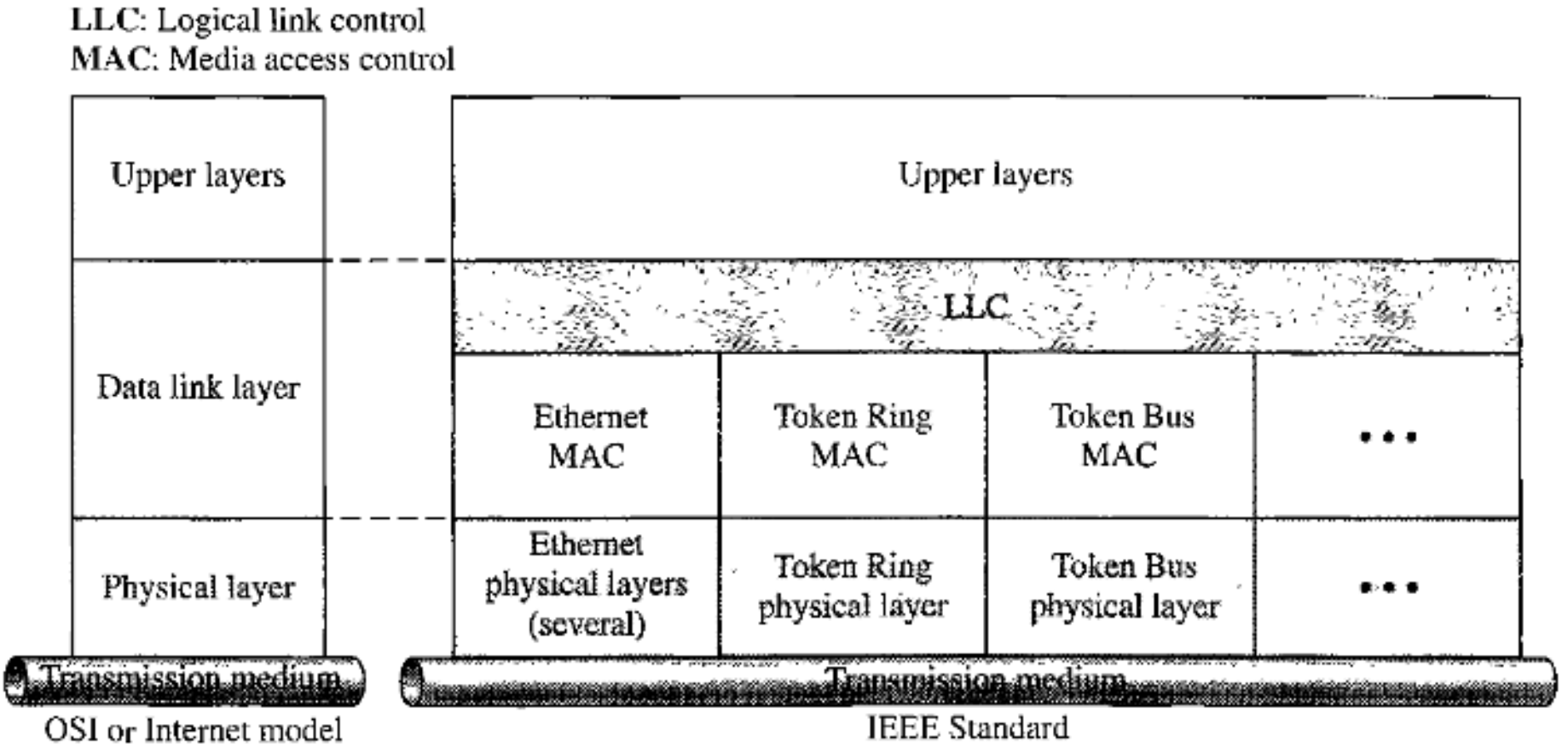
Chapter 13

Wired LANs: Ethernet

IEEE Standards

- Project 802 – to set the standards to enable intercommunication among equipment from a variety of manufacturers (1985)
- Does not seek to replace OSI but to provide a way of specifying functions of the physical layer and data link layer of major LAN protocols
- Adopted by ANSI and ISO (8802)
- Data link layer divided into logical link control (LLC) and media access control (MAC)

IEEE Standards



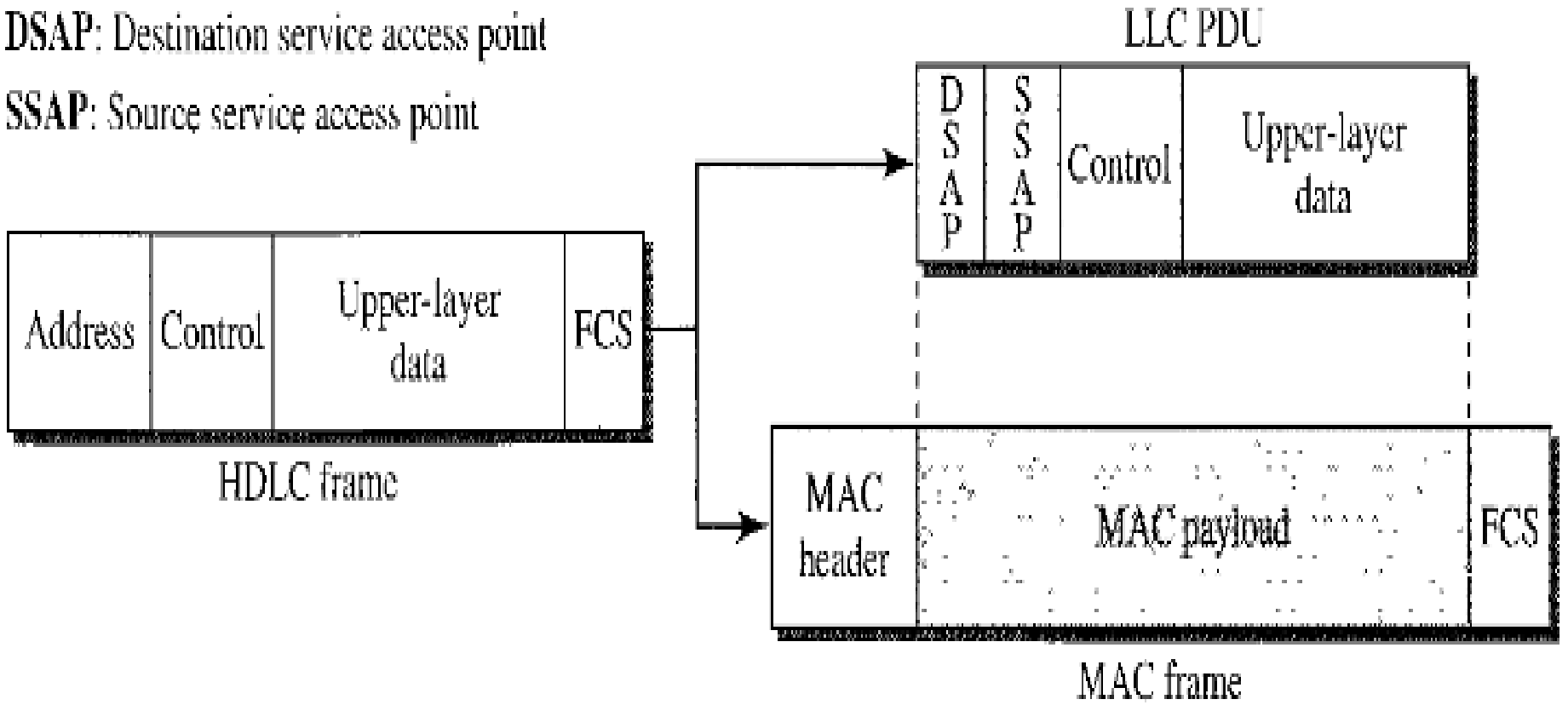
Logical Link Control

- Flow control, error control, framing
- Provides one single data link control protocol for all IEEE LANs
- Can provide interconnectivity between different LANs because it makes the MAC sublayer transparent

