Ethernet, Token Ring, Wireless Network

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Ethernet (IEEE 802.3)

- Ethernet: It is a LAN protocol that is used in Bus and Star typologies and implements CSMA/CD as the medium access method

- Original (traditional) Ethernet developed in 1980 by three companies: Digital, Intel, Xerox (DIX).

- In 1985, the Computer Society of the IEEE started a project, called Project 802, to set standards to enable intercommunication among equipment from a variety of manufacturers.
  - Current version is called IEEE Ethernet

Ethernet

- Frame formats. (a) DIX Ethernet , (b) IEEE 802.3

Bytes	8		6	6	2	0-1500	0-46	4
(a)	Preamble		Destination address	Source address	Type	Data	Pad	FCS
(b)	Preamble	SOF	Destination address	Source address	Length	Data	Pad	FCS

Ethernet

- In IEEE 802.3 Ethernet Data link layer is split into two sublayers:
  - Bottom part: MAC
    - The frame is called **IEEE 802.3**
    - Handles framing, MAC addressing, Medium Access control
    - **Specific implementation for each LAN p**rotocol
      - Defines **CSMA/CD** as the access method for Ethernet LANs and **Token passing** method for Token Ring.
    - Implemented in **hardware**
  - Top part: LLC (Logical Link Control)
    - The subframe is called **IEEE 802.2**
    - Provides **error and flow control** if needed
    - It makes the MAC sublayer transparent
      - Allows interconnectivity between different LANs data link layers
    - Used to multiplex multiple network layer protocols in the data link layer frame
    - Implemented in **software**

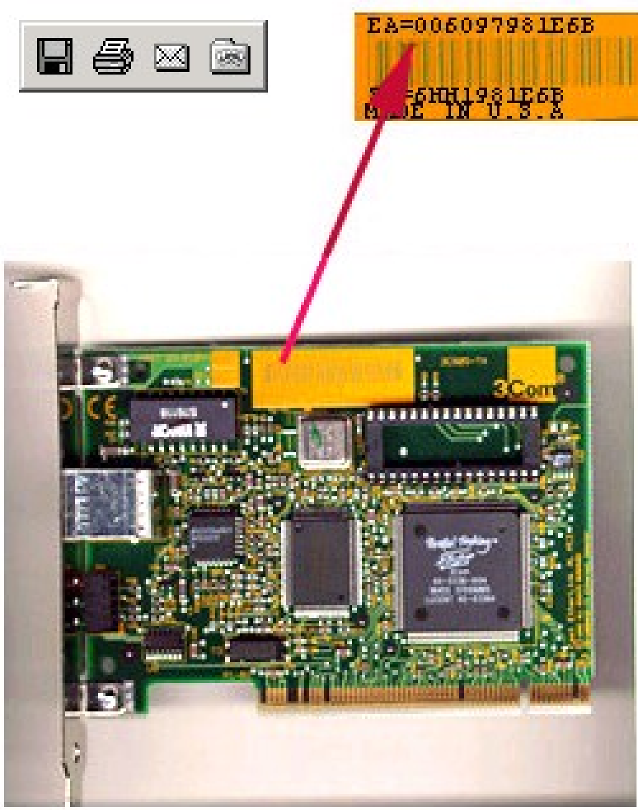
Ethernet Address

06-01-02-01-2C-4B

- Six bytes = 48 bits
- Flat address not hierarchical
- Burned into the NIC ROM
- First three bytes from left specify the vendor. Cisco 00-00-0C, 3Com 02-60-8C and the last 24 bit should be created uniquely by the company
- Destination Address can be:
  - **Unicast:** second digit from left is even (one recipient)
  - **Multicast:** Second digit from left is odd (group of stations to receive the frame – conferencing applications)
  - **Broadcast** (ALL ones) (all stations receive the frame)
- Source address is always Unicast

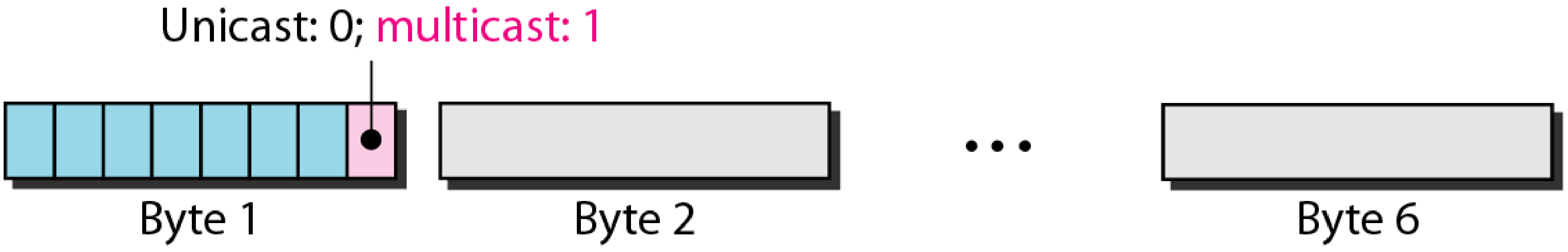
Ethernet Address for Desktop PC ethernet card

For the 3Com 3C905-TX PCI PnP network card

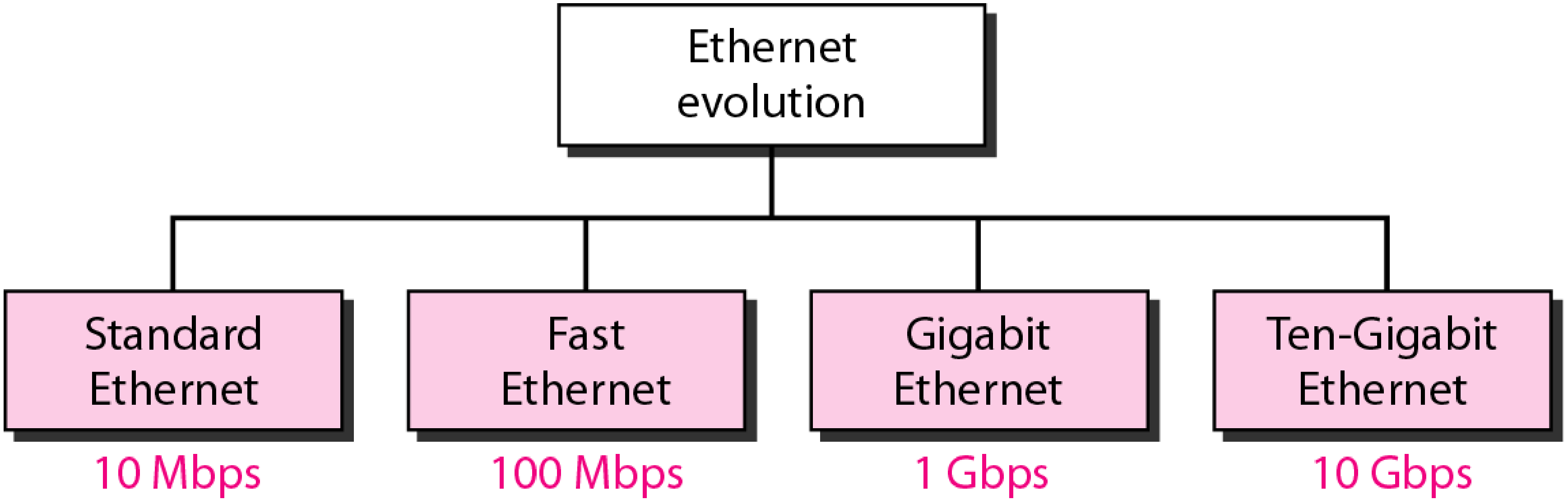


The ethernet address for the above network card is : 006097981E6B

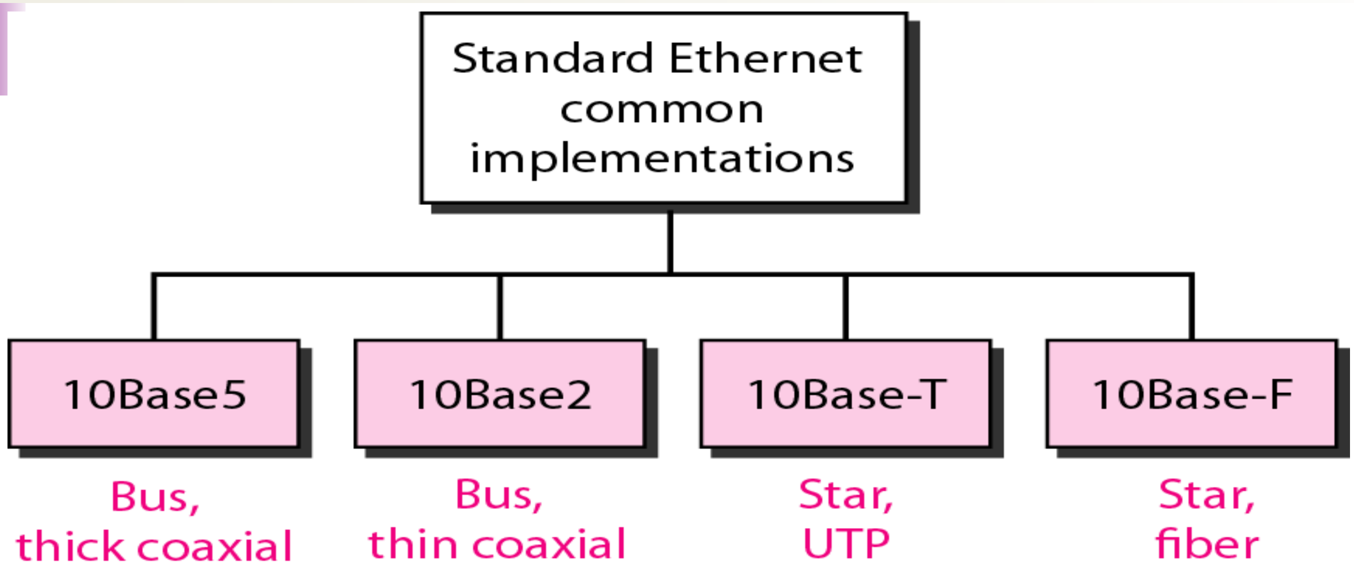
Unicast /Multicast Address



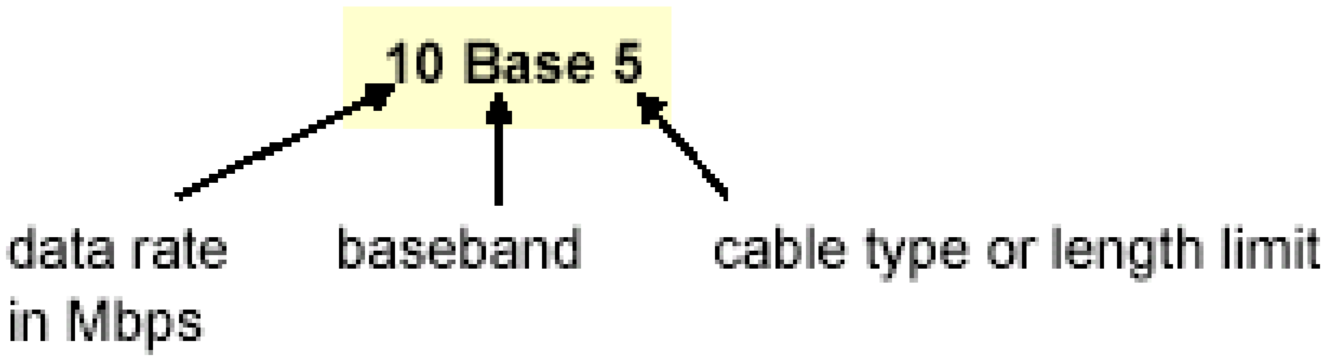
Ethernet evolution through four generations



