澳 門 理 工 大 學
Universidade Politécnica de Macau
Macao Polytechnic University

Faculty of Applied Sciences
B.Sc. in Computing

Academic Year 2022/2023 2nd Semester

COMP123 – 121/122

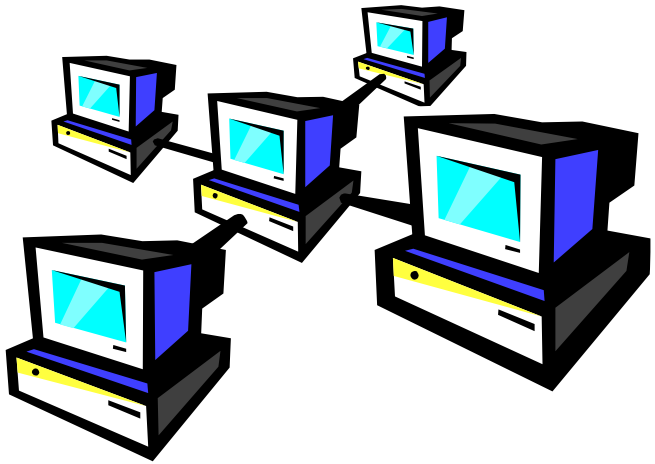
Data Communications

Data Transport Networks

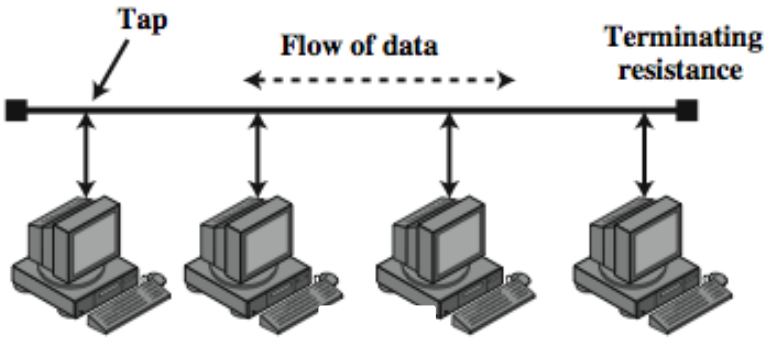
(LAN Technologies)

Local Area Networks (LANs)

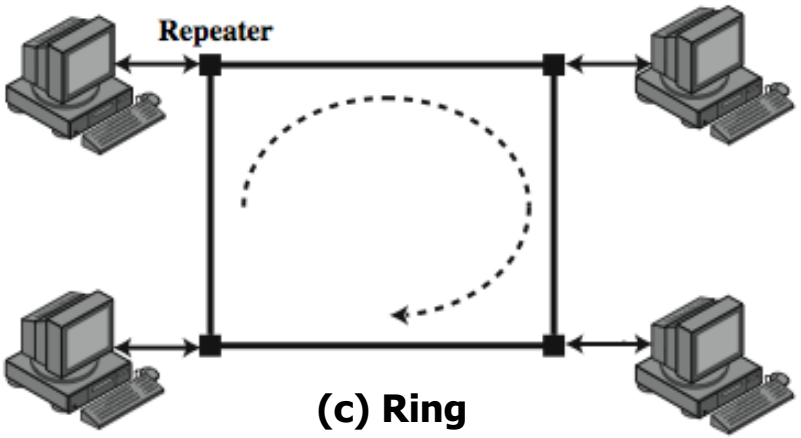
- usually owned by the organization that is using the network to interconnect equipment
- key elements:
  - topology
  - transmission medium
  - wiring layout
  - medium access control



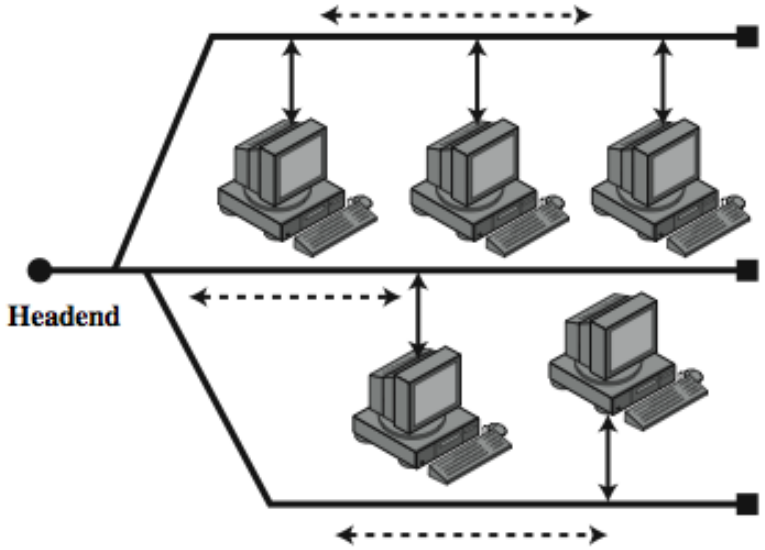
LAN Topologies



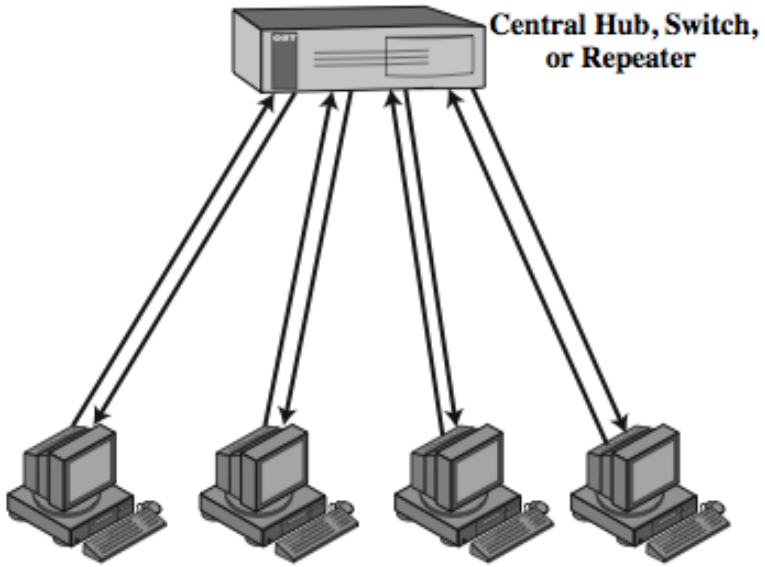
(a) Bus



(c) Ring



(b) Tree



(d) Star-wired Bus (or Star)

Bus and Tree

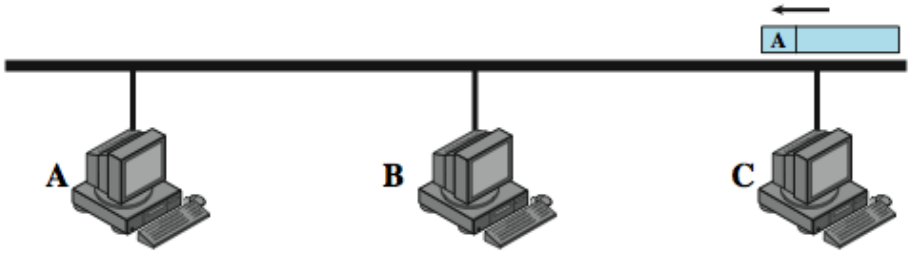
Bus:

- stations attach through tap to bus
- full duplex allows transmission and reception
- transmission propagates throughout medium
- heard by all stations
- terminator at each end

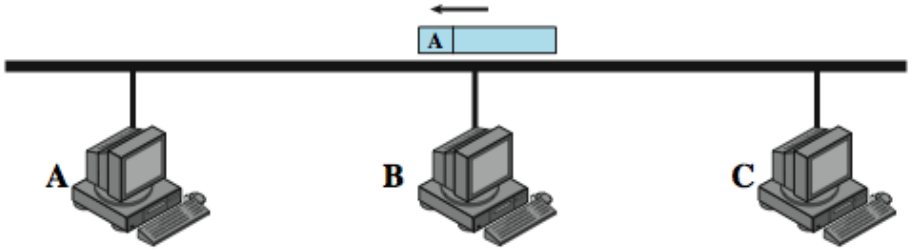
Tree:

- a generalization of bus
- branching cable with no closed loops
- tree layout begins at headend and branches out
- heard by all stations