Logical Link Control

- Framing (Header Fields)
  - Contains a control field similar to HDLC
  - Destination service access point (DSAP) – defines the upper layer protocol at the destination
  - Source service access point (SSAP) – defines the upper layer protocol at the source
- Purpose of LLC is to provide flow and error control for the upper-layer protocols
- IP does not use LLC

Logical Link Control



Media Access Control

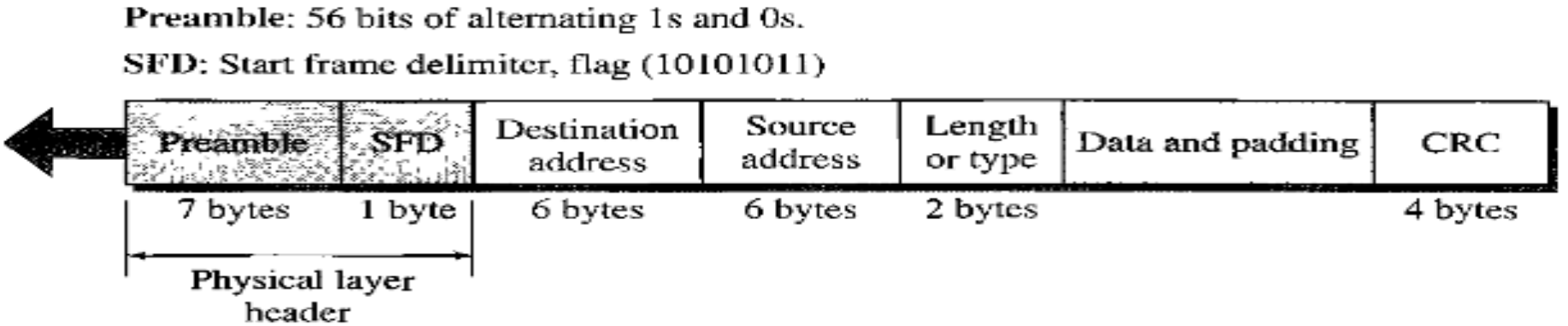
- Defines the specific access method (mutiple access methods) for each LAN
- Also handles framing

Standard Ethernet (802.3)

- Origial Ethernet was created in 1976 at Xerox's Palo Alto Research Center (PARC)
  - Standard Ethernet (10 Mbps)
  - Fast Ethernet (100 Mbps)
  - Gigabit Ethernet (1 Gbps)
  - Ten-Gigabit Ethernet (10 Gbps)

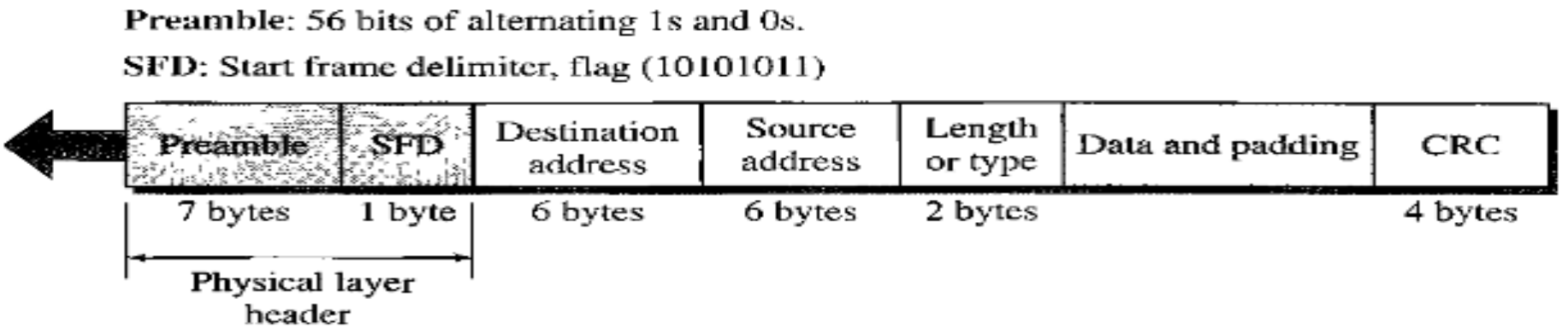
Standard Ethernet (802.3)

- Preamble – 7 bytes (56 bits) of alternating 0s and 1s, for synchronization
- Start of frame delimiter (SFD) – 10101011, signals the beginning of the frame
- Destination address (DA) – 6 bytes
- Source address (SA) – 6 bytes



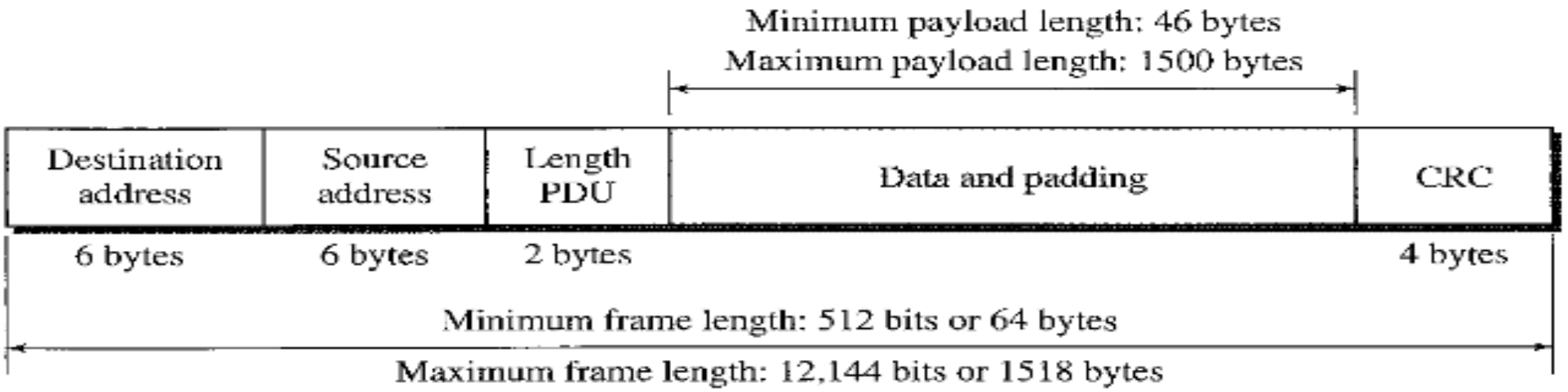
Standard Ethernet (802.3)

- Length or type – type of upper layer protocol or number of bytes in data field
- Data – carries data encapsulated from the upper-layer protocols, minimum of 46 and maximum of 1500 bytes
- CRC – CRC-32 for error detection



