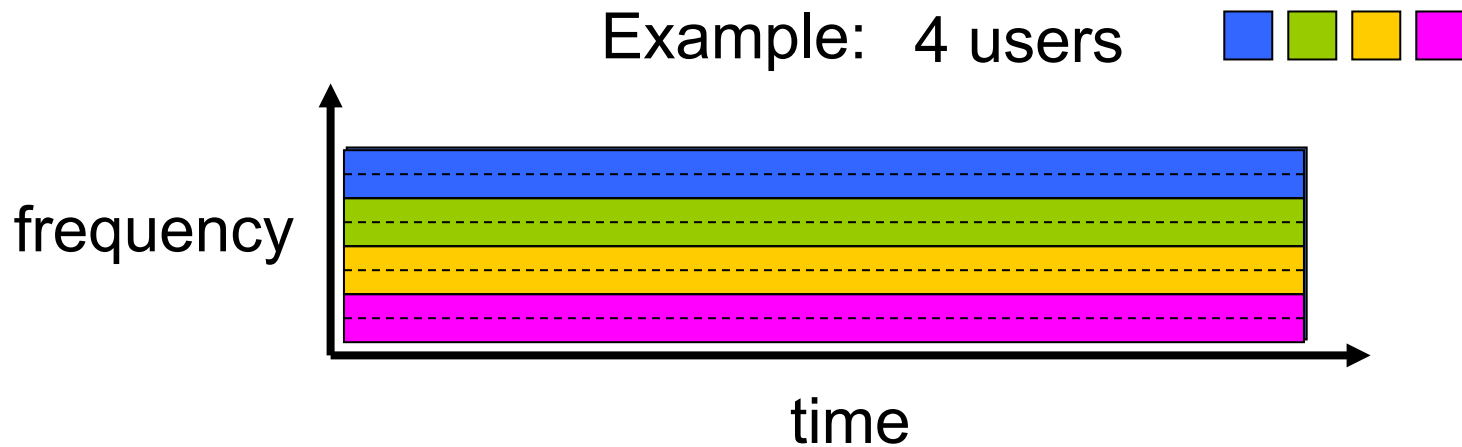
- Frequency Division multiplexing
- The frequency is divided into multi-bands
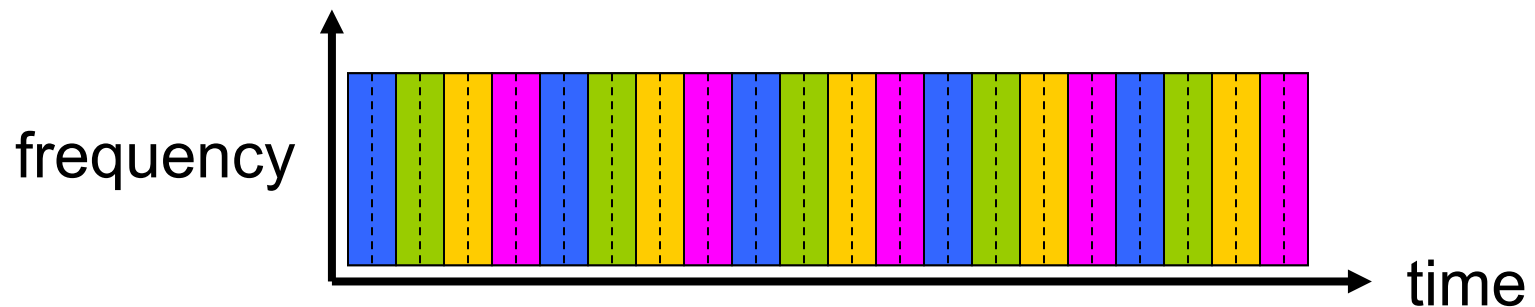- Each user carry one frequency band