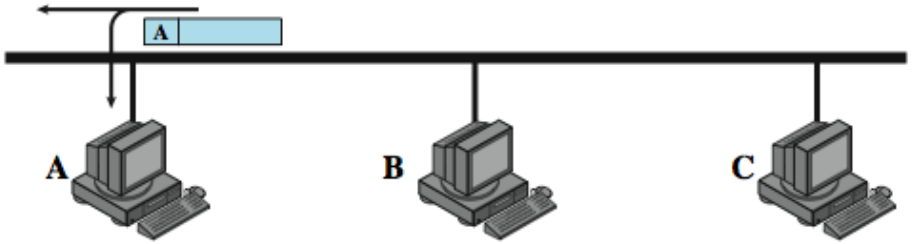
Frame Transmission on Bus LAN



C transmits frame addressed to A



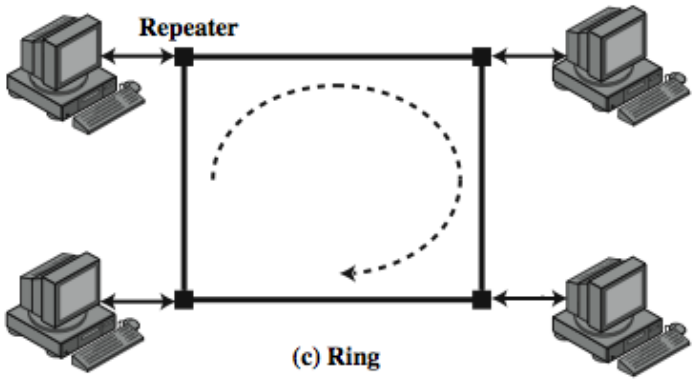
Frame is not addressed to B; B ignores it



A copies frame as it goes by

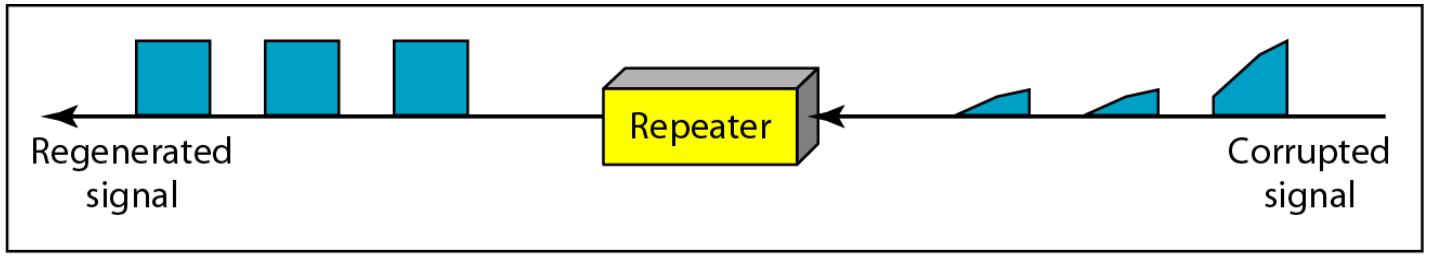
Ring Topology

- a closed loop of repeaters joined by point-to-point links
- receive data on one link & retransmit on another
  - links unidirectional
  - stations attach to repeaters
- data transmitted in frames
  - circulate past all stations
  - destination recognizes address and copies frame
  - frame circulates back to source where it is removed
- medium access control (MAC) determines when a station can insert frame

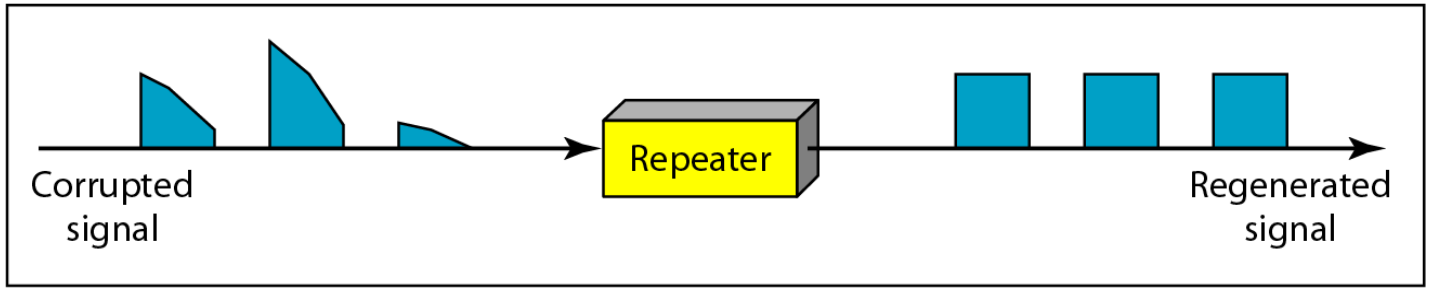


Repeaters (1/2)

- A simple and cheap layer 1 device that regenerate the signal and forward the incoming frame
- It is not an amplifier



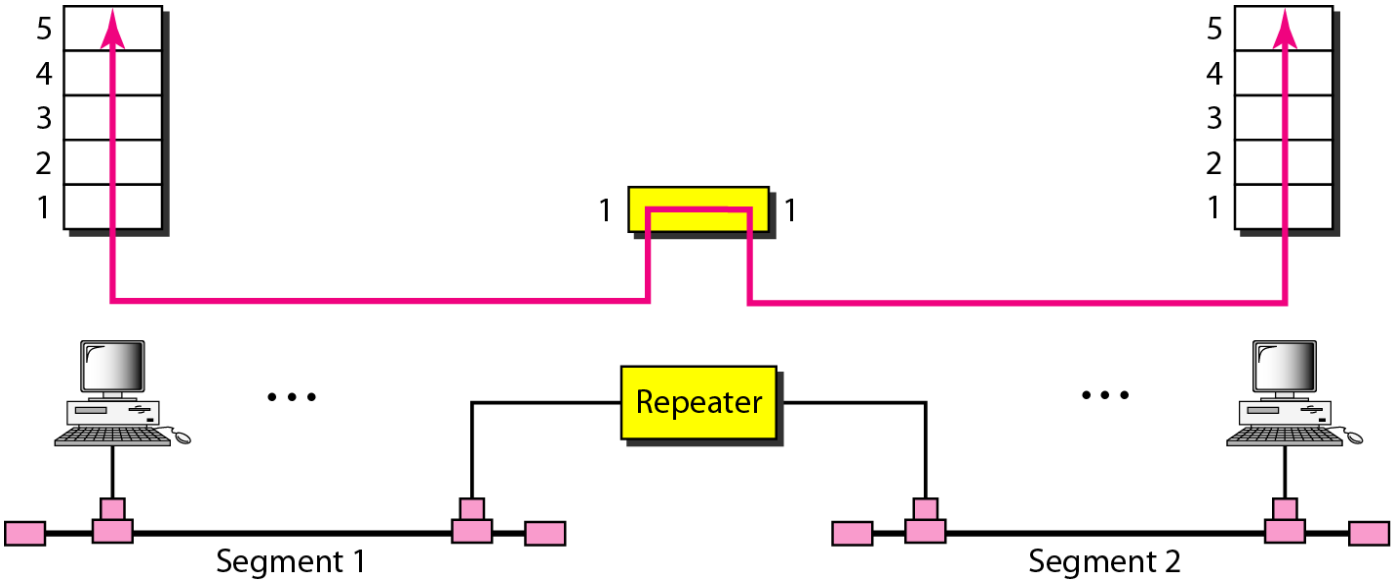
a. Right-to-left transmission.



b. Left-to-right transmission.

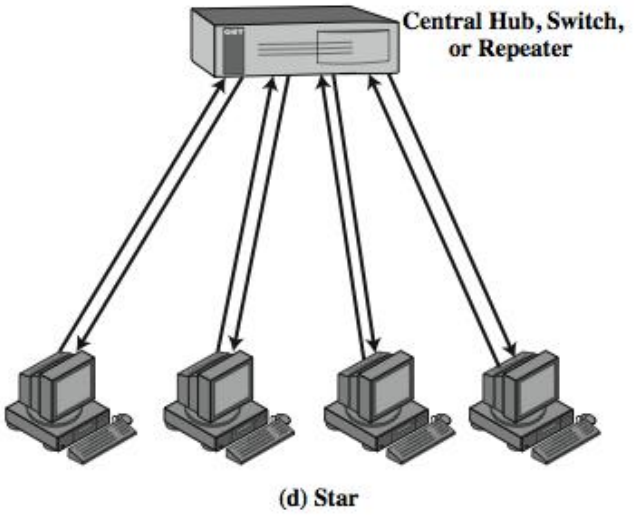
Repeaters (2/2)

- A repeater connects segments of a LAN
- A *dummy* device that has no filtering capacity (processing)



Star Topology

- each station connects to common central node
  - usually via two point-to-point link
    - one for transmission and one for reception



(d) Star

central node

- operate in broadcast fashion
- physical star, logical bus
- only one station can transmit at a time (hub)
- can act as frame switch