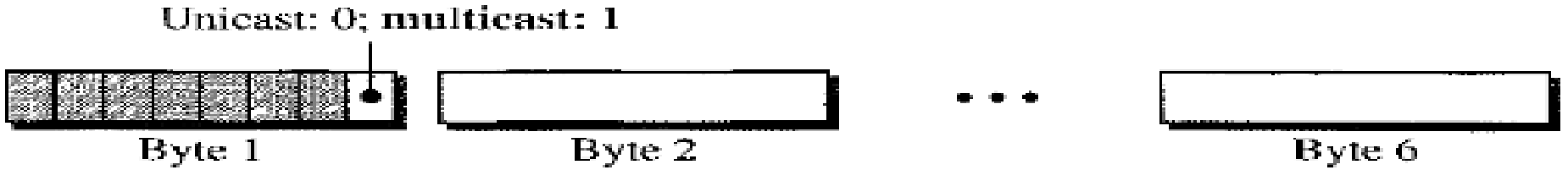
Standard Ethernet (802.3)

- Has minimum and maximum frame length
- Padding is added if minimum is not met
- Maximum length: reduce buffer size, prevent monopoly of link



Standard Ethernet (802.3)

- Network Interface Card (NIC) has a 6-byte (48 bits) physical address written in hex with colon between bytes
  - ex. 68:a3:c4:ce:8c:e2
- Destination address can be unicast, multicast, or broadcast; least significant bit of first byte determines the type; broadcast has all 1s



Standard Ethernet (802.3)

- Examples
  - 4A:30:10:21:10:1A → unicast (A is 1010)
  - 47:20:1B:2E:08:EE → multicast (7 is 0111)
  - FF:FF:FF:FF:FF:FF → broadcast
- Address is sent left to right: 47:20:1B:2E:08:EE
  - ← 11100010 00000100 11011000 .. and so on

Standard Ethernet (802.3)

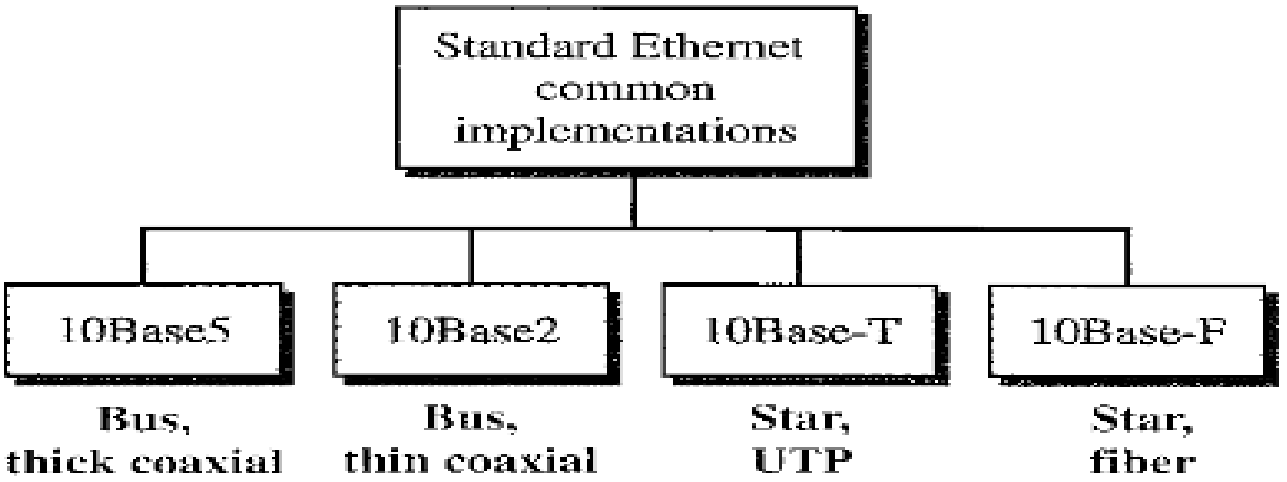
- Uses 1-persistent CSMA/CD
- Slot time = round-trip time + time to send jam sequence; time required for a station to send 512 bits; 51.2 micro seconds
- Why 512-bit slot time?
  - Sender needs to be aware that a collision has occurred before it is too late
  - Sender needs to listen only for a collision only during the time the first 512 bits are sent

Standard Ethernet (802.3)

- Maximum network length (aka collision domain)
- Dependent on propagation speed in the particular medium (2×10^8 m/s)
- MaxLength = PropSpeed x (SlotTime/2)
- For traditional Ethernet: MaxLength(Theoretical) = 5120m; Actual is 2500m (delays in repeaters)

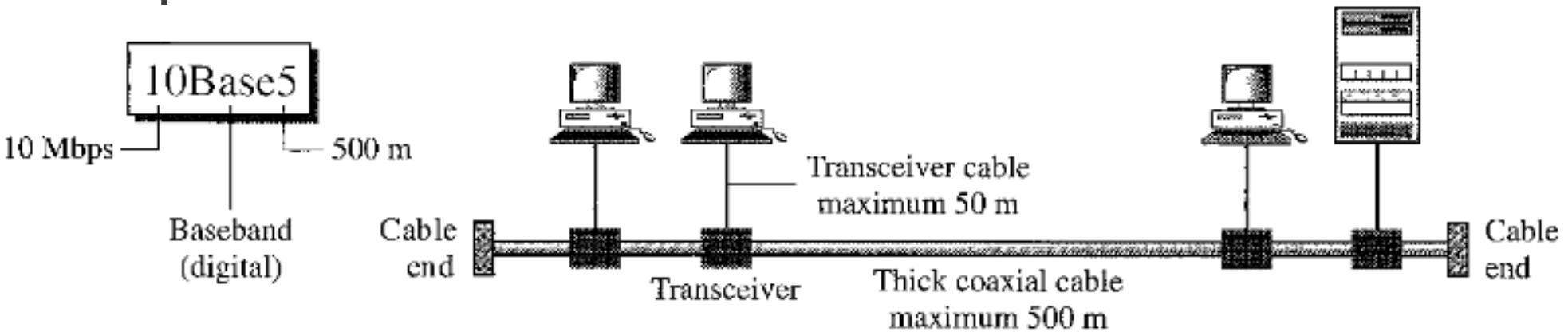
Standard Ethernet (802.3)

- Physical Layer implementations
- Uses digital signaling (baseband) at 10Mbps
- Uses Manchester encoding (self-timing)