Applications of FDM

- Television broadcasting
- FM and AM radio broadcasting
- First generation cellular phones
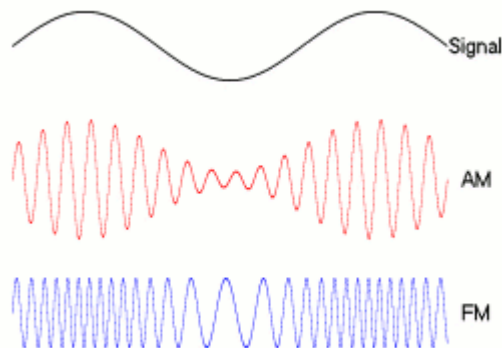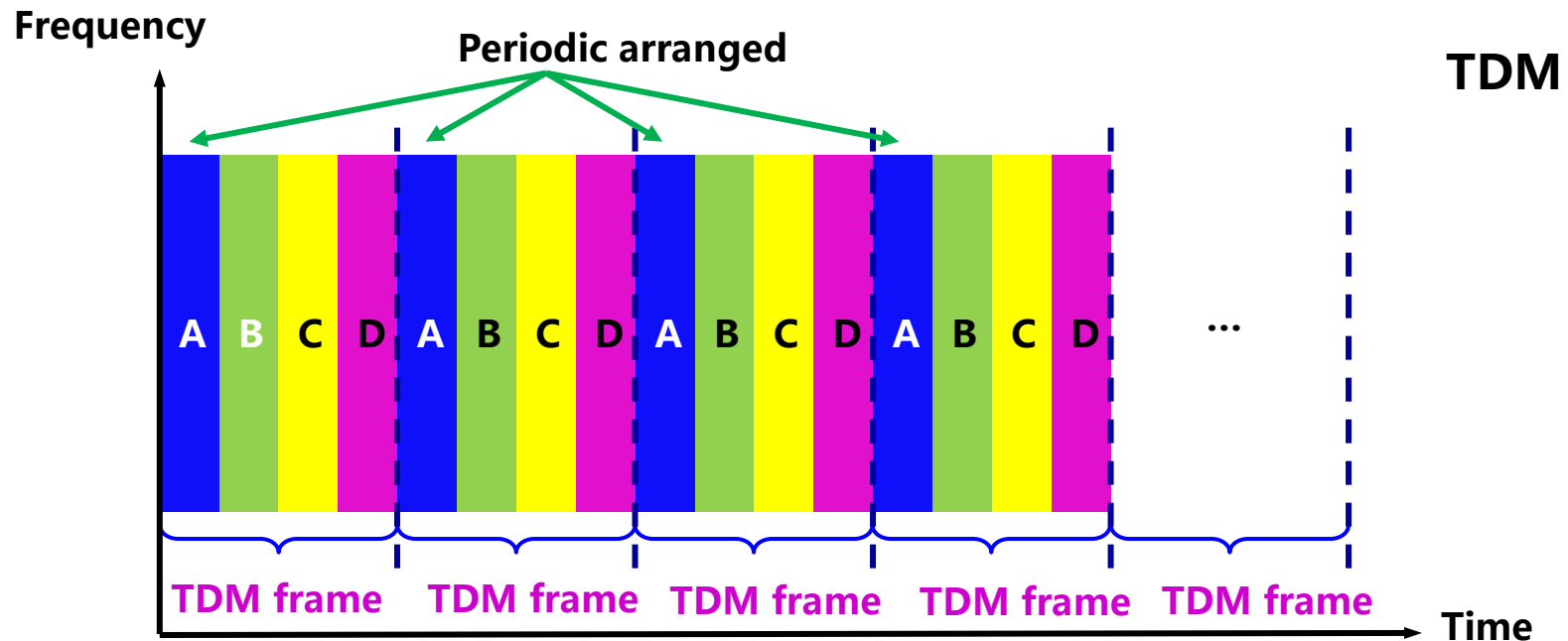
Circuit switching: TDM

Example: 4 users

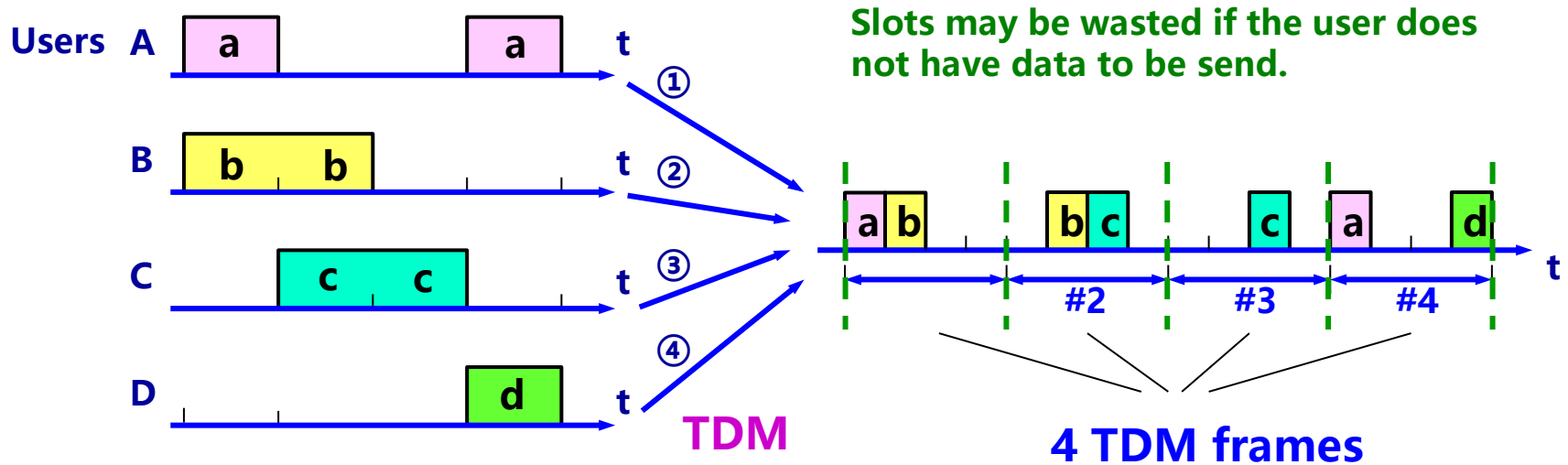All same-color slots are allocated to a specific sender-receiver pair/user