Ring and Star Topologies

Ring

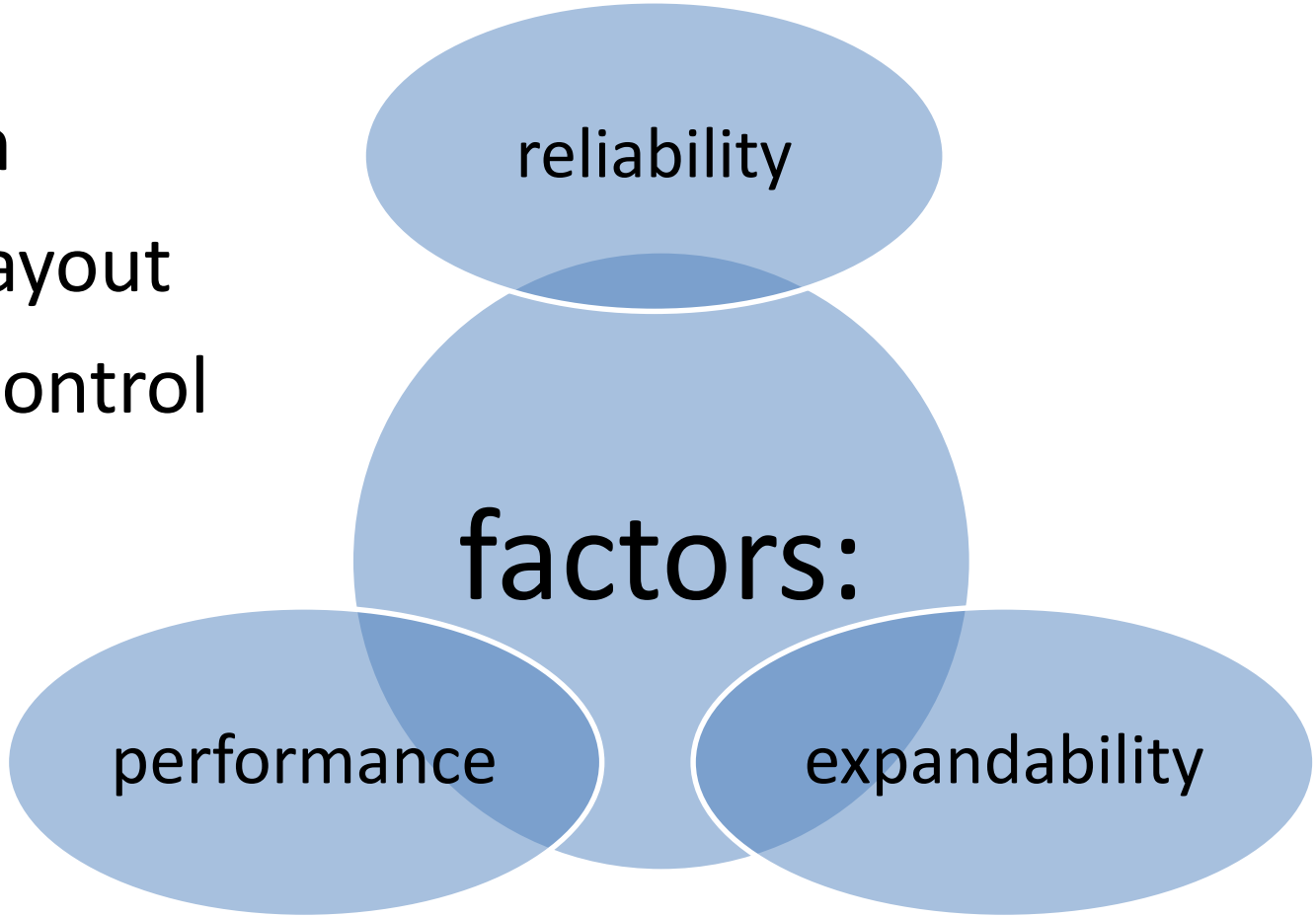
- very high speed links over long distances
- potential of providing best throughput
- single link or repeater failure disables network

Star

- uses natural layout of wiring in building
- best for short distances
- high data rates for small number of devices

Choice of Topology

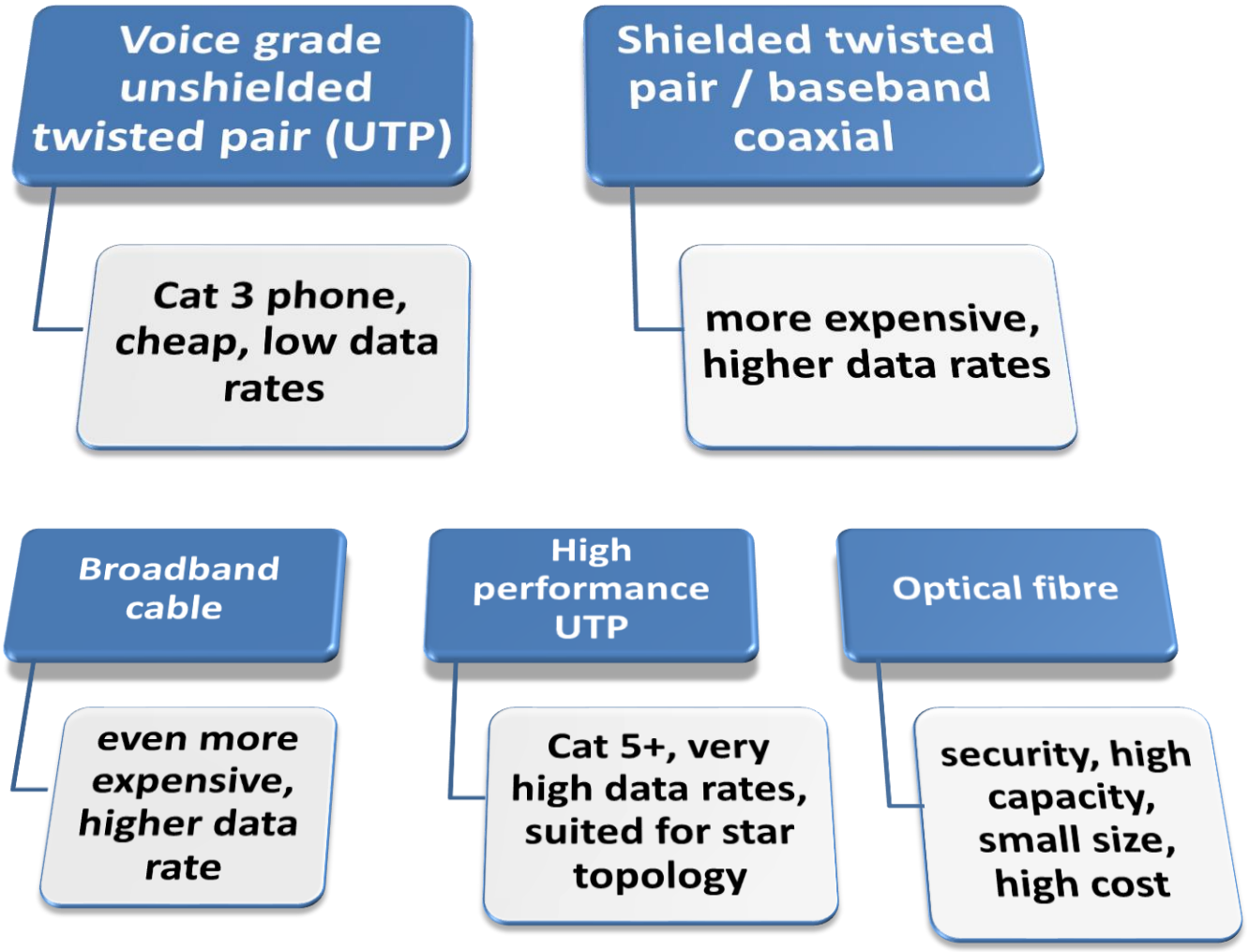
- medium
- wiring layout
- access control