Categories of traditional Ethernet



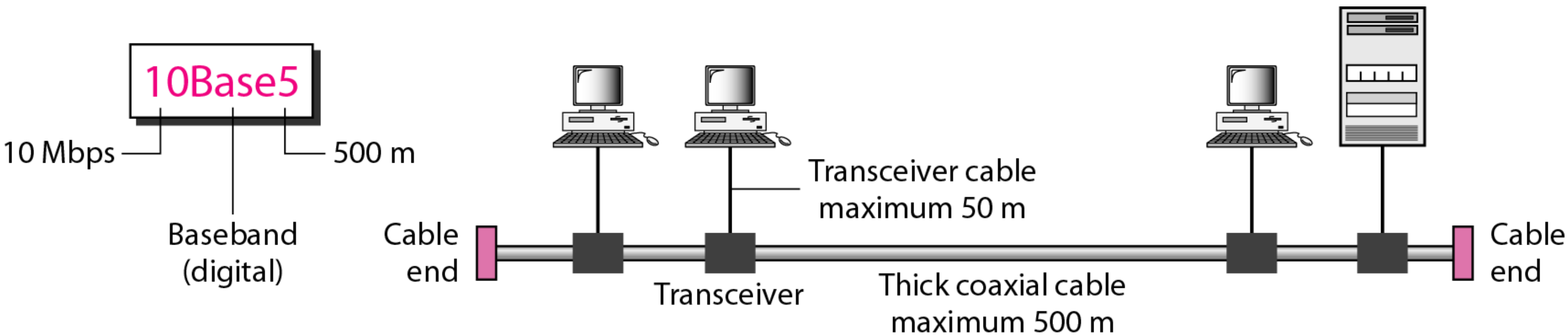
- <data rate><Signaling method><Max segment length or cable type>



IEEE 802.3 Cable Types

Name	Cable Max.	Max Cable Segment Length	Nodes /segment	Toplogy
10Base5	thick coax	500 meters	100	Bus
10Base2	thin coax	185 meters	30	Bus
10BaseT	twisted pair	100 meters	1	Star
10BaseF	Fiber Optic	2Km	1	Star

10Base5 implementation

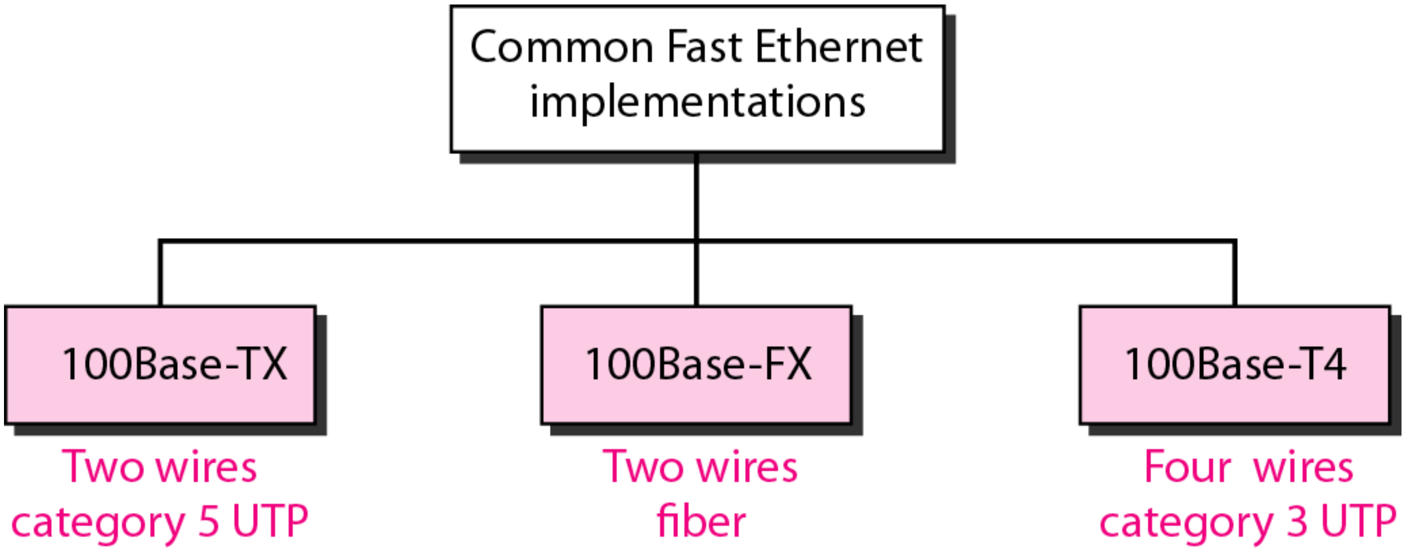


Fast Ethernet

- 100 Mbps transmission rate
- same frame format, media access, and collision detection rules as 10 Mbps Ethernet
- can **combine 10 Mbps** Ethernet and Fast Ethernet on same network using a ***switch***
- media: twisted pair (CAT 5) or fiber optic cable (no coax)
- Star-wire topology
  - Similar to 10BASE-T

Name	Cable	Max. segment	
100Base-T4	Twisted pair	100 m	CAT 3
100Base-TX	Twisted pair	100 m	CAT 5
100Base-FX	Fiber optics	2000 m	

Fast Ethernet implementations



Gigabit Ethernet

- Speed 1Gpbs
- Minimum frame length is 512 bytes
- Operates in full/half duplex modes mostly full duplex

Name	Cable	Max. segment	Advantages
1000Base-SX	Fiber optics	550 m	Multimode fiber (50, 62.5 microns)
1000Base-LX	Fiber optics	5000 m	Single (10 μ) or multimode (50, 62.5 μ)
1000Base-CX	2 Pairs of STP	25 m	Shielded twisted pair
1000Base-T	4 Pairs of UTP	100 m	Standard category 5 UTP