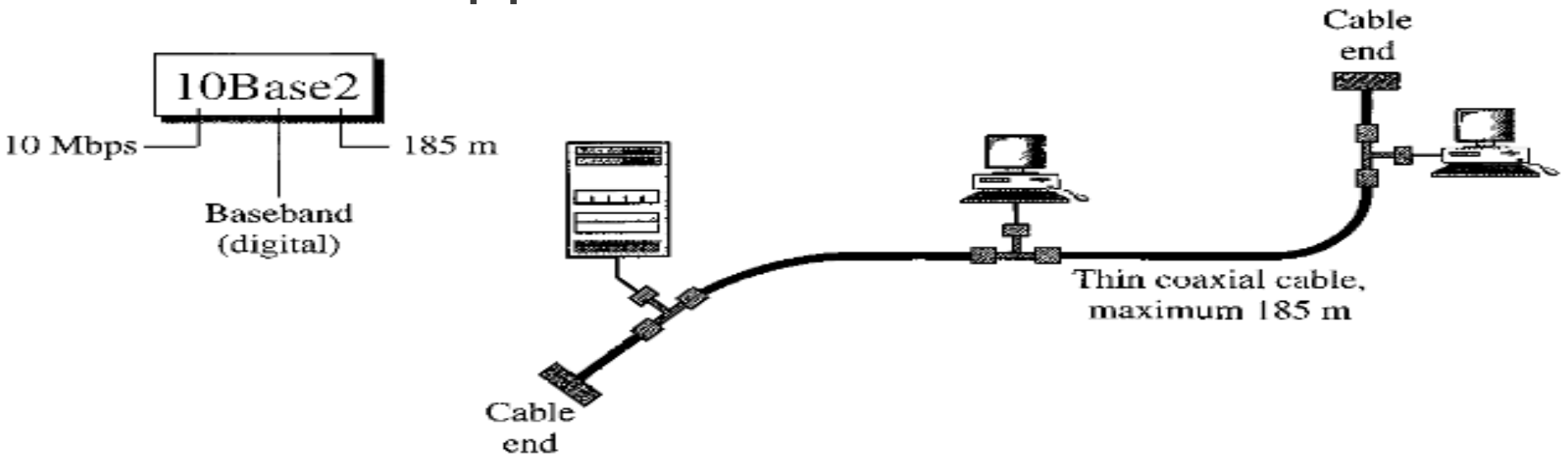
Standard Ethernet (802.3)

- 10Base5, thick Ethernet, Thicknet
- Uses bus topology using tranceivers (transmitter/receiver)
- Max length of coax must not exceed 500m
- Maximum of five segments connected with repeaters



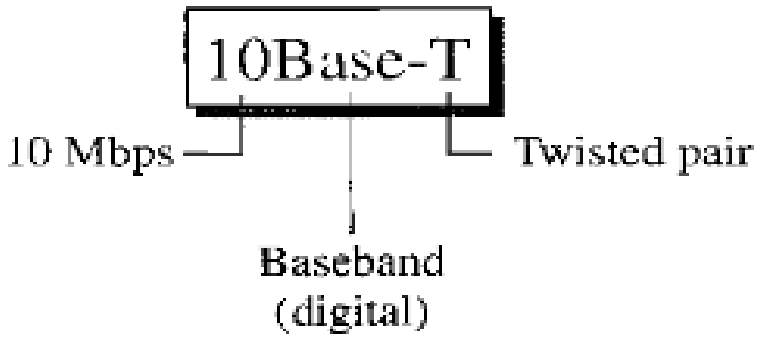
Standard Ethernet (802.3)

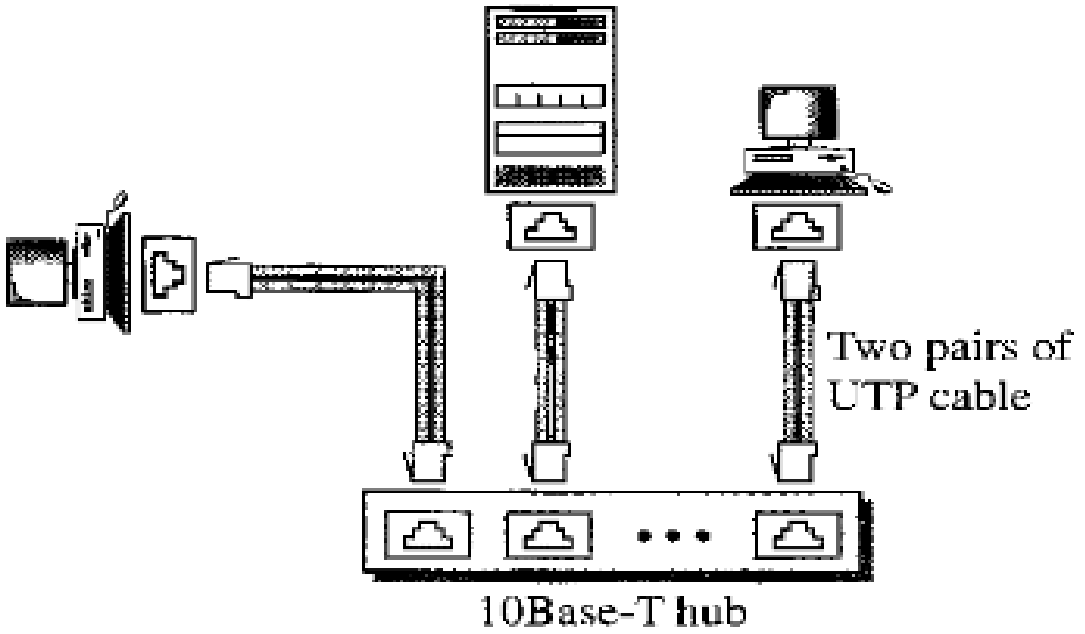
- 10Base2, thin Ethernet, Thinnet, Cheapernet
- Tranceiver part of network interface
- Less expensive, easy installation, length cannot exceed 185m
- Collisions happen in the cable



Standard Ethernet (802.3)

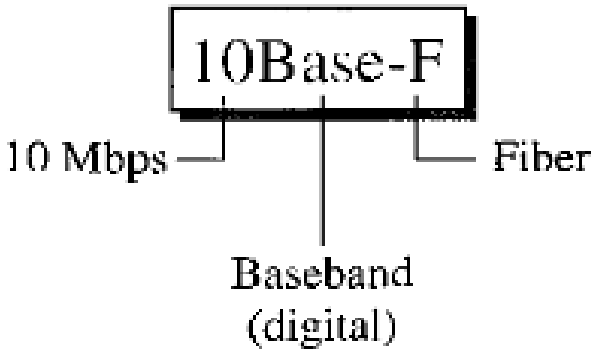
- 10Base-T, twisted-pair Ethernet
- Physical star topology;collisions happen in the hub;maximum length is 100m

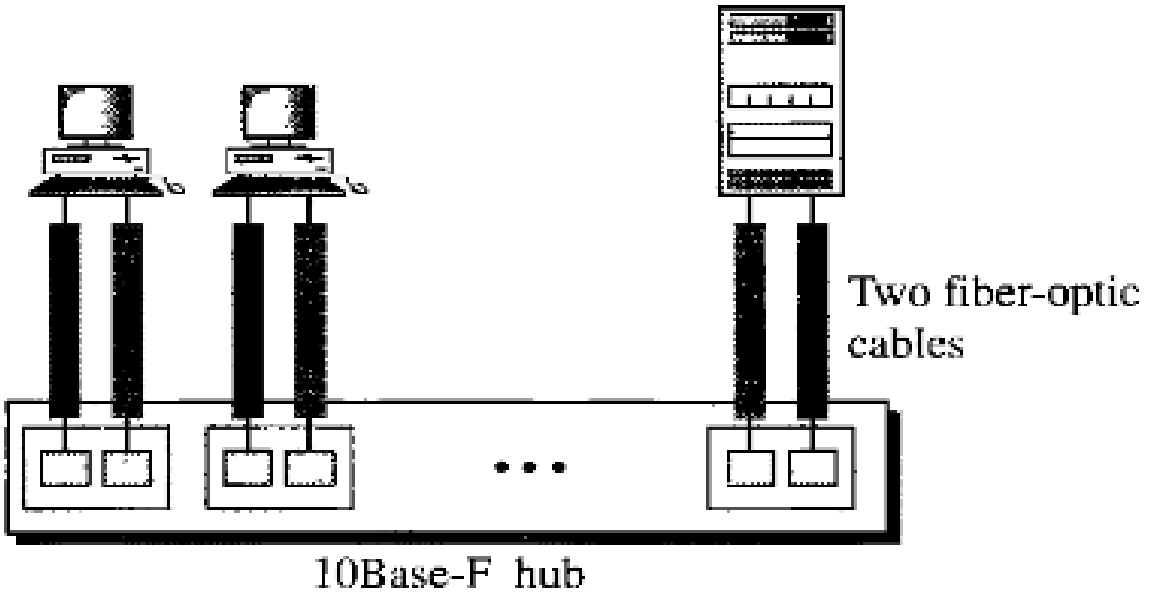




Standard Ethernet (802.3)