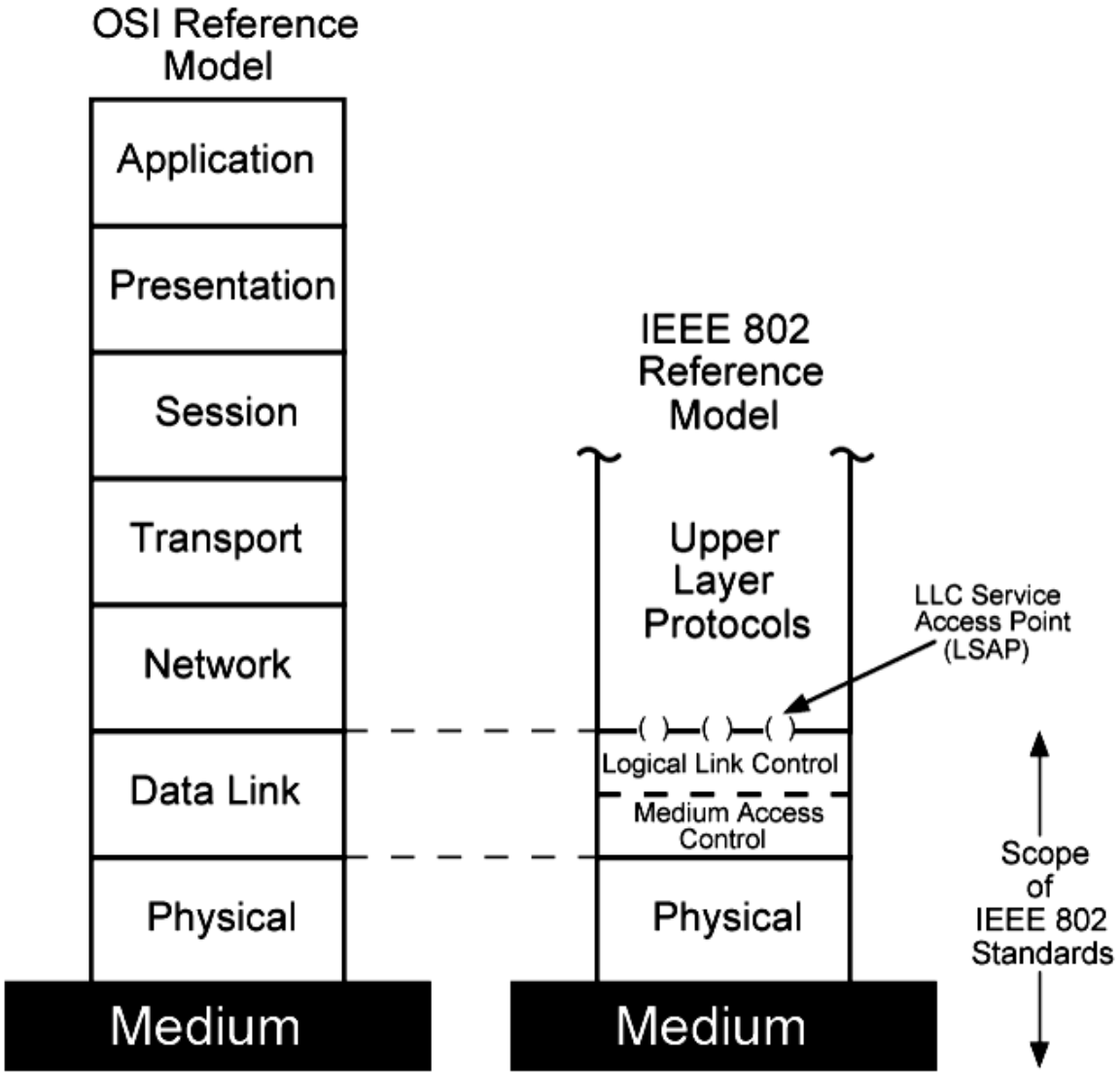
Choice of Medium

- constrained by LAN topology
- capacity
  - to support the expected network traffic
- reliability
  - to meet requirements for availability
- types of data supported
  - tailored to the application
- environmental scope
  - provide service over the range of environments

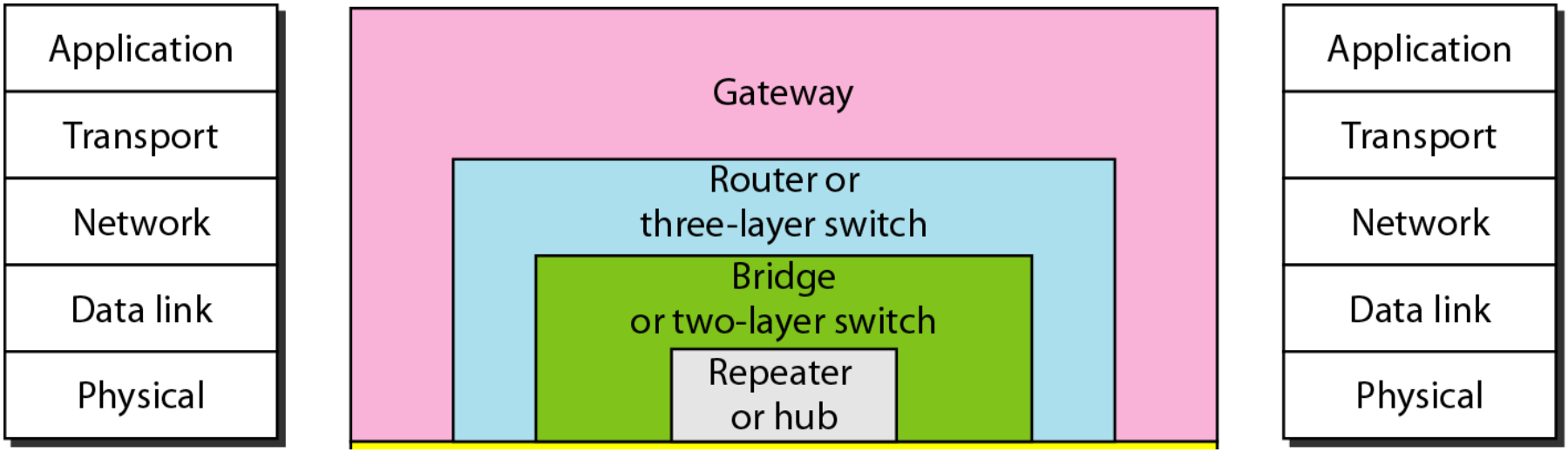
Media Available



LAN Protocol Architecture

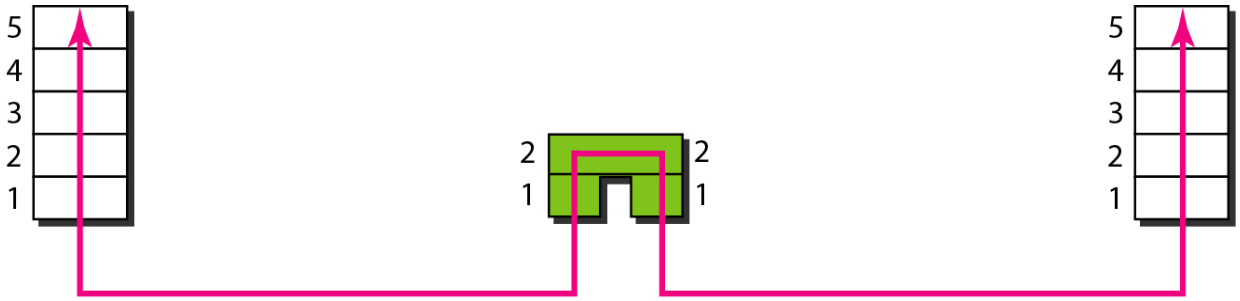


Categories of Internetworking Devices



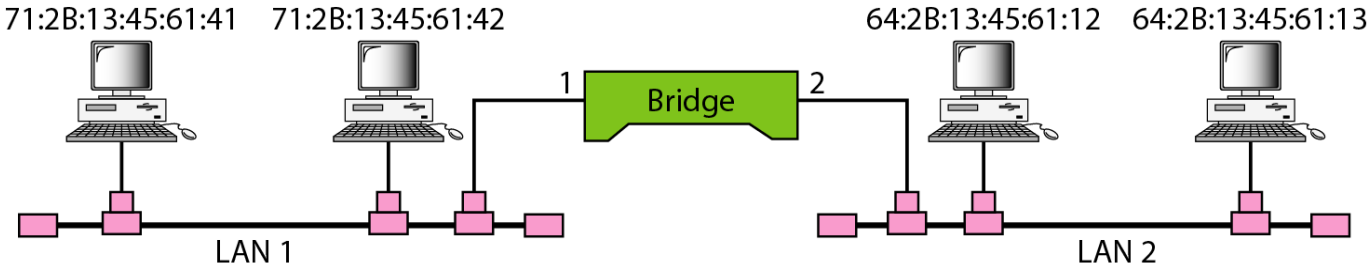
Bridges (1/2)

- A layer 2 device that connects similar LANs with identical physical and link layer protocols



Address	Port
71:2B:13:45:61:41	1
71:2B:13:45:61:42	1
64:2B:13:45:61:12	2
64:2B:13:45:61:13	2

Bridge Table



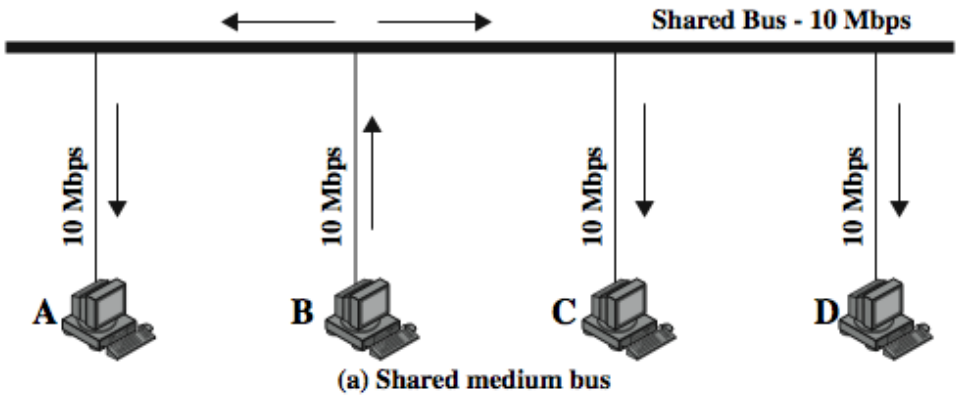
Bridges (2/2)