Figure 13.22 *Topologies of Gigabit Ethernet*

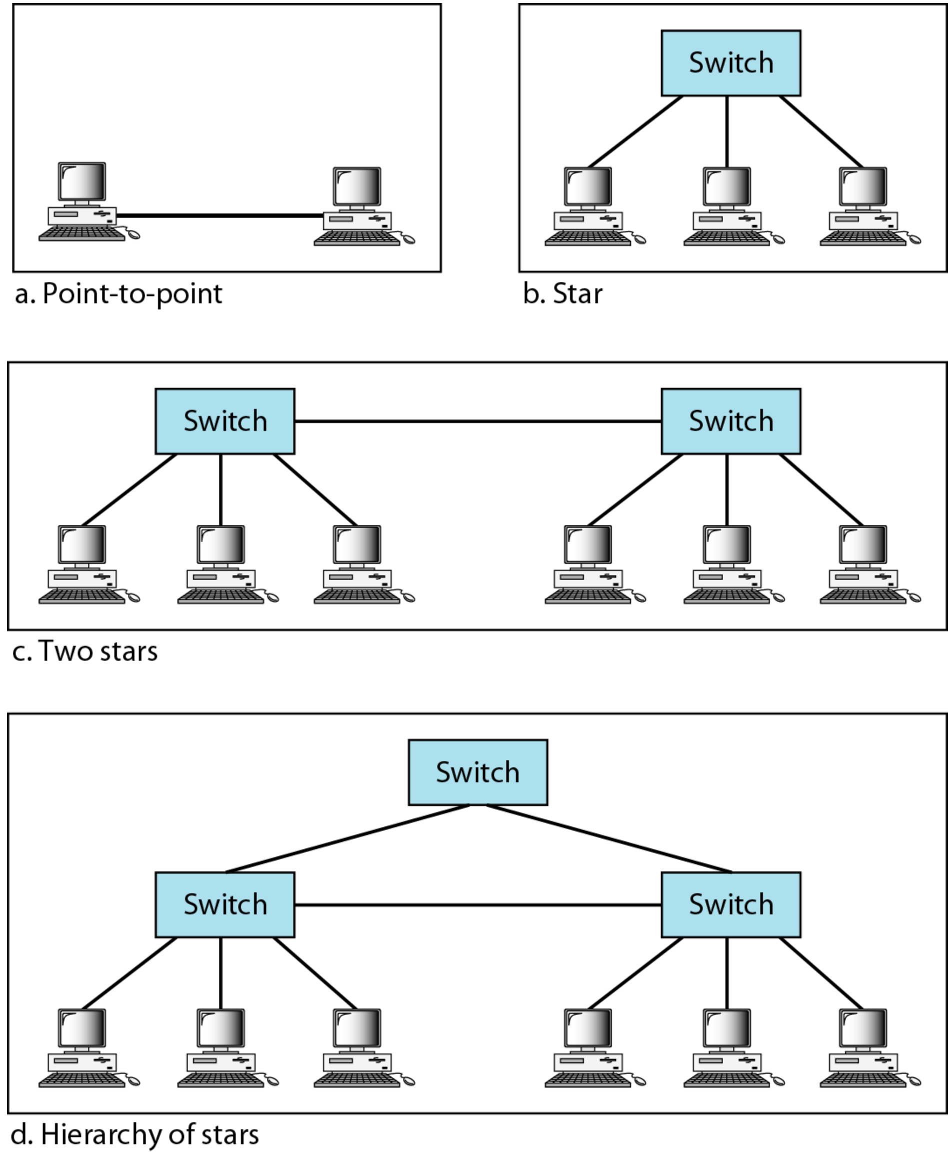
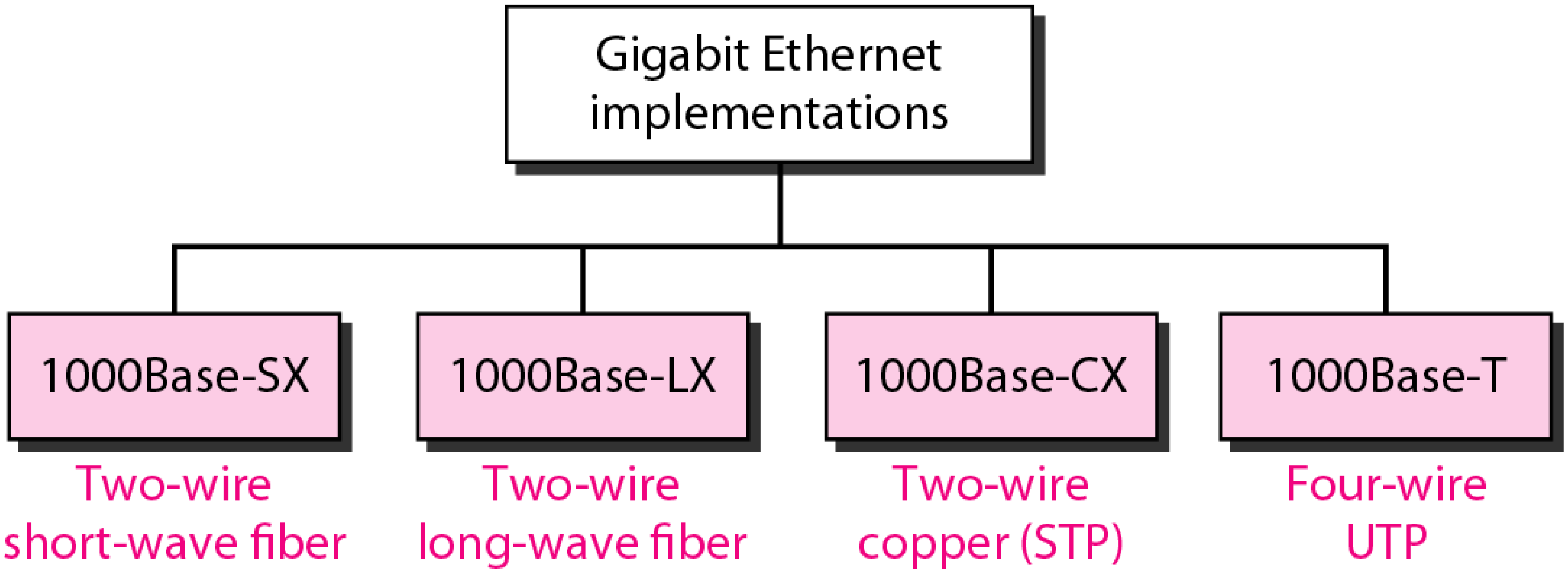
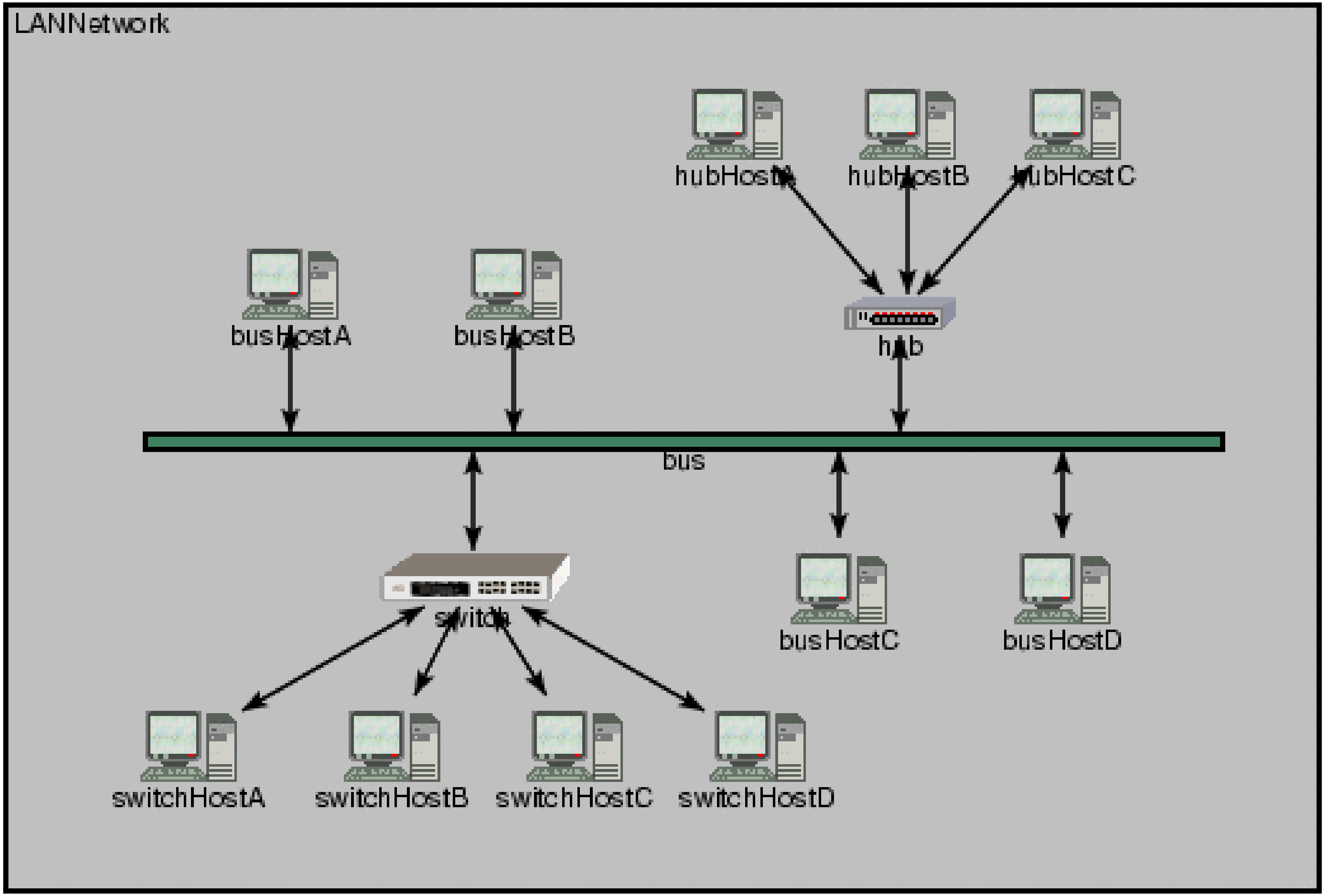


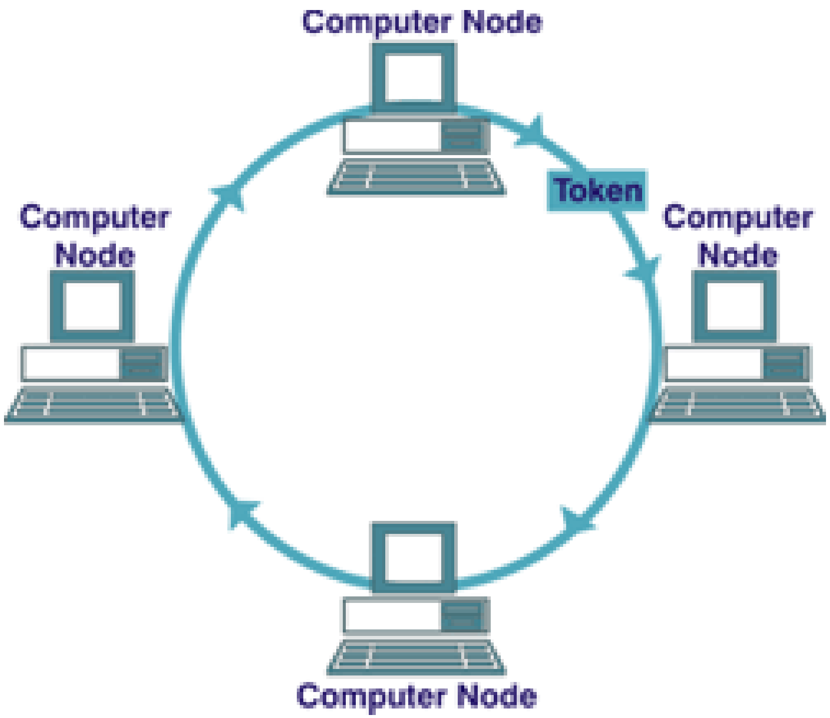
Figure 13.23 *Gigabit Ethernet implementations*



10Gbps Ethernet

- Maximum link distances cover 300 m to 40 km
- Full-duplex mode only
- No CSMA/CD
- Uses optical fiber only


LANNetwork
hubHostA
hubHostB
hubHostC
busHostA
busHostB
hub
bus
switch
busHostC
busHostD
switchHostA
switchHostB
switchHostC
switchHostD



TOKEN RING (IEEE 802.5)

Token Ring

- Proposed in 1969 and initially referred to as a *Newhall ring.*

Token ring :: a number of stations connected by transmission links in a ring topology. Information flows ***in one direction along the ring*** from source to destination and back to source.