- 10Base-F
- Max length is 2000m





Standard Ethernet (802.3)

- Summary

Characteristics	*10Base5*	*10Base2*	*10Base-T*	*10Base-F*
Media	Thick coaxial cable	Thin coaxial cable	2 UTP	2 Fiber
Maximum length	500 m	185 m	100 m	2000 m
Line encoding	Manchester	Manchester	Manchester	Manchester

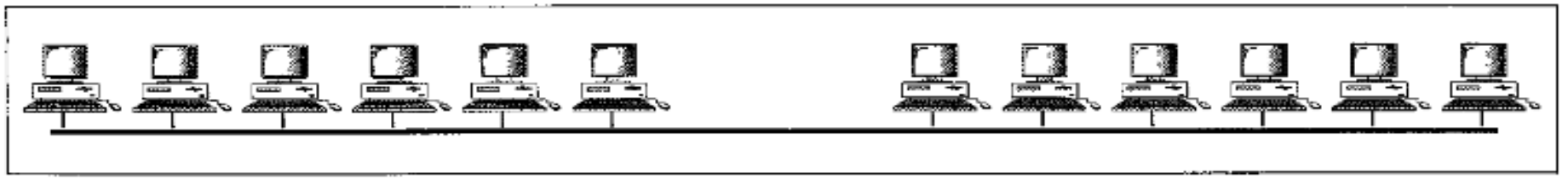
Bridged Ethernet

- Two effects of bridges
  - Raise the bandwidth
  - Separate collision domains

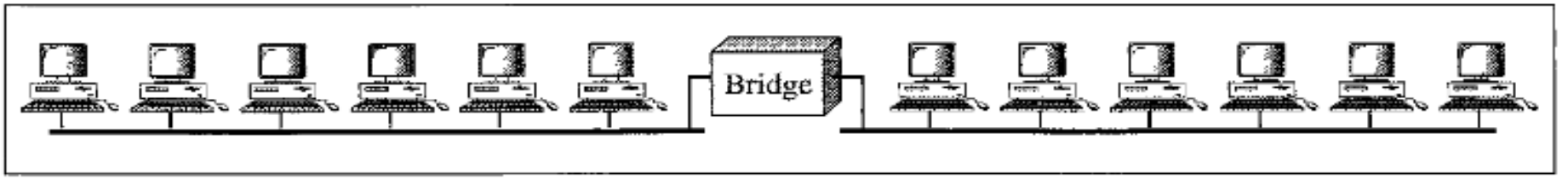
Bridged Ethernet

- In unbridged Ethernet, 10Mbps is shared among all stations with a frame to send
- If two stations has a lot of frames to send, they alternate in usage; on the average each stations sends 5 Mbps
- A bridge divides the network into two or more networks (raising the bandwidth)