- Time Division Multiplexing
- The time is divided into multiple frames.
- Each frame is divided into multiple time slots

TDM frame

- The slots are allocated in a fixed order to the different incoming channels.
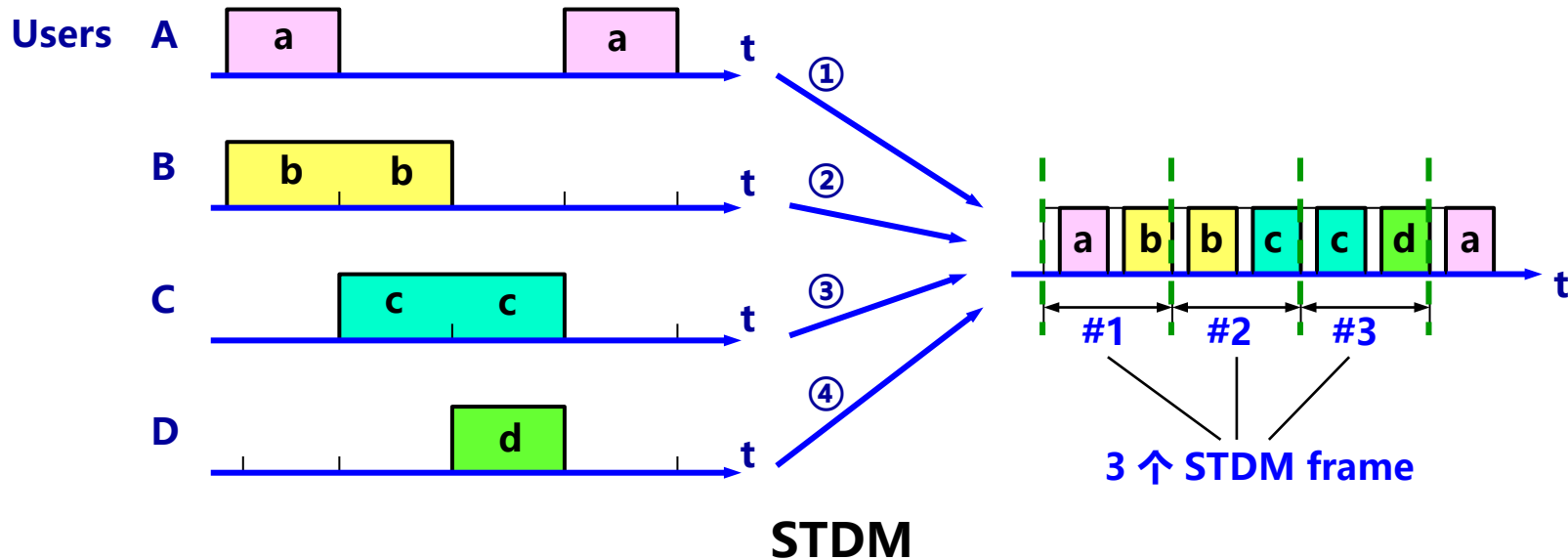
Problems with TDM

bandwidth wastage in case of e.g.,
- slot reservation for station without any data to transmit
- uneven distribution of traffic

Statistical TDM: An improvement from TDM

STDM

- Designed to make use of the free time slots
- Time slots used as needed
- But more complex to implement

TAKEAWAYS

- **Physical Media**
  - Guided media
  - Unguided media

- **Circuit Switching**
  - Basic principles
  - Multiplexing