Medium access control is provided by a small frame, **the token**, that circulates around the ring when all stations are idle. *Only the station possessing the token is allowed to transmit at any given time.*

Token Ring Operation

- When a station wishes to transmit, it must wait for token to pass by and *seize the token.*
  - One approach: change one bit in token which transforms it into a *"start-of-frame sequence"* and appends frame for transmission.
  - Second approach: station claims token by removing it from the ring.
- Frame circles the ring and is removed by the transmitting station.
- Each station interrogates passing frame, if destined for station, it copies the frame into local buffer. *{Normally, there is a one bit delay as the frame passes through a station.}*

Re-inserting token on the ring

Choices:

1. After station has completed transmission of the frame.
2. After leading edge of transmitted frame has returned to the sending station

The essential issue is whether more than one frame is allowed on the ring at the same time.

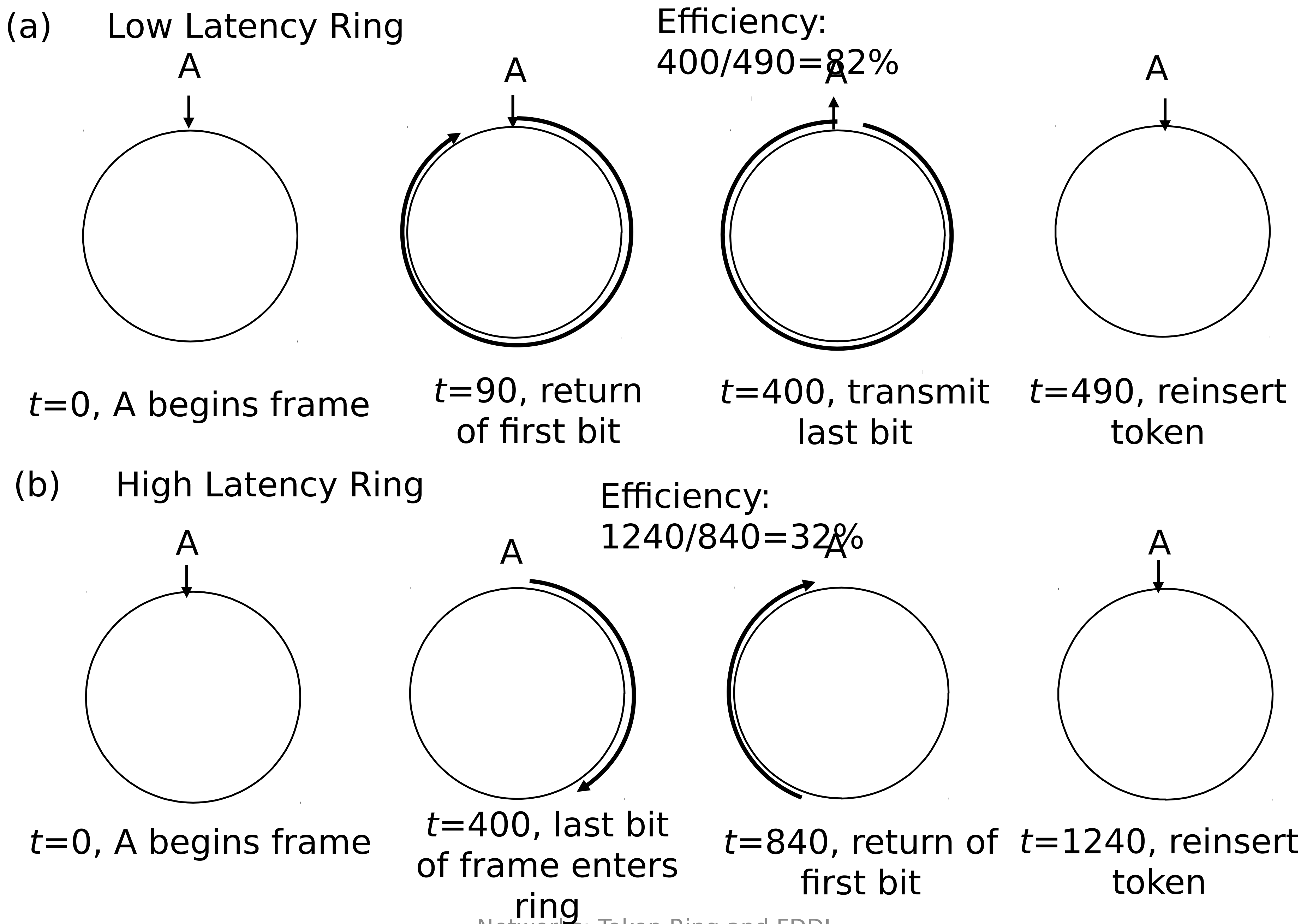
Ring Latency

$$\tau' = d/v + Mb/R \text{ seconds} \qquad \text{and} \qquad \tau' R = dR/v + Mb \text{ bits}$$

- Where d is distance, v is velocity
- M is number of station
- B is bits of delay in each station (2.5 is standard)
- R is data rate

Token Insertion

- If R= 4Mbps M=20 stations separated by 100 meters and b=2.5bits.
- The Ring latency $20 \times 100 \times 4 \times 10^6/(2 \times 10^8) + 20(2.5) = 90$
- The first bit reaches back to sender after 90 bits
- If speed =16 Mbps and M=80 then
- Ring latency $80 \times 100 \times 16 \times 10^6/ \ (2 \times 10^8) + 80(2.5) = 840$ bits.
- Assume Length of frame = 400 bits.

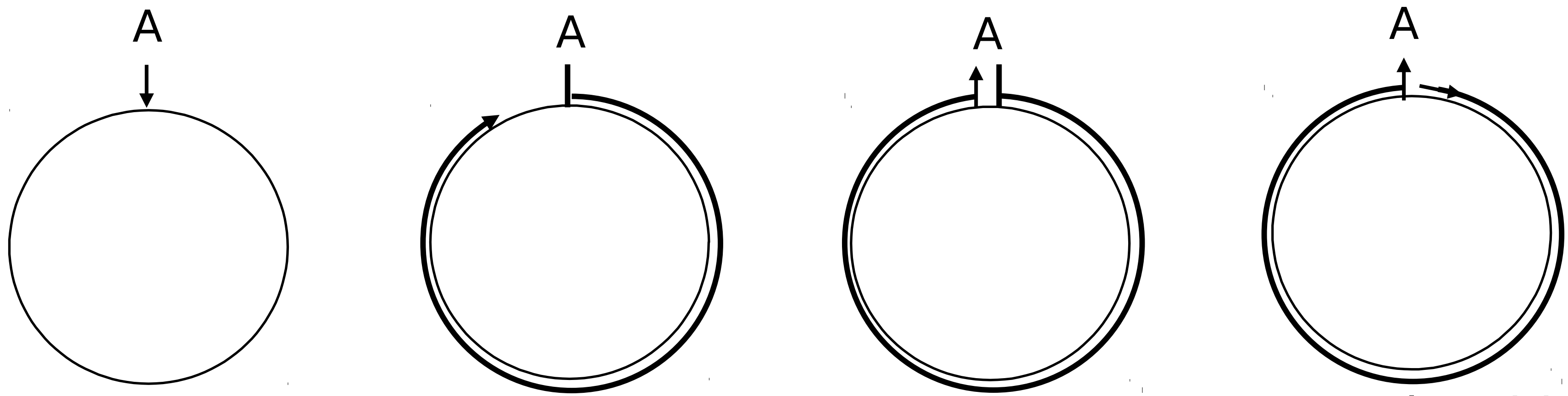


Leon-Garcia & Widjaja: *Communication Networks*
Figure 6.59

Token Insertion

Now suppose that the token reinsertion strategy is to reinsert the token after the frame transmission is completed but not until after the header of the frame returns to the sending station. Suppose that the header is 15 bytes = 120 bits long. The header returns after $90 + 120 = 210$ bits in the first ring, as shown in Figure 6.60a. The sending station can therefore reinsert the token immediately after transmitting bit 400 of the frame. Figure 6.60b shows that in the second ring the header returns after $840 + 120 = 960$ bits. Consequently, the sending station must send an idle signal for 560 bit times before that station can reinsert the token into the ring. The first ring now operates efficiently, but the second ring has an efficiency of $400/960 = 42$ percent.

(a) Low Latency Ring



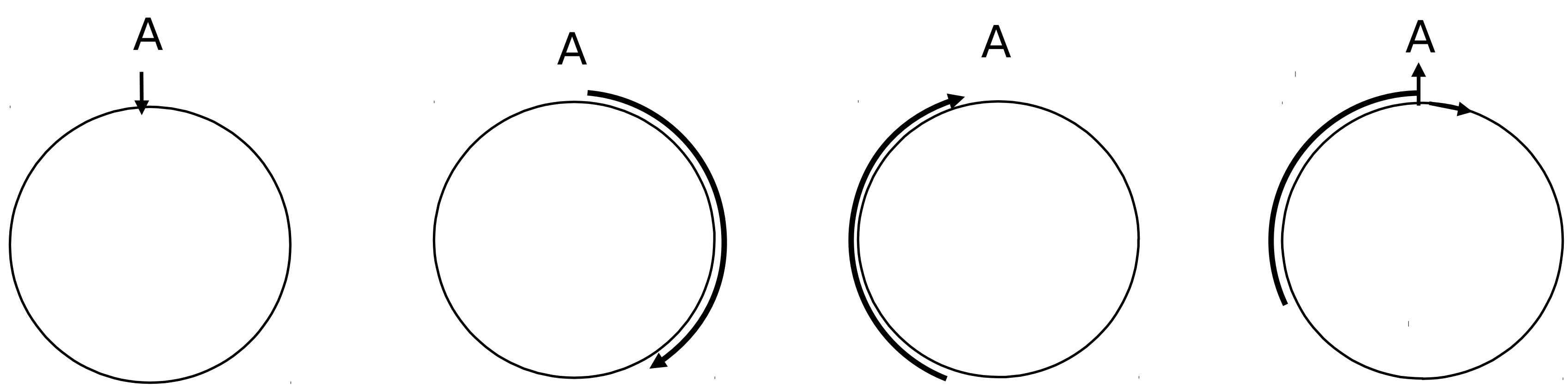
t=0, A begins frame

t=90, return of first bit

t=210, return of header

t=400, last bit enters ring, reinsert token

(b) High Latency Ring



t=0, A begins frame

t=400, transmit last bit

t=840, arrival first frame bit

t=960, reinsert token

Leon-Garcia & Widjaja: *Communication Networks*

Figure 6.60

IEEE 802.5 Token Ring

- 4 and 16 Mbps using twisted-pair cabling with differential Manchester line encoding.
- Maximum number of stations is 250.
- Waits for last byte of frame to arrive before reinserting token on ring *{new token after received}*.
- 8 priority levels provided via two 3-bit fields (priority and reservation) in data and token frames.
- Permits 16-bit and 48-bit addresses (same as 802.3).