Bridged Ethernet



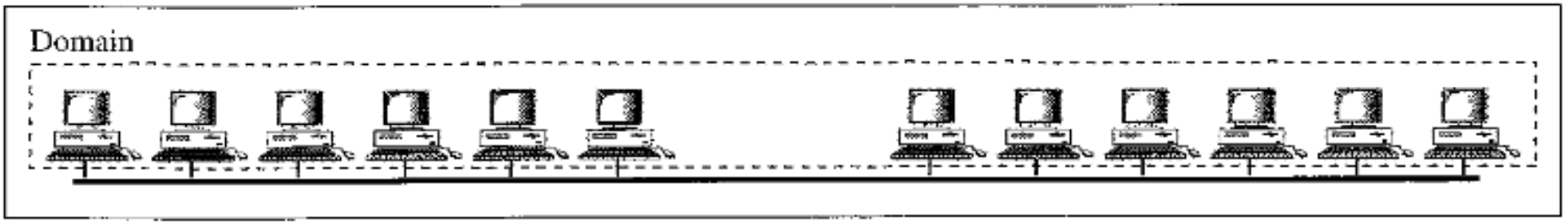
a. Without bridging



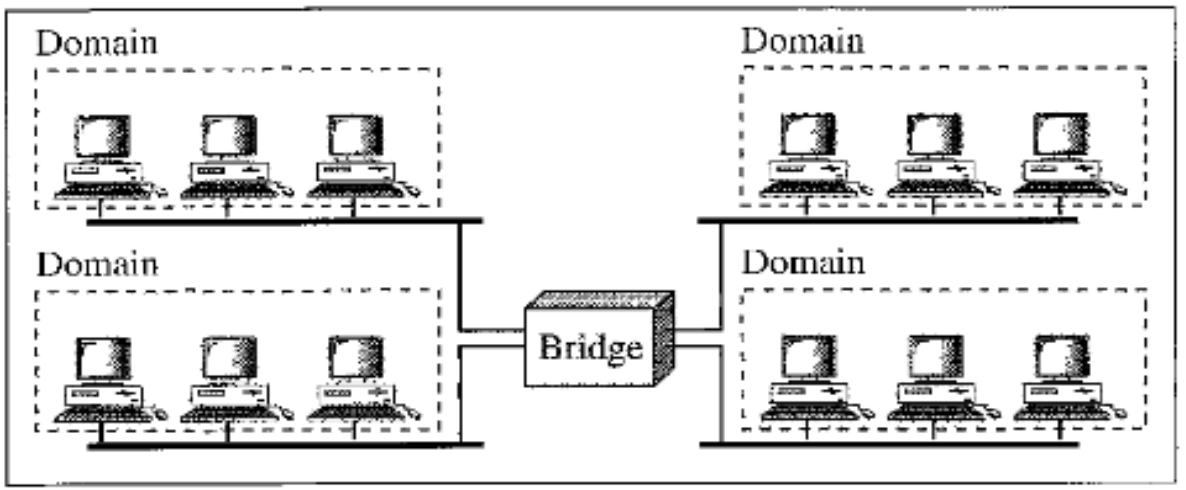
b. With bridging

Bridged Ethernet

- Collision domains



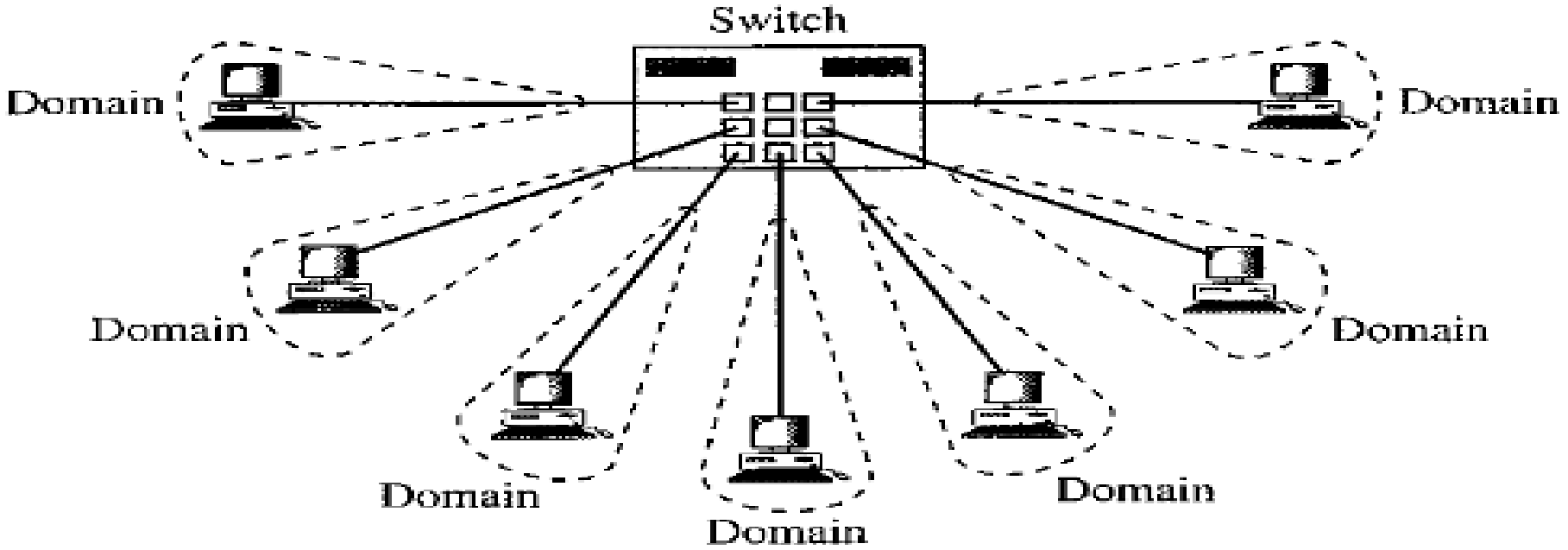
a. Without bridging



b. With bridging

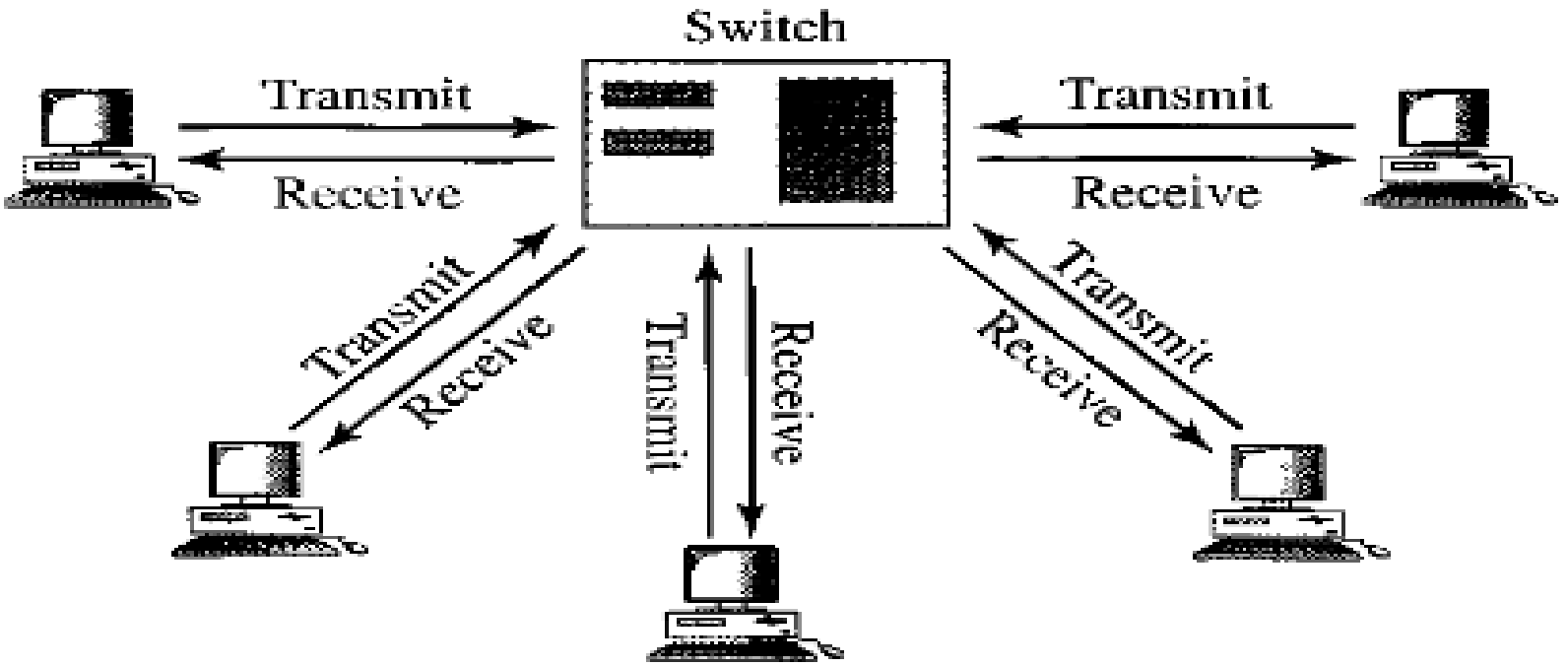
Switched Ethernet

- A layer 2 switch is an N-port bridge with additional sophistication that allows faster handling of packets; bandwidth is shared only between the station and the switch



Full-Duplex Switched Ethernet

- 10Base5 and 10Base2 are half-duplex
- No need for CSMA/CD



Fast Ethernet

- Designed to compete with FDDI
- 802.3u
- Backwards compatible with Standard Ethernet
- 100 Mbps

Fast Ethernet

- Goals
  - Upgrade the data rate to 100 Mbps
  - Make it compatible with Standard Ethernet
  - Keep the same 48-bit address
  - Keep the same frame format
  - Keep the same minimum and maximum frame lengths