- minimal processing (uses similar protocol)
- can map between MAC formats
- reasons for use:
  - reliability
  - Performance
  - security
  - geography

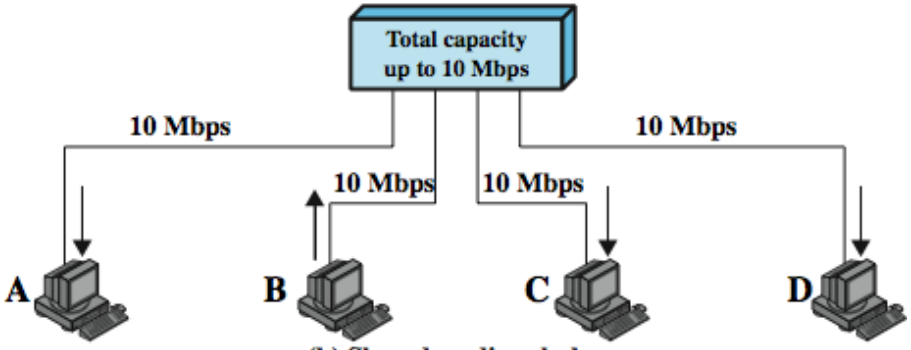
Hubs

- active central element of star layout
- each station connected to hub by two UTP lines
- hub acts as a repeater
- limited to about 100m by UTP properties
- optical fiber may be used out to 500m
- physically star, logically bus
- transmission from a station seen by all others
- if two stations transmit at the same time have a collision

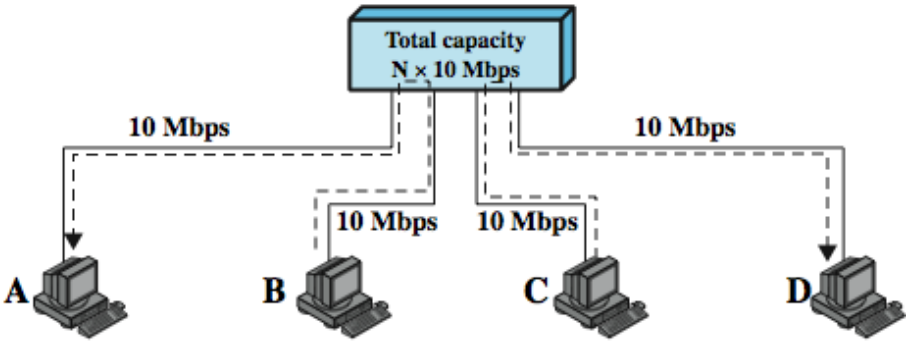
LAN Hubs vs Switches



(a) Shared medium bus



(b) Shared medium hub



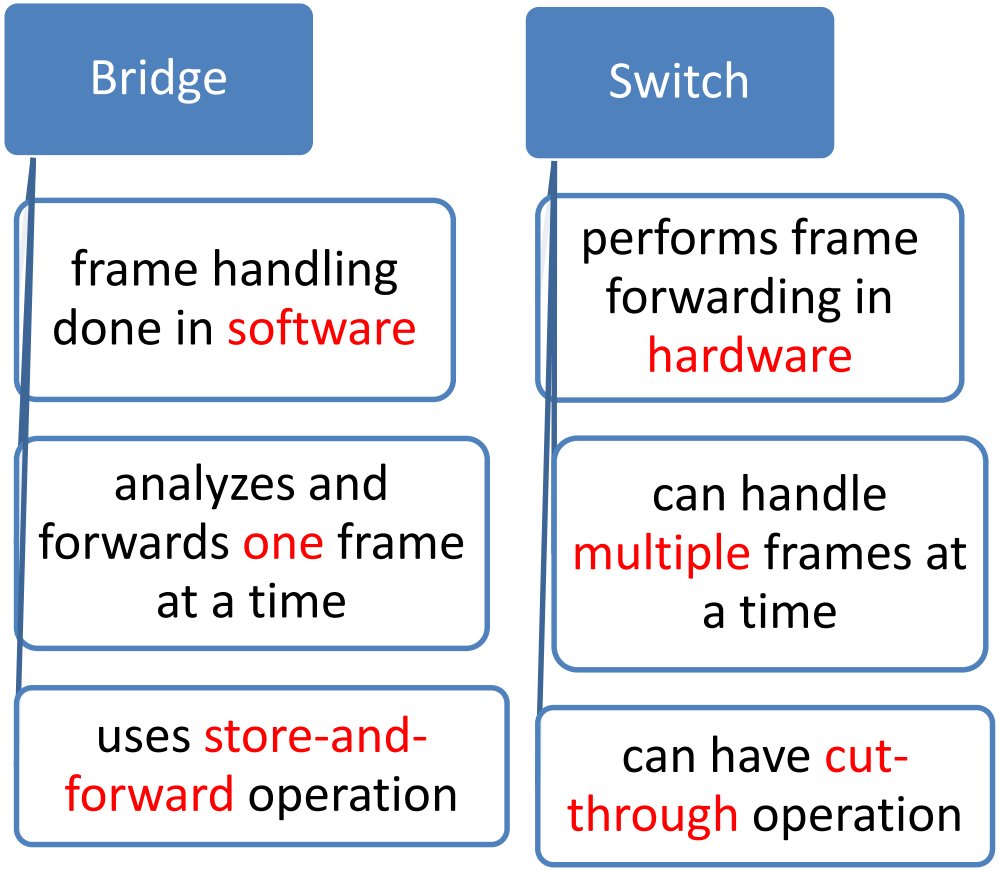
(c) Layer 2 switch

Layer 2 Switch Benefits

- no change to attached devices to convert bus LAN or hub LAN to switched LAN
  - e.g. Ethernet LANs use Ethernet MAC protocol
- have dedicated capacity equal to original LAN
  - assuming switch has sufficient capacity to keep up with all devices
- scales easily
  - additional devices attached to switch by increasing capacity of layer 2

Layer 2 Switch vs. Bridge

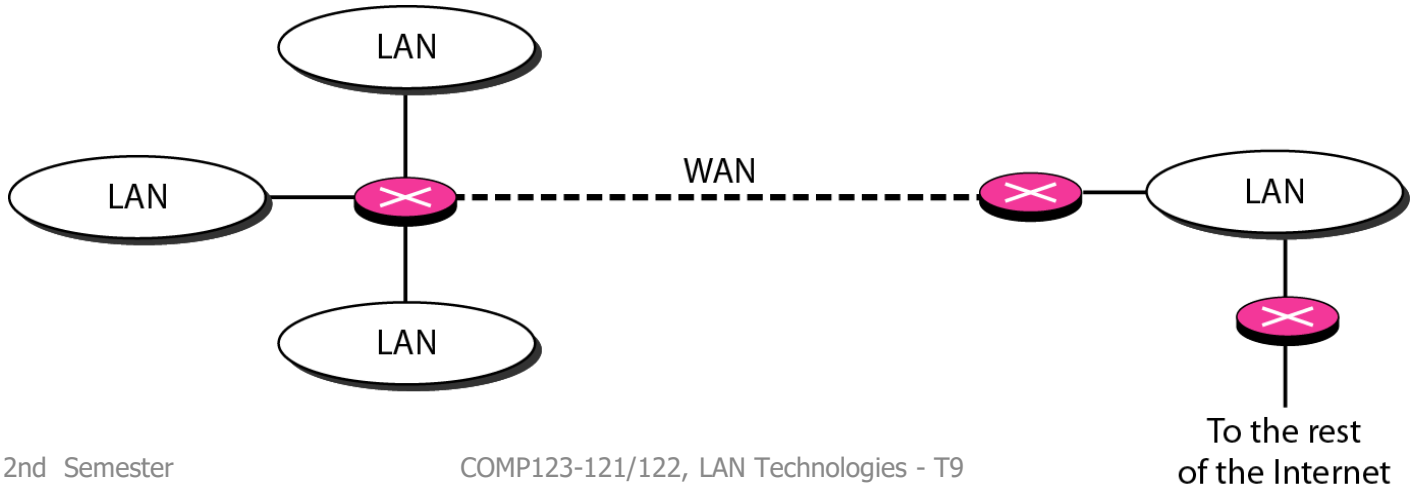
- differences between switches & bridges:



- layer 2 switch can be viewed as full-duplex hub
- incorporates logic to function as multiport bridge
- new installations typically include layer 2 switches with bridge functionality rather than bridges

Routers

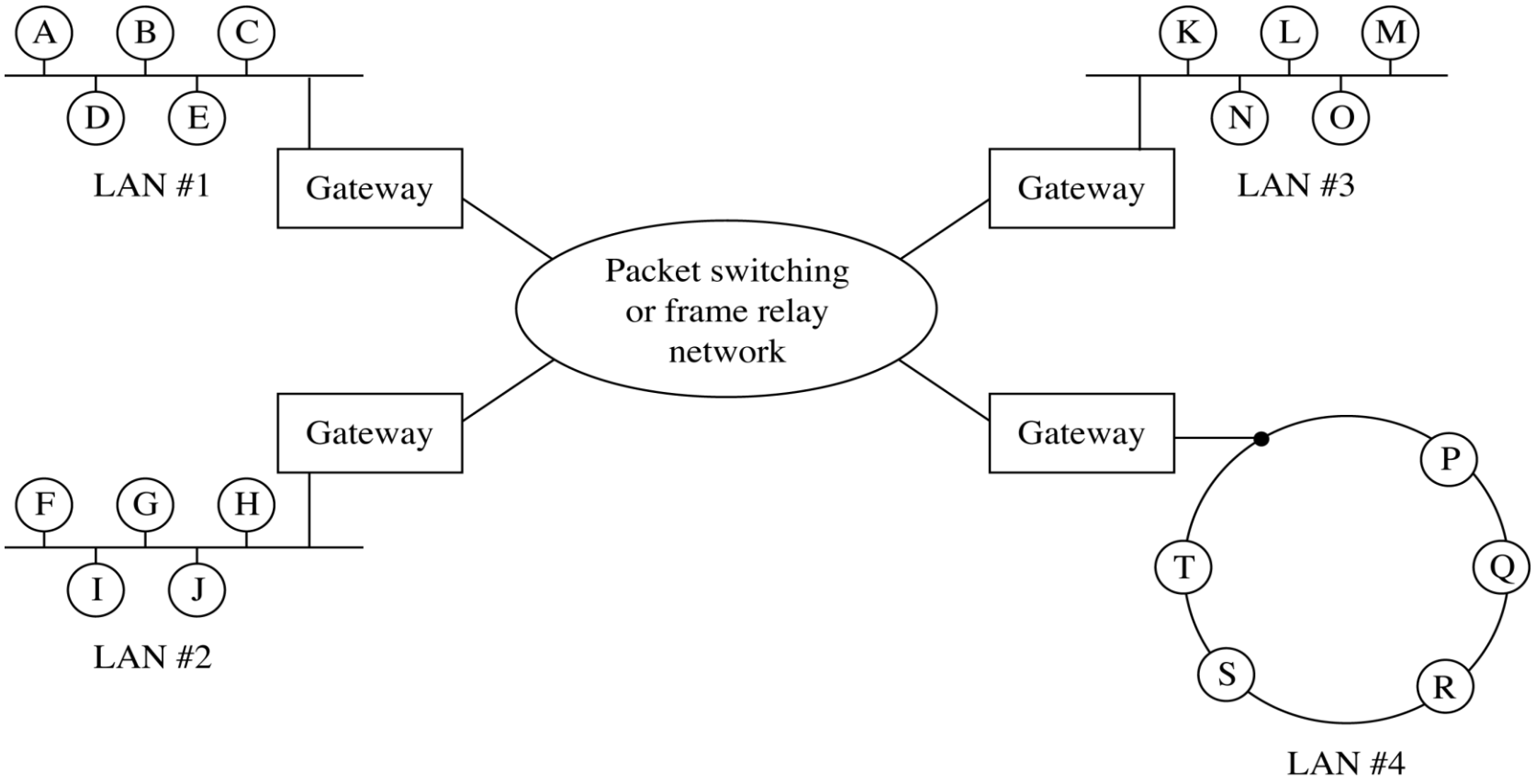
- A faster and more sophisticated three-layer switch that forwards and routes packets based on logical address, e.g. IP address
- Usually support different protocols, e.g. network layer
- Routers can ***select the shortest path***, and if one path has problems, it will use another path.



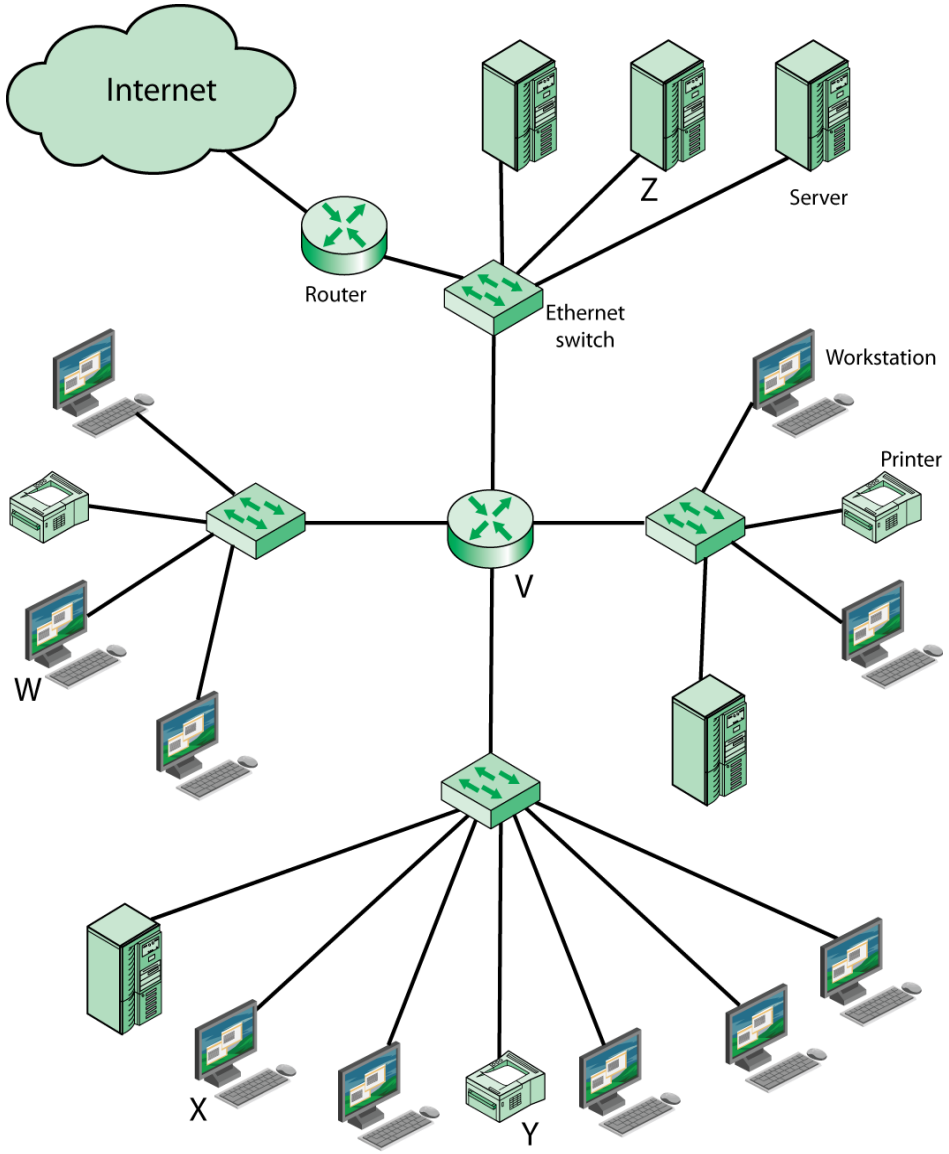
Gateway

- *Operate at the OSI layers higher than layer 3*
- Perform the function of a *protocol converter*.
- Two separate networks, each using totally different communications method, can be connected using a gateway.
- Gateway is used for specific network interconnection. No general gateways.
- It is the most complicated equipment, and very expensive.