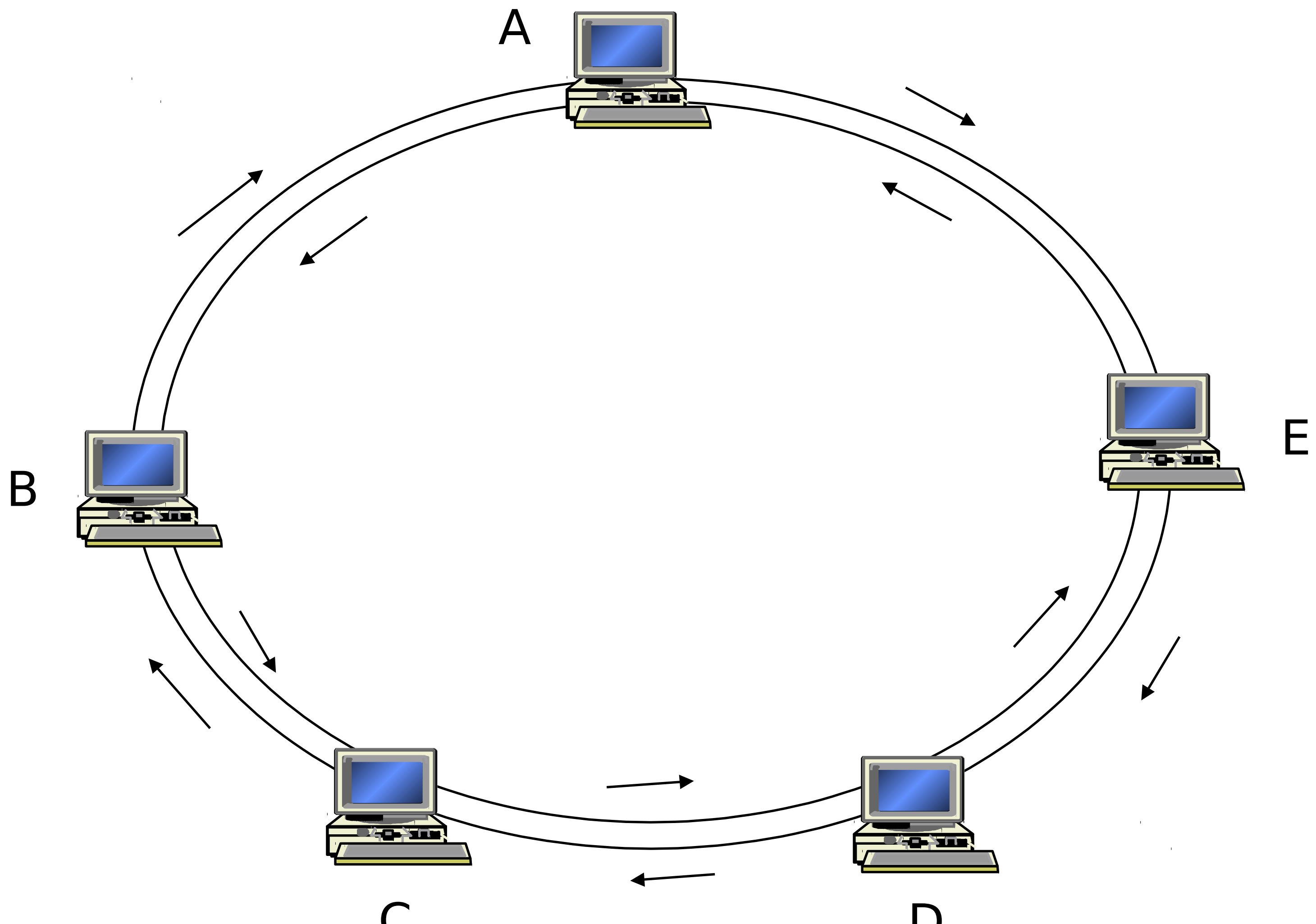
Token Ring

- Under light load – delay is added due to waiting for the token.
- Under heavy load – ring is *“round-robin”*
- The ring must be long enough to hold the complete token.
- Advantages – fair access
- Disadvantages – ring is single point of failure, added issues due to token maintenance.

Fiber Distributed Data Interface (FDDI)

- FDDI uses a ring topology of multimode or single mode optical fiber transmission links operating at 100 Mbps to span up to 200 kms and permits up to 500 stations.
- ***Employs dual counter-rotating rings.***
- 16 and 48-bit addresses are allowed.
- In FDDI, token is absorbed by station and released as soon as it completes the frame transmission ***{release after transmission}***.

FDDI Token Ring



Leon-Garcia & Widjaja: *Communication Networks*
Figure 6.62

Differences between **802.5** and **FDDI**

Token Ring

- Shielded twisted pair
- 4, 16 Mbps
- No reliability specified
- Differential Manchester
- Centralized clock
- Priority and Reservation bits
- New token *after receive*

FDDI

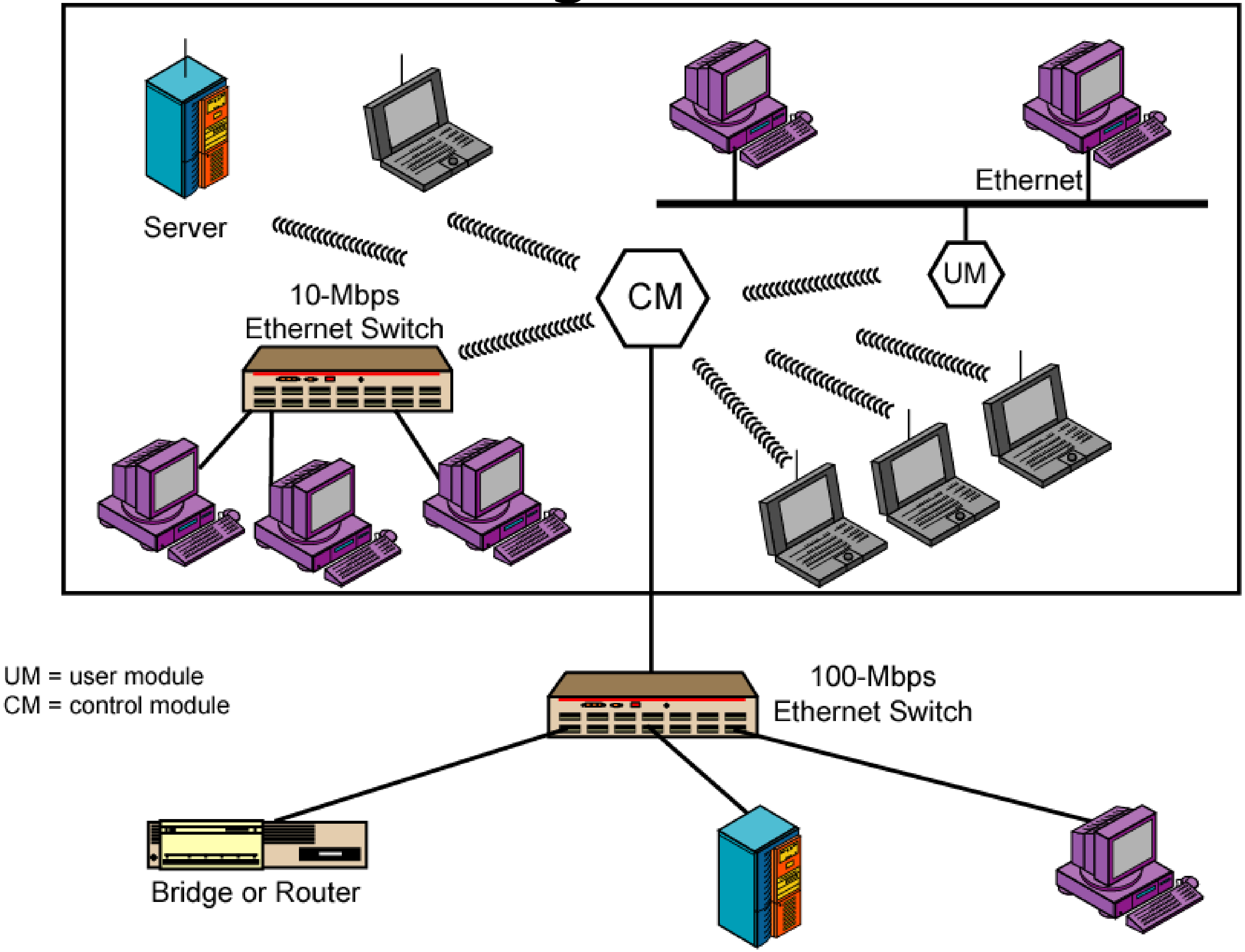
- Optical Fiber
- 100 Mbps
- Reliability specified (dual ring)
- 4B/5B encoding
- Distributed clocking
- Timed Token Rotation Time
- New token *after transmit*

WIRELESS NETWORK (IEEE 802.11)