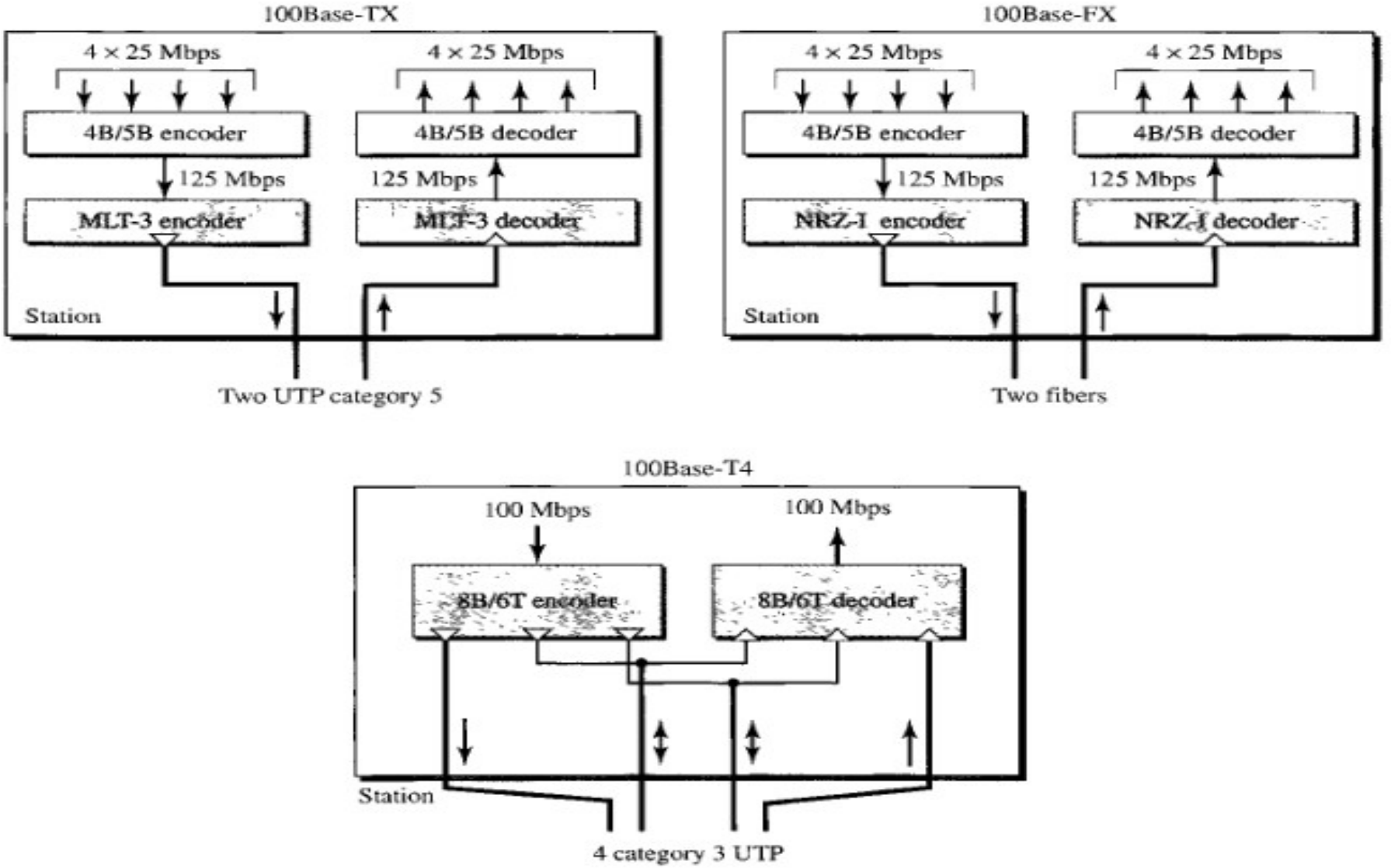
Fast Ethernet

- Keep the MAC sublayer untouched
- Only supports star topology
- CSMA/CD for half-duplex
- Autonegotiation – allows two devices to negotiate the mode or data rate of operation
  - Allow incompatible devices to connect (10 Mbps and 100Mbps)
  - Allow device to have multiple capabilities
  - Allow a station to check hub's capabilities

Fast Ethernet

- Topology may be point-to-point if only two stations
- 100Base-TX – two wires CAT 5 UTP
- 100Base-FX – two wires fiber
- 100Base-T4 – four wires CAT 3 UTP
- Manchester encoding is not suitable (needs 200-Mbaud)

Fast Ethernet



Fast Ethernet

Characteristics	*100Base-TX*	*100Base-FX*	*100Base-T4*
Media	Cat 5 UTP or STP	Fiber	Cat 4 UTP
Number of wires	2	2	4
Maximum length	100 m	100 m	100 m
Block encoding	4B/5B	4B/5B	
Line encoding	MLT-3	NRZ-I	8B/6T

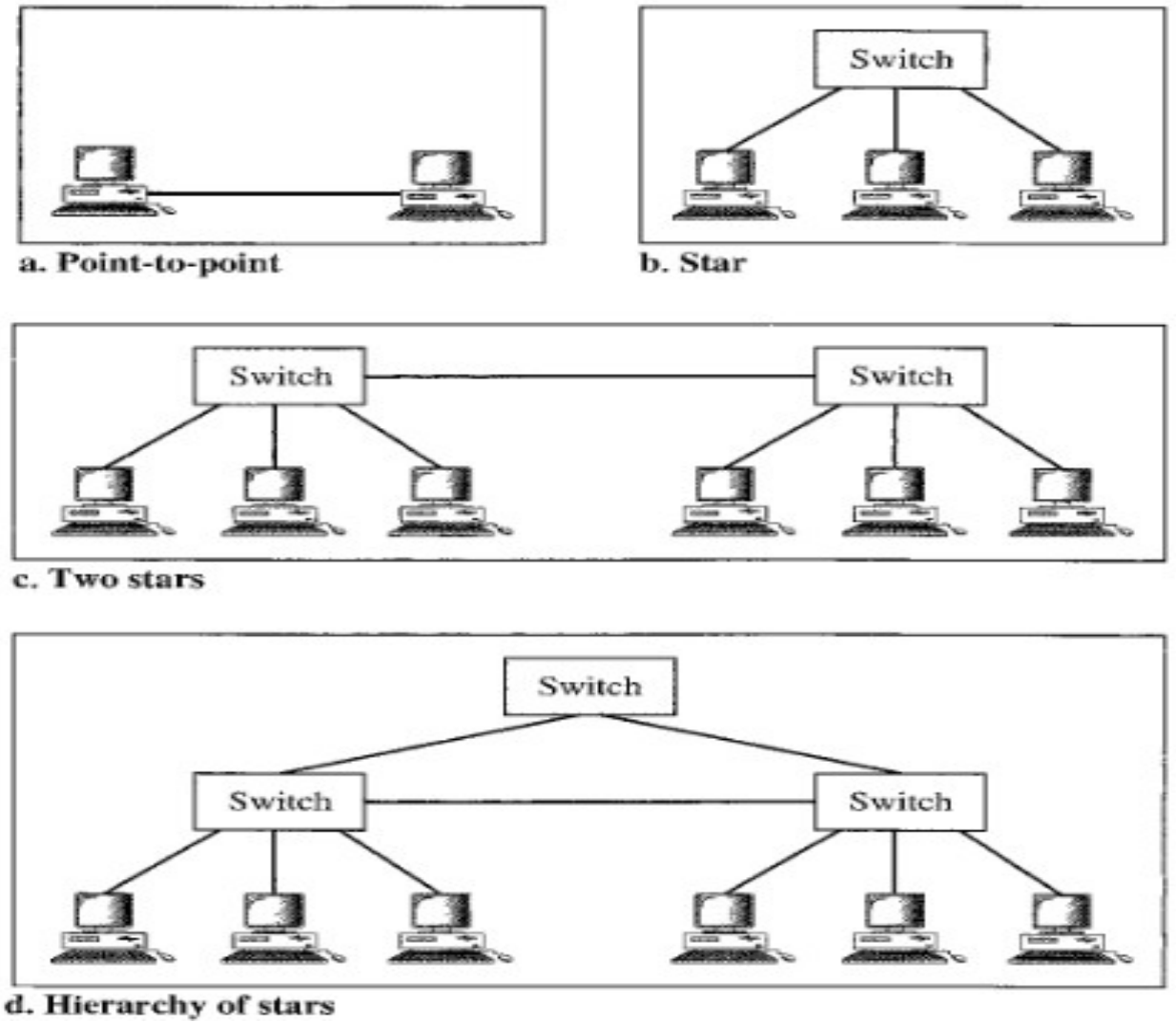
Gigabit Ethernet

- Goals
  - Upgrade data rate to 1 Gbps
  - Make it compatible with Standard or Fast Ethernet
  - Use the same 48-bit address
  - Use the same frame format
  - Keep same minimum and maximum frame lengths
  - To support autonegotiation as defined in Fast Ethernet