Internetworking with Gateways



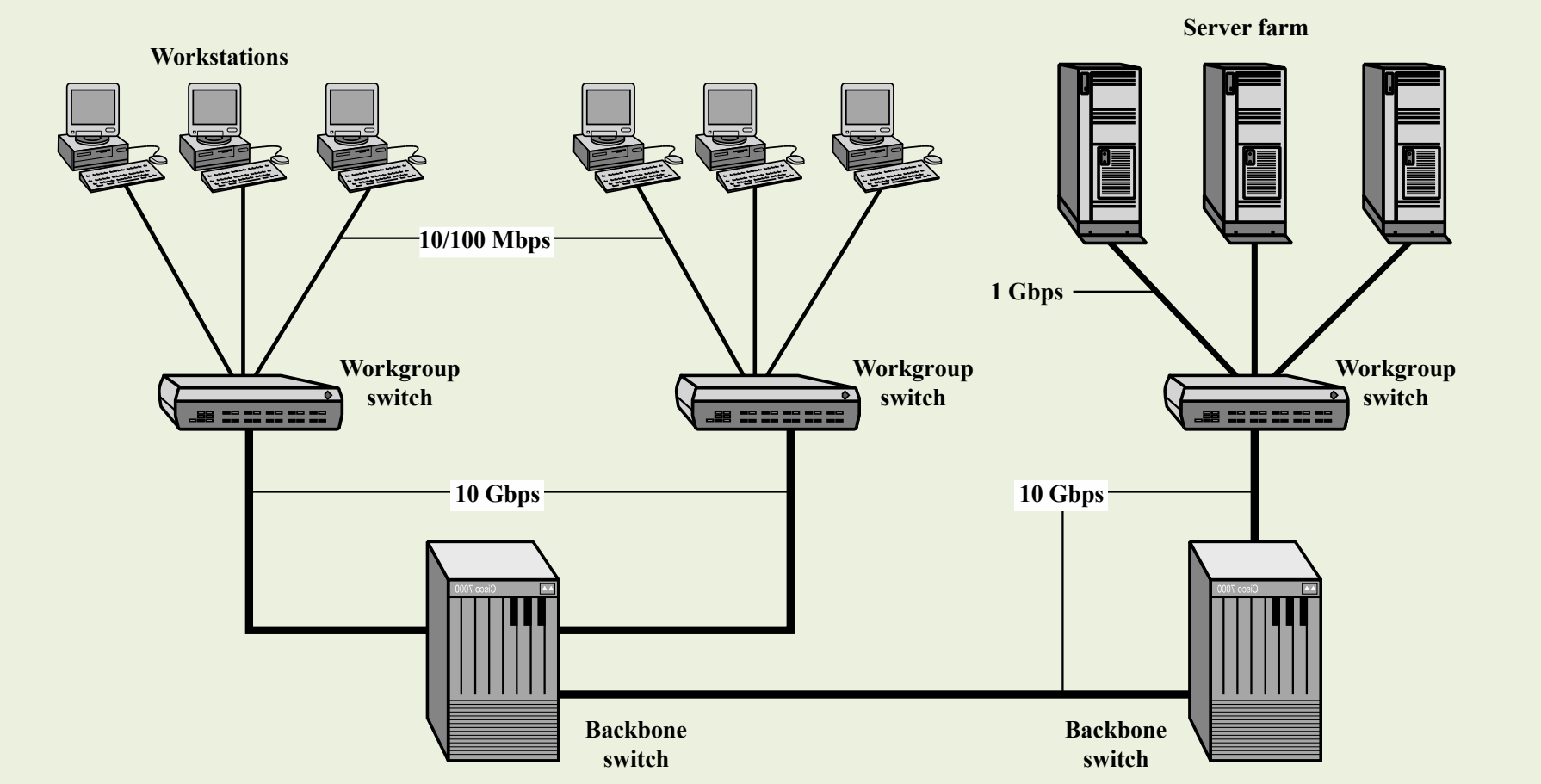
A Partitioned LAN Configuration



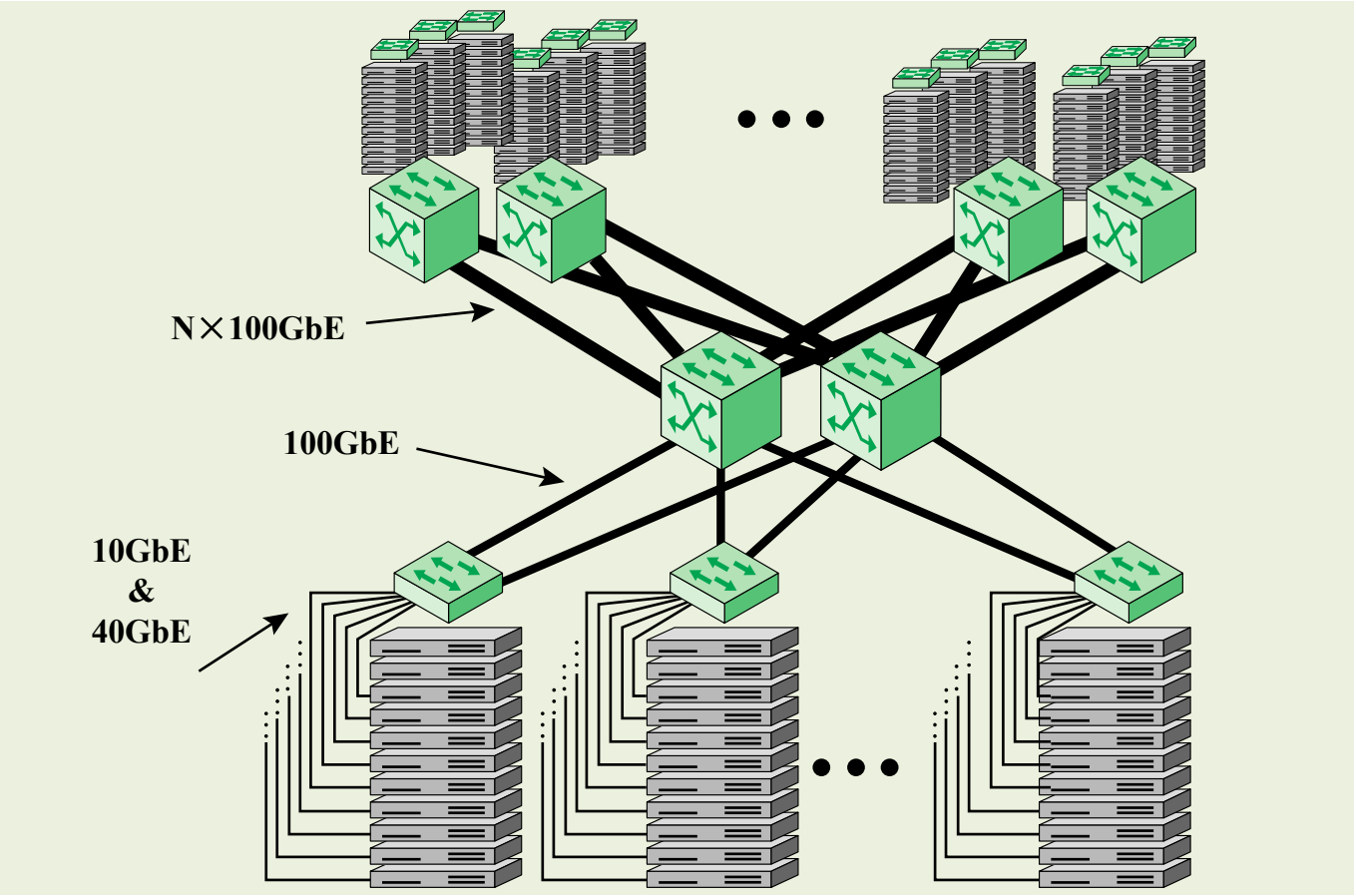
Characteristics of Some High-Speed LANs

	Fast Ethernet	Gigabit Ethernet	Fibre Channel	Wireless LAN
Data Rate	100 Mbps	1 Gbps, 10 Gbps, 100 Gbps	100 Mbps - 3.2 Gbps	1 Mbps - 54 Mbps
Transmission Media	UTP, STP, optical fiber	UTP, shielded cable, optical fiber	Optical fiber, coaxial cable, STP	2.4-GHz, 5-GHz microwave
Access Method	CSMA/CD	Switched	Switched	CSMA/Polling
Supporting Standard	IEEE 802.3	IEEE 802.3	Fibre Channel Association	IEEE 802.11