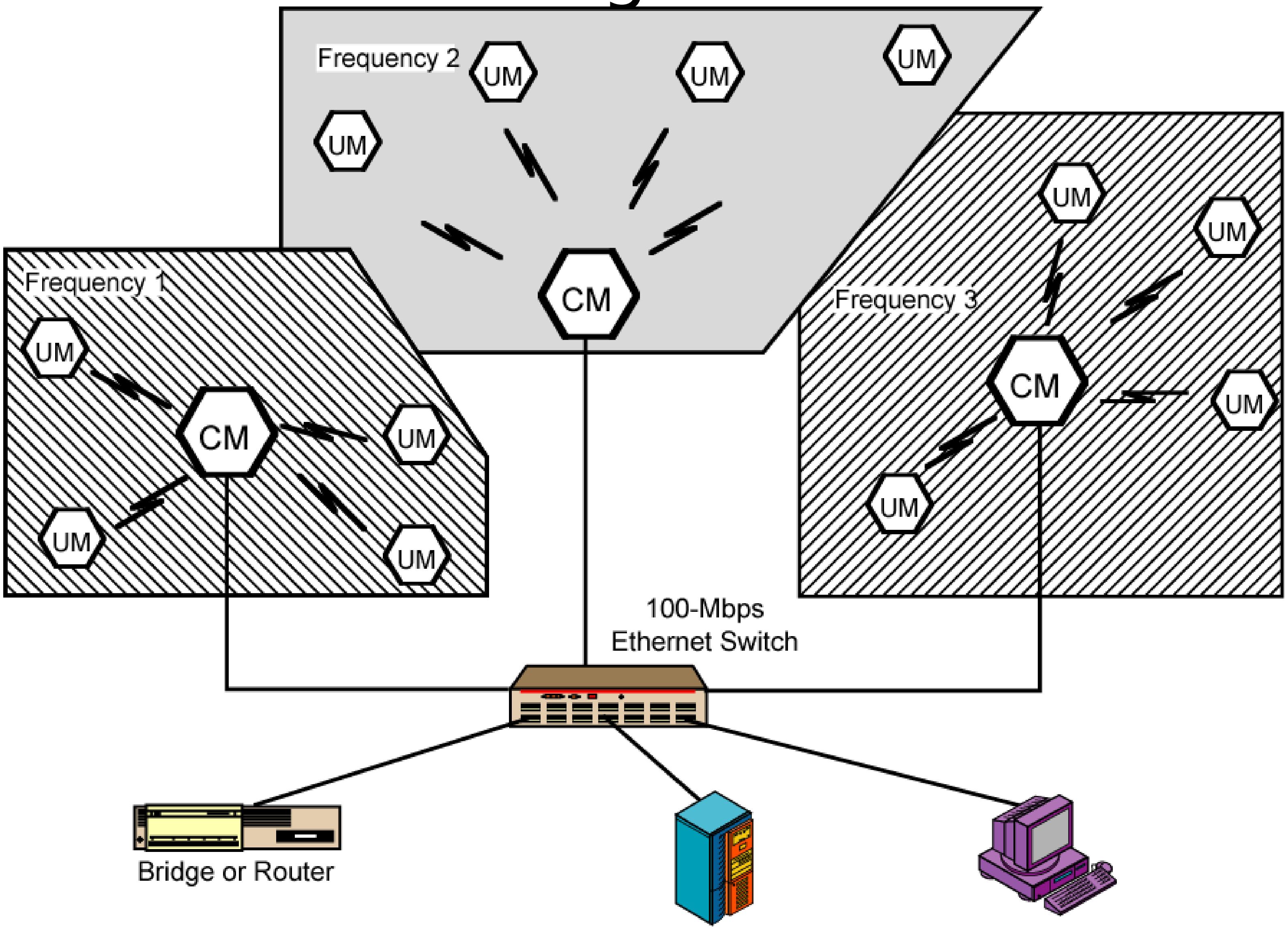
Wireless LAN

- A wireless LAN uses wireless transmission medium
- Used to have high prices, low data rates, occupational safety concerns, and licensing requirements
- Problems have been addressed
- Popularity of wireless LANs has grown rapidly