Gigabit Ethernet

- In full-duplex mode, there is no collision, and the maximum length of the cable is determined by the signal attenuation in the cable
- In half-duplex mode, uses CSMA/CD; three methods: traditional, carrier extension, frame bursting

Gigabit Ethernet



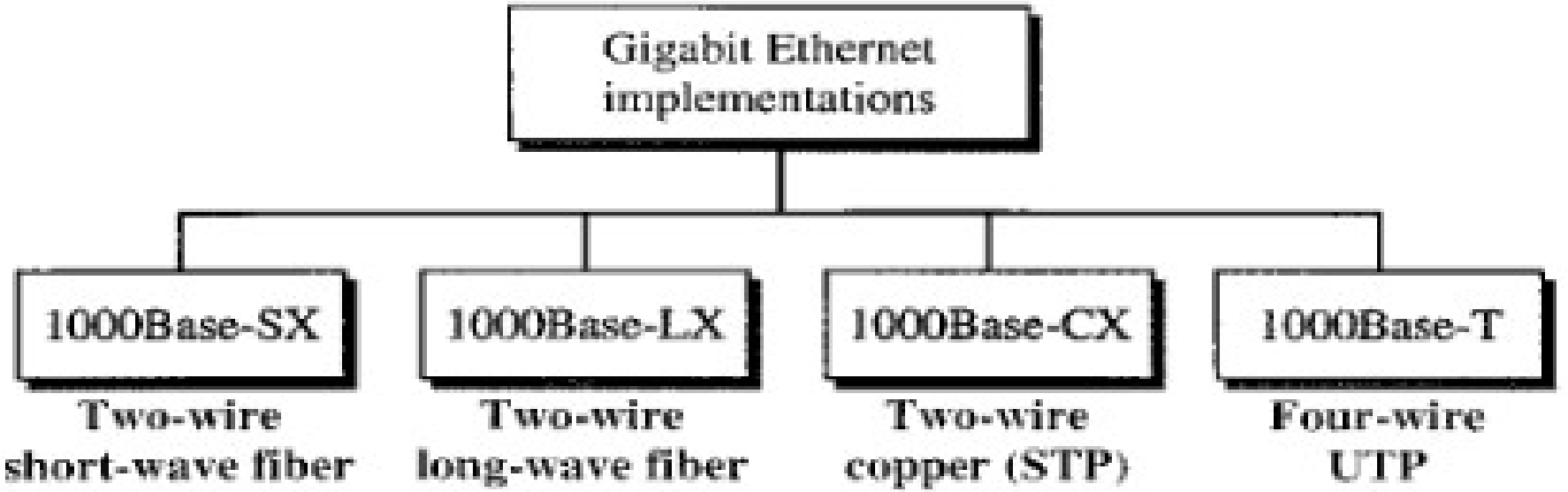
a. Point-to-point

b. Star

c. Two stars

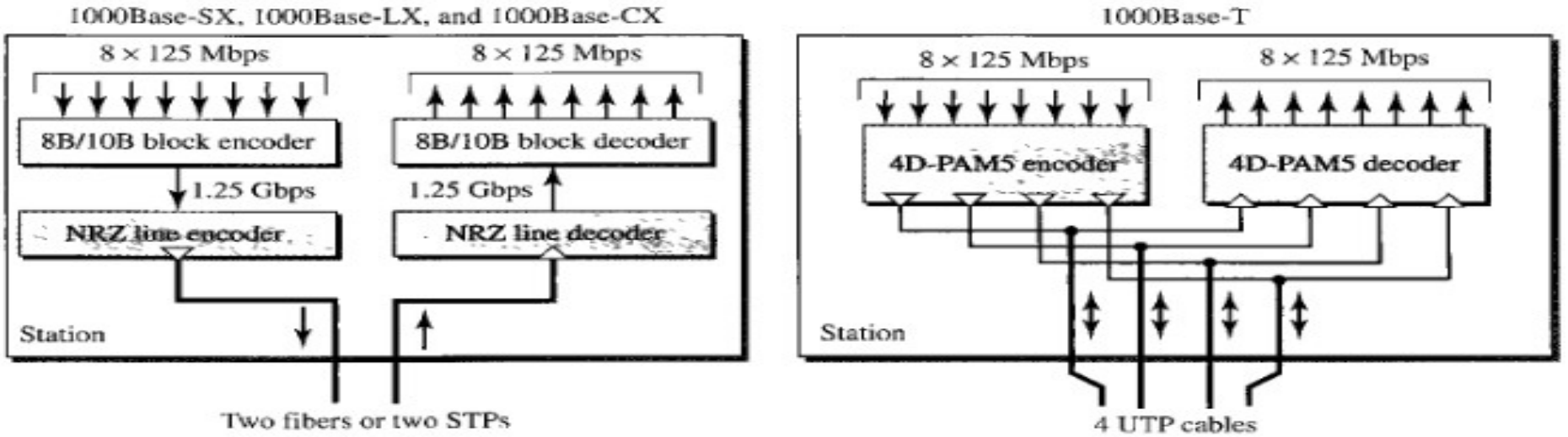
d. Hierarchy of stars

Gigabit Ethernet



Gigabit Ethernet

- Encoding



Gigabit Ethernet

- Summary

Characteristics	*1000Base-SX*	*1000Base-LX*	*1000Base-CX*	*1000Base-T*
Media	Fiber short-wave	Fiber long-wave	STP	Cat 5 UTP
Number of wires	2	2	2	4
Maximum length	550 m	5000 m	25 m	100 m
Block encoding	8B/10B	8B/10B	8B/10B	
Line encoding	NRZ	NRZ	NRZ	4D-PAM5

Ten-Gigabit Ethernet (802.3ae)

- Goals
  - Upgrade data rate to 10 Mbps
  - Make it compatible with Standard, Fast, and Gigabit Ethernet
  - Use the same 48-bit address
  - Use the same frame format
  - Keep same minimum and maximum frame lengths
  - Interconnect LANs to MANs or WANs
  - Make Ethernet compatible with Frame Relay and ATM

Ten-Gigabit Ethernet (802.3ae)

Characteristics	*10GBase-S*	*10GBase-L*	*10GBase-E*
Media	Short-wave 850-nm multimode	Long-wave 1310-nm single mode	Extended 1550-mm single mode
Maximum length	300 m	10 km	40 km

Enjoy! :)