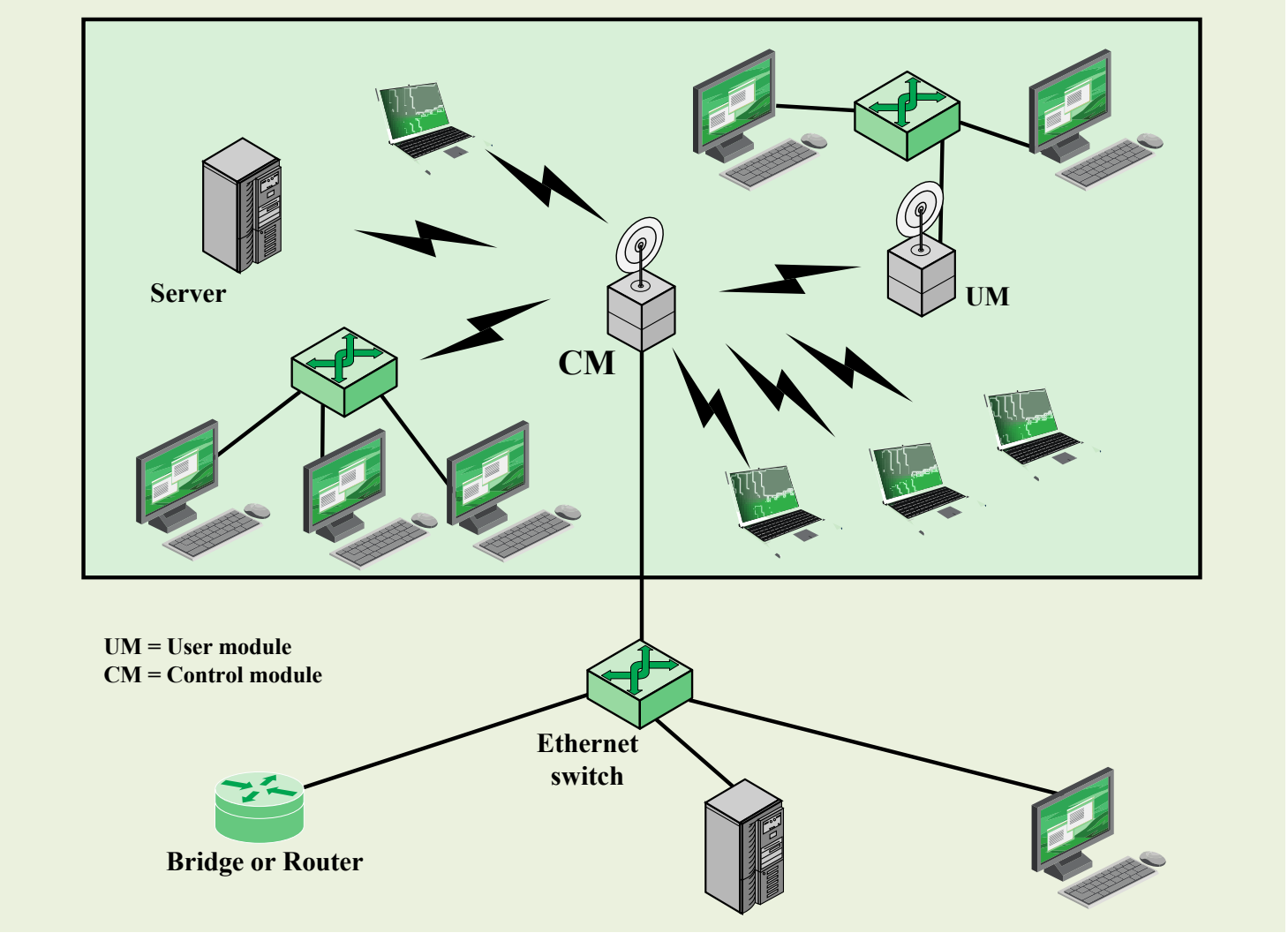
Gigabit Ethernet Configuration



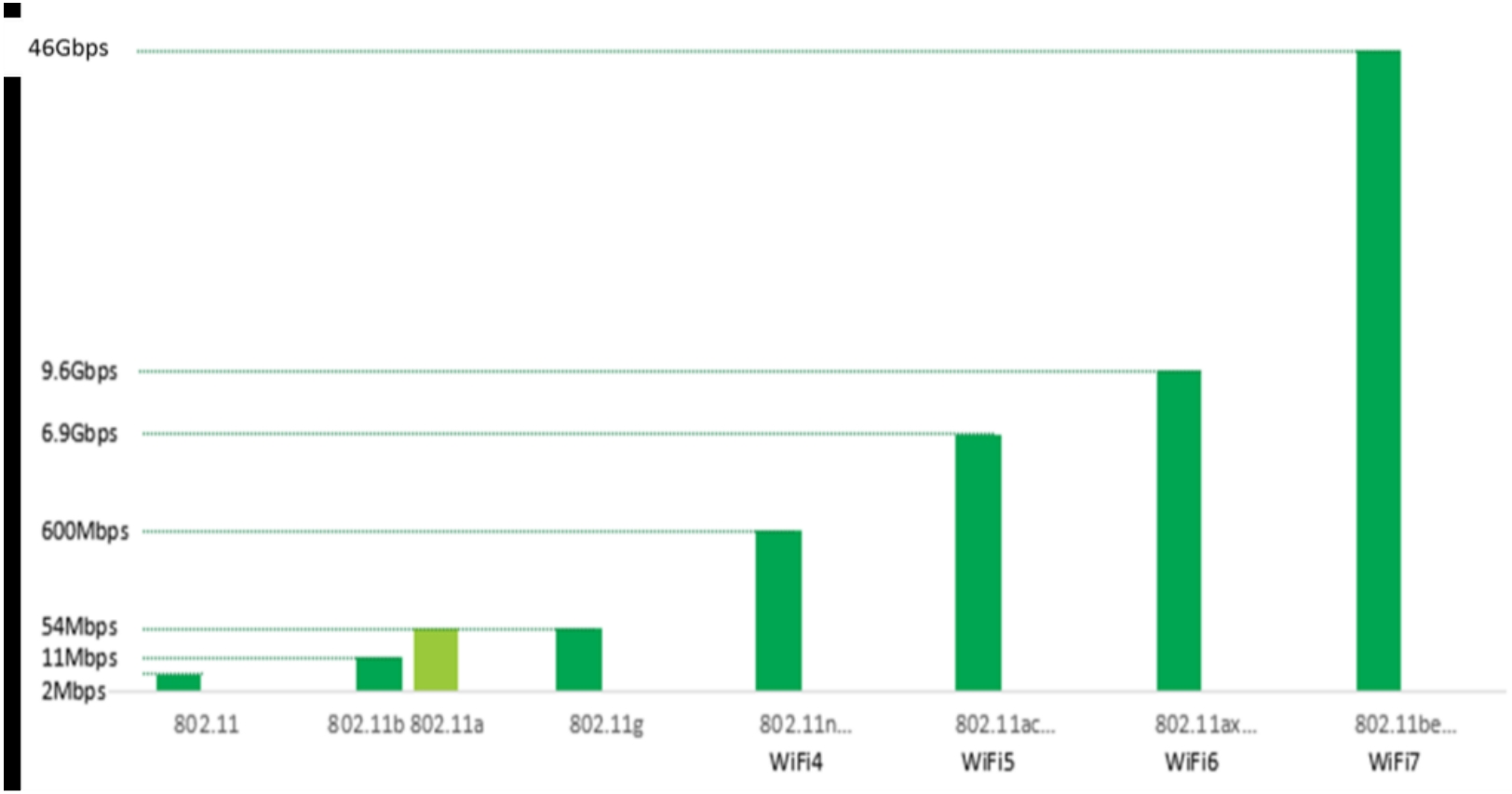
100-Gbps Gigabit Ethernet Configuration



Single-Cell Wireless LAN Configuration



Evolution of IEEE 802.11



IEEE 802.11ac

- Published in 2013
- Operate in 5GHz band
- Support up to 256QAM
- Support MU-MIMO(Multi-user Multiple Input Multiple Output) in downlink
  - On the downlink the transmitter can use its antenna resources to transmit multiple frames to different stations, all at the same time and over the same frequency spectrum.
  - Each antenna of a MU-MIMO AP can simultaneously communicate with a different single-antenna device, such as a smartphone or tablet.

IEEE 802.11ax

- Published in 2019
- Operate on 2.4GHz and 5GHz
- Support up to 1024QAM
- Support MU-MIMO for both uplink and downlink
- Support OFDMA (Orthogonal Frequency Division Multiple Access)
  - The channel can be split into small bands and allocated to different users at the same time.

802.11 ac vs. 802.11ax

	802.11ac	802.11ax
BANDS	5 GHz	**2.4 GHz** and 5 GHz
CHANNEL BANDWIDTH	20 MHz, 40 MHz, 80 MHz, 80+80 MHz & 160 MHz	20 MHz, 40 MHz, 80 MHz, 80+80 MHz & 160 MHz
FFT SIZES	64, 128, 256, 512	256, 512, 1024, 2048
SUBCARRIER SPACING	312.5 kHz	**78.125 kHz**
OFDM SYMBOL DURATION	3.2 us + 0.8/0.4 us CP	**12.8 us + 0.8/1.6/3.2 us CP**
HIGHEST MODULATION	256-QAM	**1024-QAM**
DATA RATES	433 Mbps (80 MHz, 1 SS) 6933 Mbps (160 MHz, 8 SS)	600.4 Mbps (80 MHz, 1 SS) 9607.8 Mbps (160 MHz, 8 SS)

Summary

- LAN topologies and transmission media
  - bus, tree, ring, star
- LAN protocol architecture
  - IEEE 802, LLC, MAC
- bridges, hubs, layer 2 switches, routers
- 802.11 standards