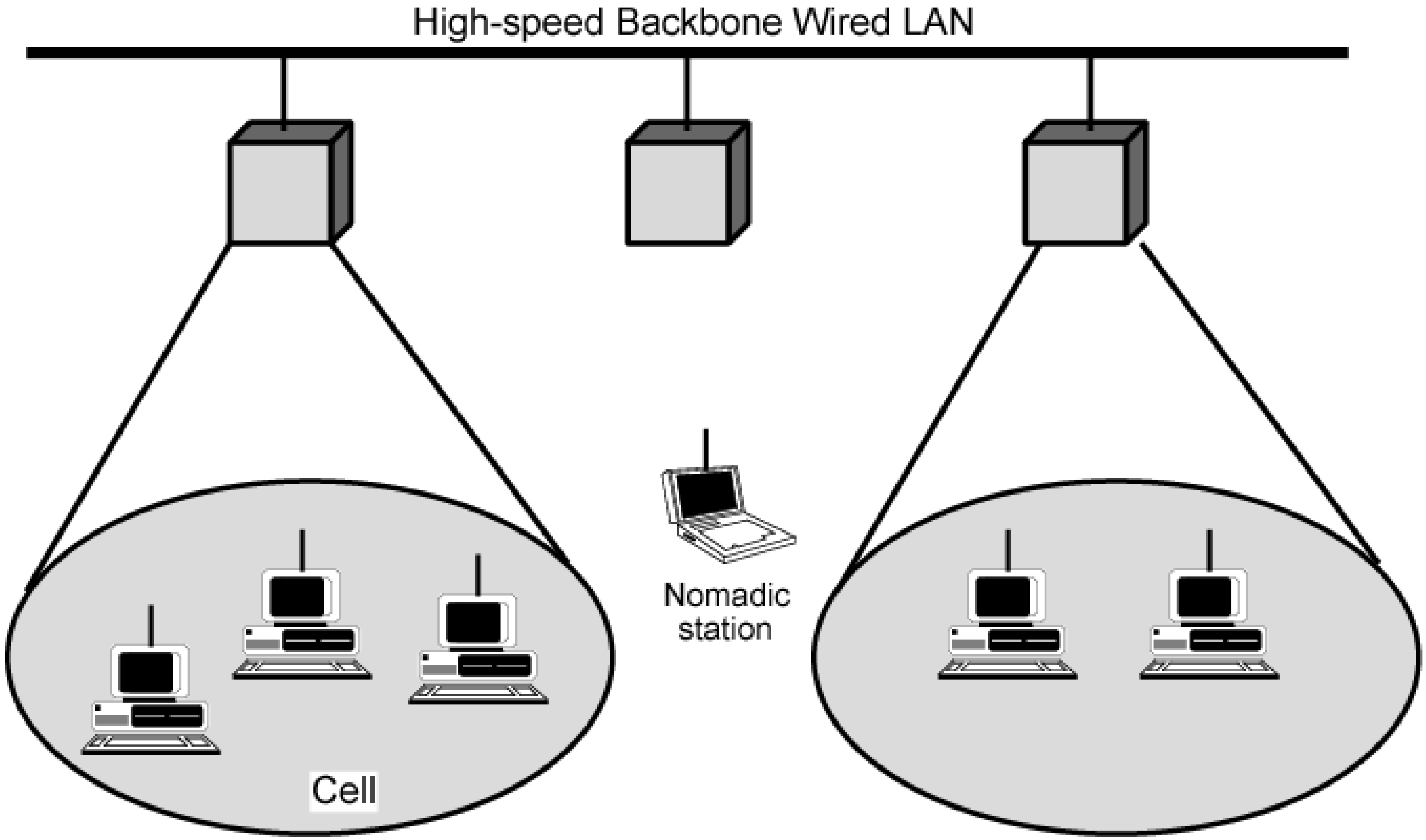
Single Cell Wireless LAN Configuration



Multi-Cell Wireless LAN Configuration

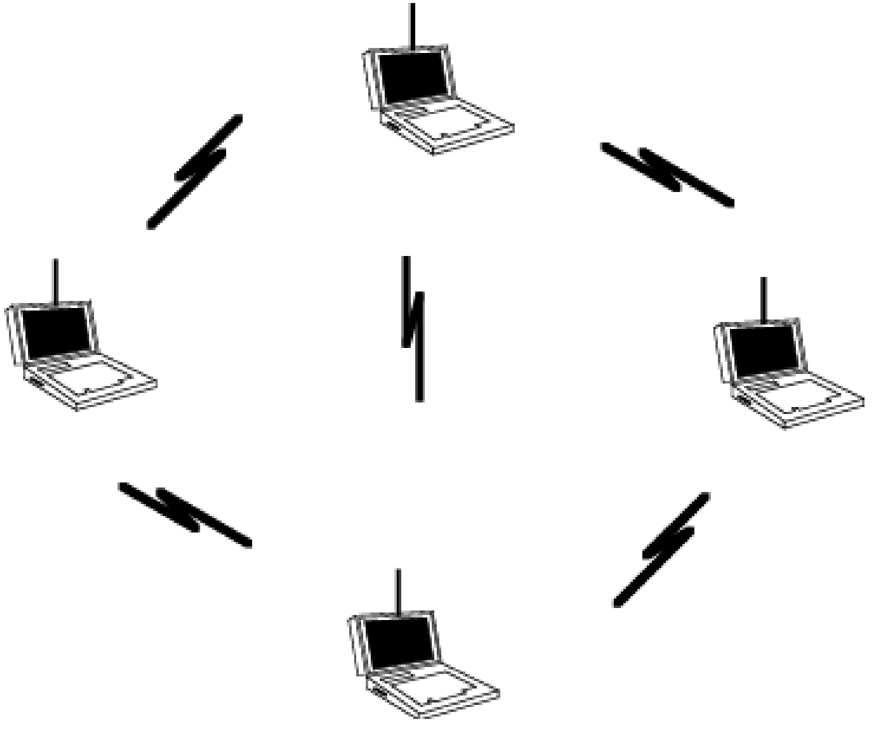


Infrastructure Wireless LAN

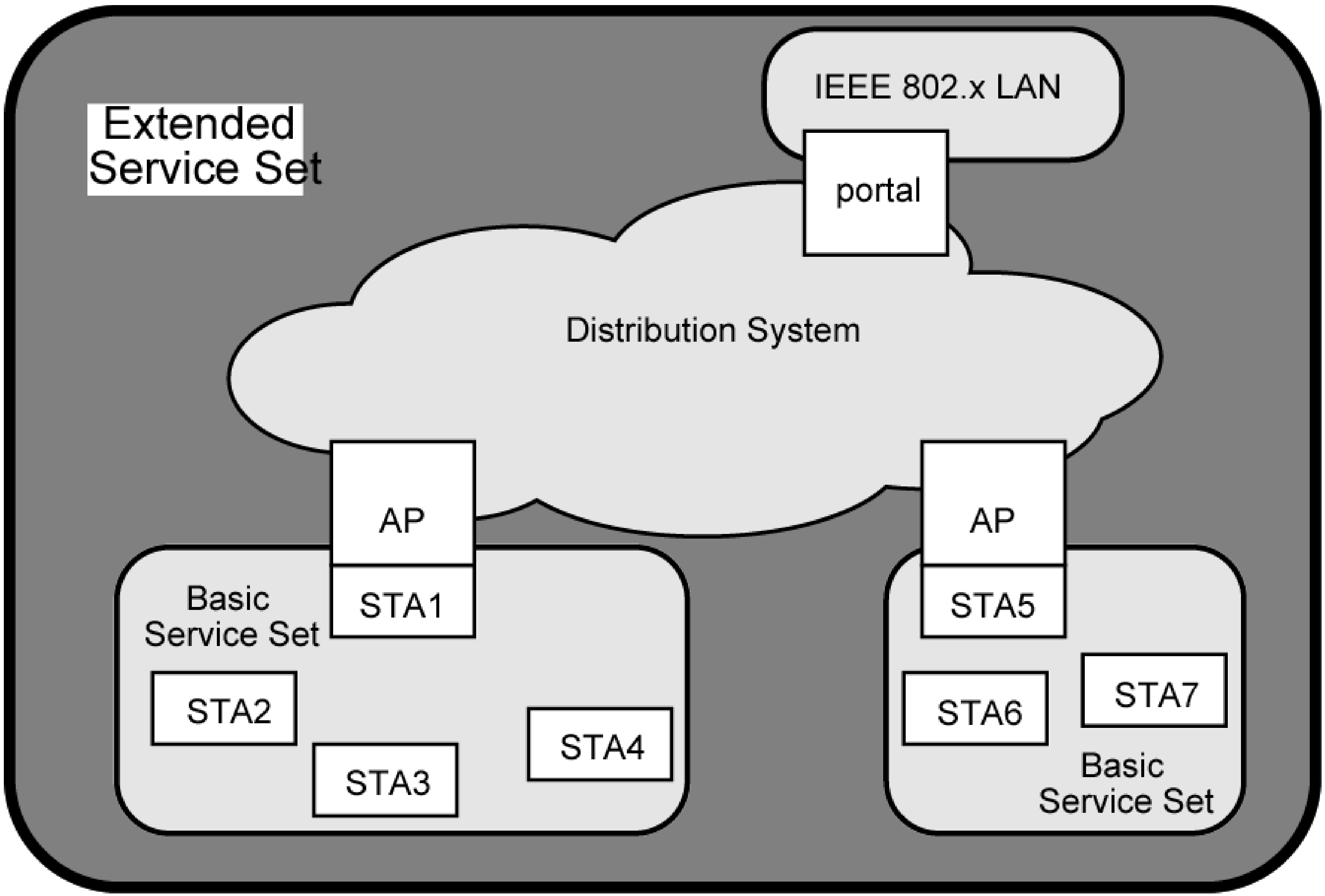


(a) Infrastructure Wireless LAN

Add Hoc LAN



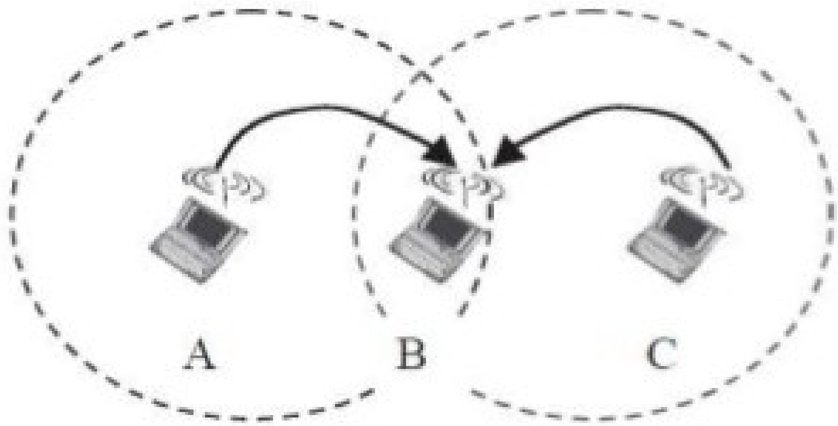
IEEE 802.11 Architecture



STA = station
AP = access point

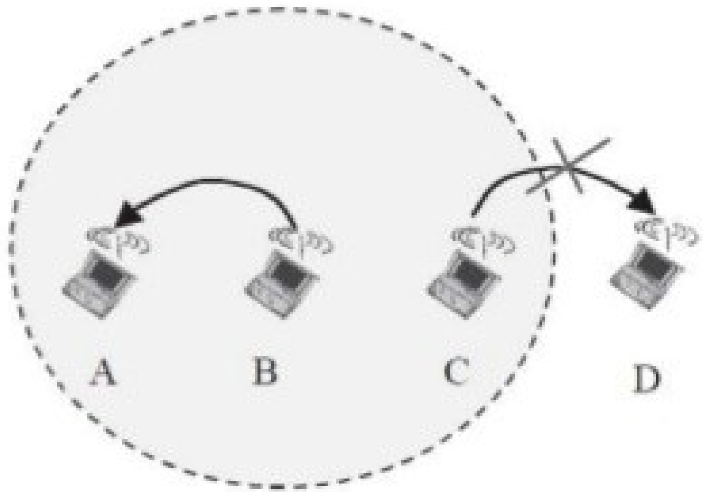
Hidden-terminal problem

- When two terminals can not detect each other's transmission due to being outside of each others range. The collision can occur.



Exposed-terminal problems.

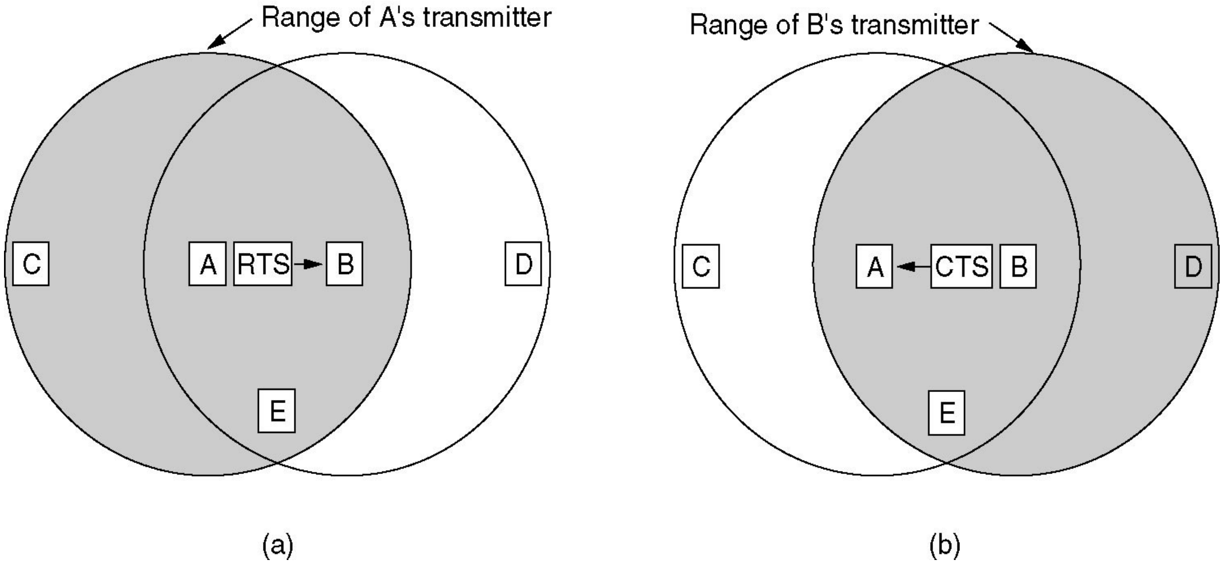
- Occur when a permissible transmission from a node to another node has to be delayed due to the irrelevant transmission between two other nodes.



Solution for hidden node and exposed node problem

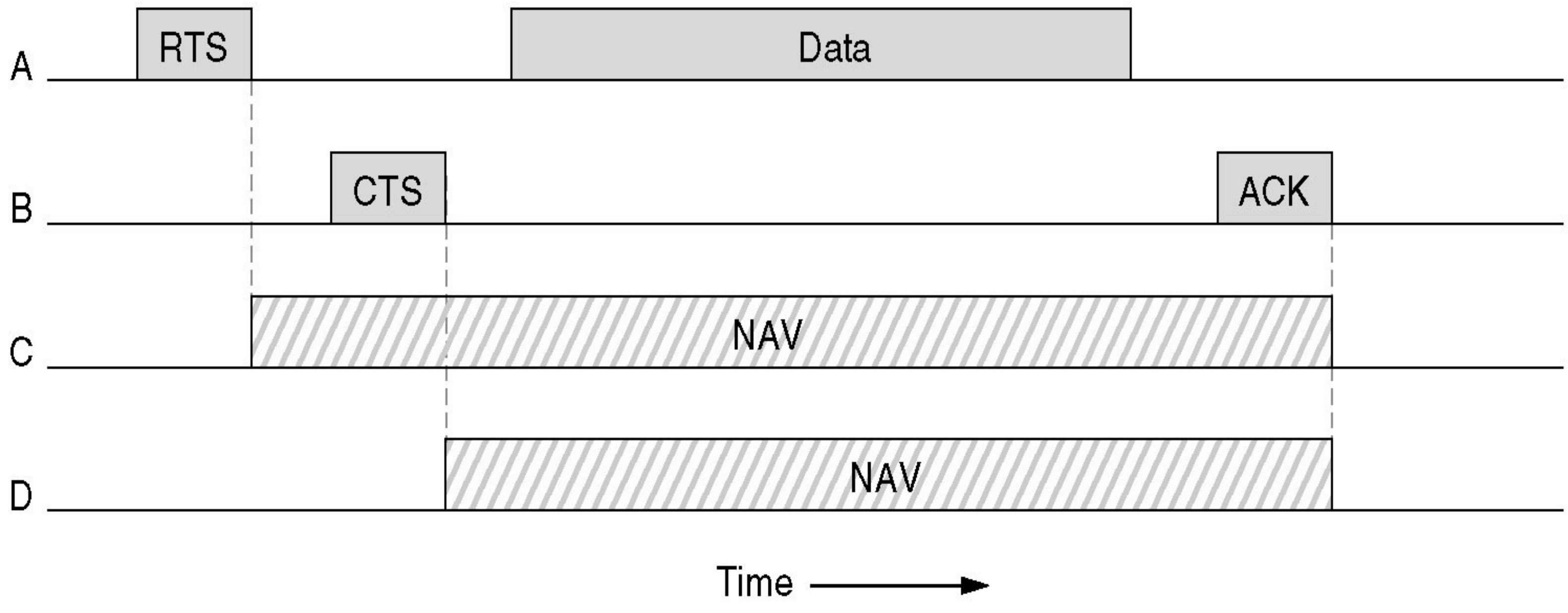
- Send Ready-to-Send (*RTS*) and Clear-to-Send (*CTS*) first
- RTS, CTS helps determine who else is in range or busy (Collision avoidance).
- Can a collision still occur?

RTS/CTS


Range of A's transmitter
C
A
RTS
B
D
E
(a)
Range of B's transmitter
C
A
CTS
B
D
E
(b)

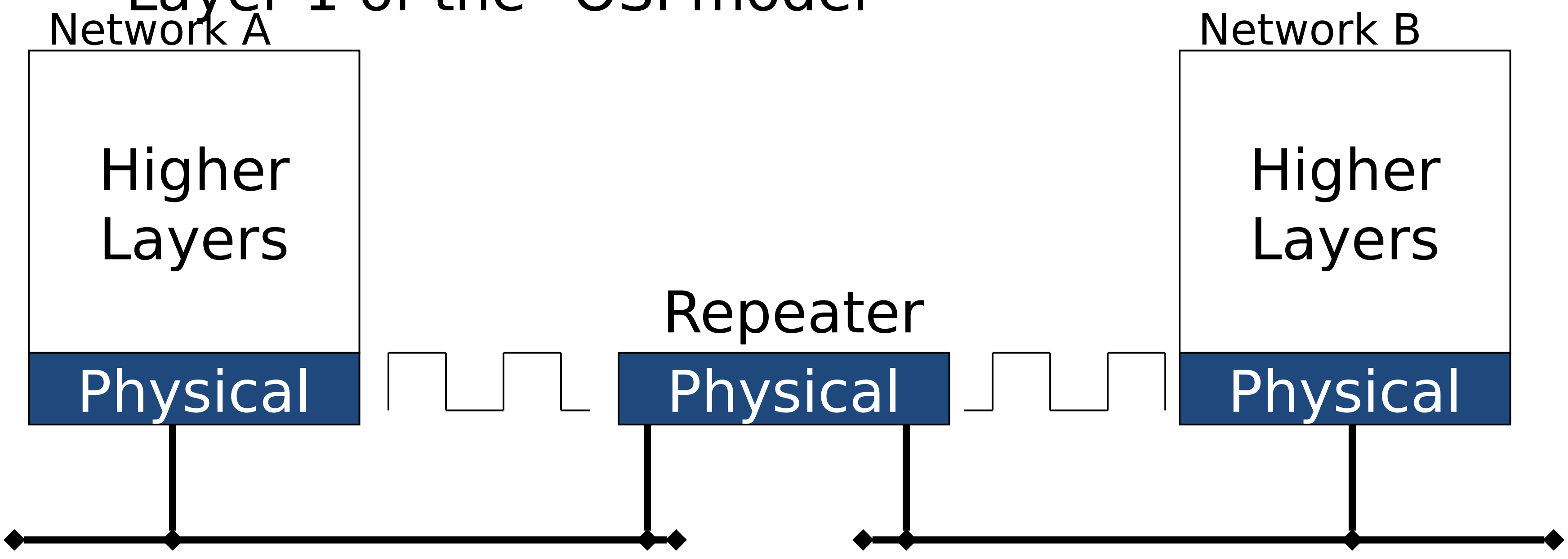
Virtual channel sensing

- NAV: Network Allocation Vector



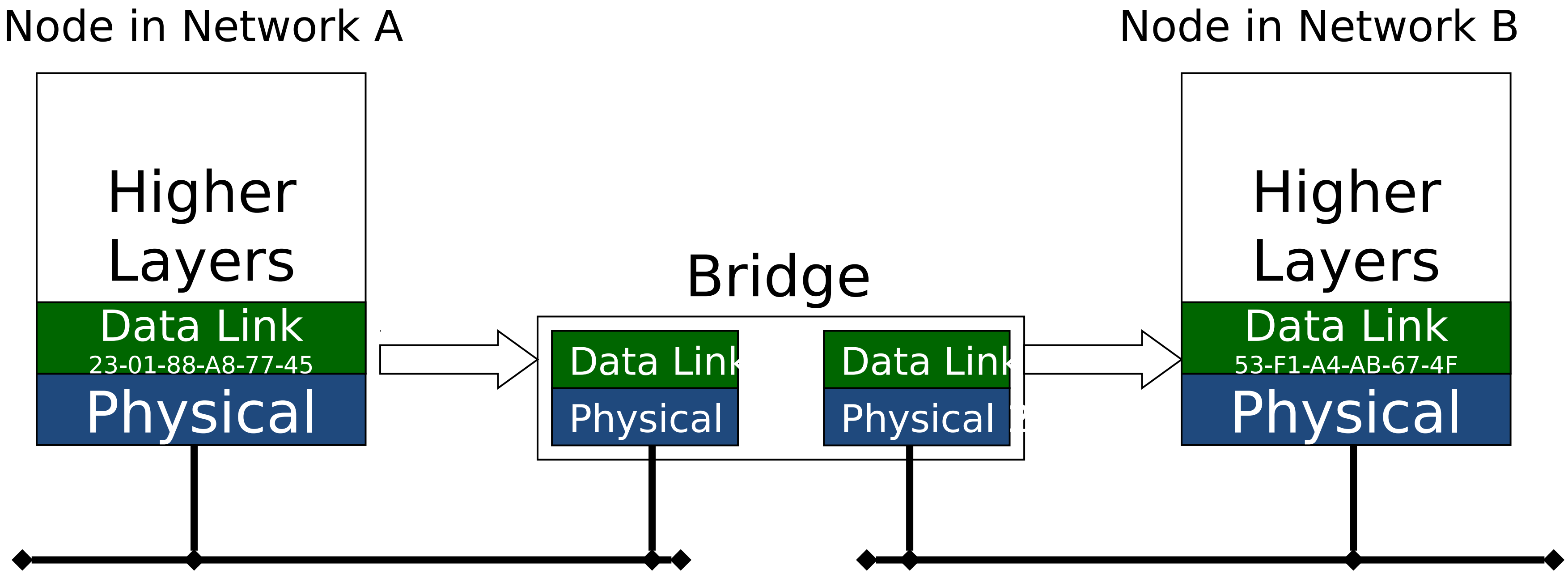
Repeater

- Regenerates and propagates all electrical transmissions between 2 or more LAN segments
- Allows extension of a network beyond physical length limitations
- Layer 1 of the “OSI model”



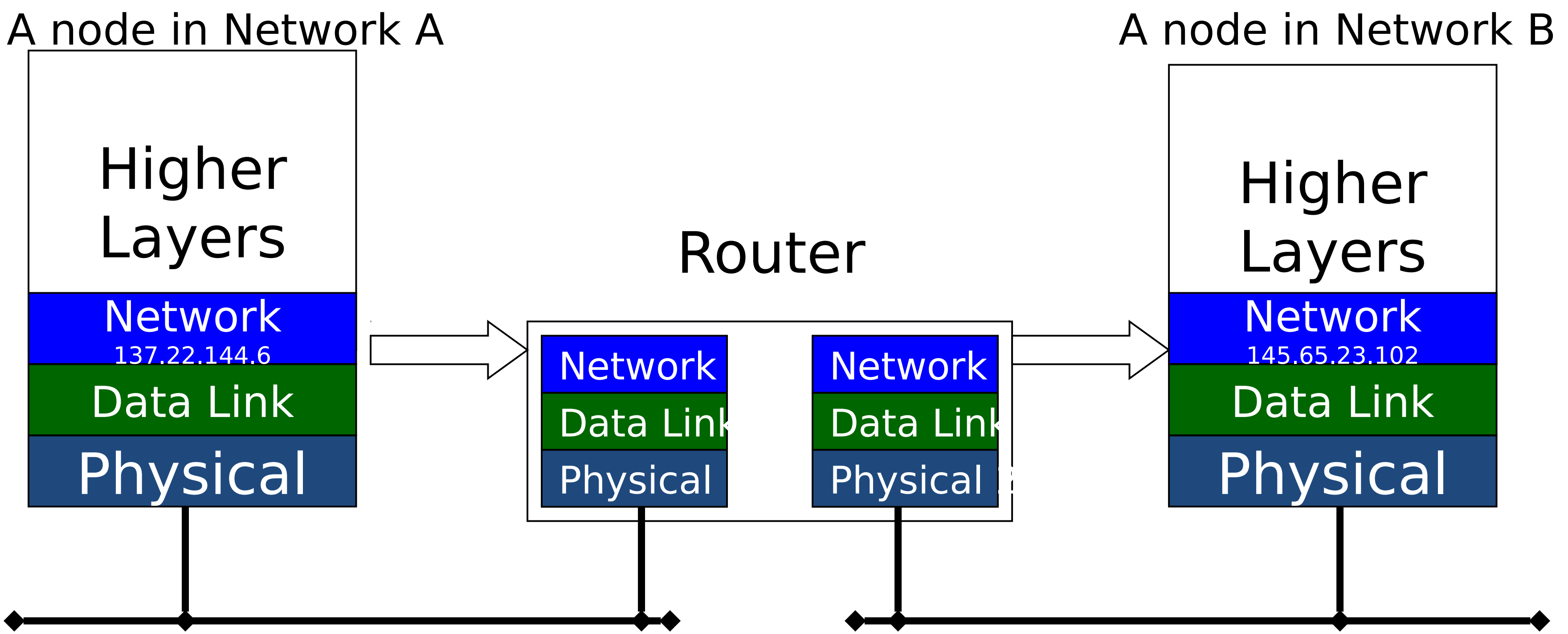
Bridge

- Connects 2 or more LAN segments and uses data link layer addresses (e.g.MAC addresses) to make data forwarding decisions
- Copies frames from one network to the other
- Layer 2 of the "OSI model"



Router

- Connects 2 or more networks and uses network layer addresses (like IP address) to make data forwarding decisions
- Layer 3 of the "OSI model"



Gateway

- Connects 2 or more networks that can be of different types and provides protocol conversion so that end devices with dissimilar protocol architectures can interoperate