# Chapter 13-Wired LANs Ethernet

# Figure 13.1 *IEEE standard for LANs*

LLC: Logical link control
MAC: Media access control
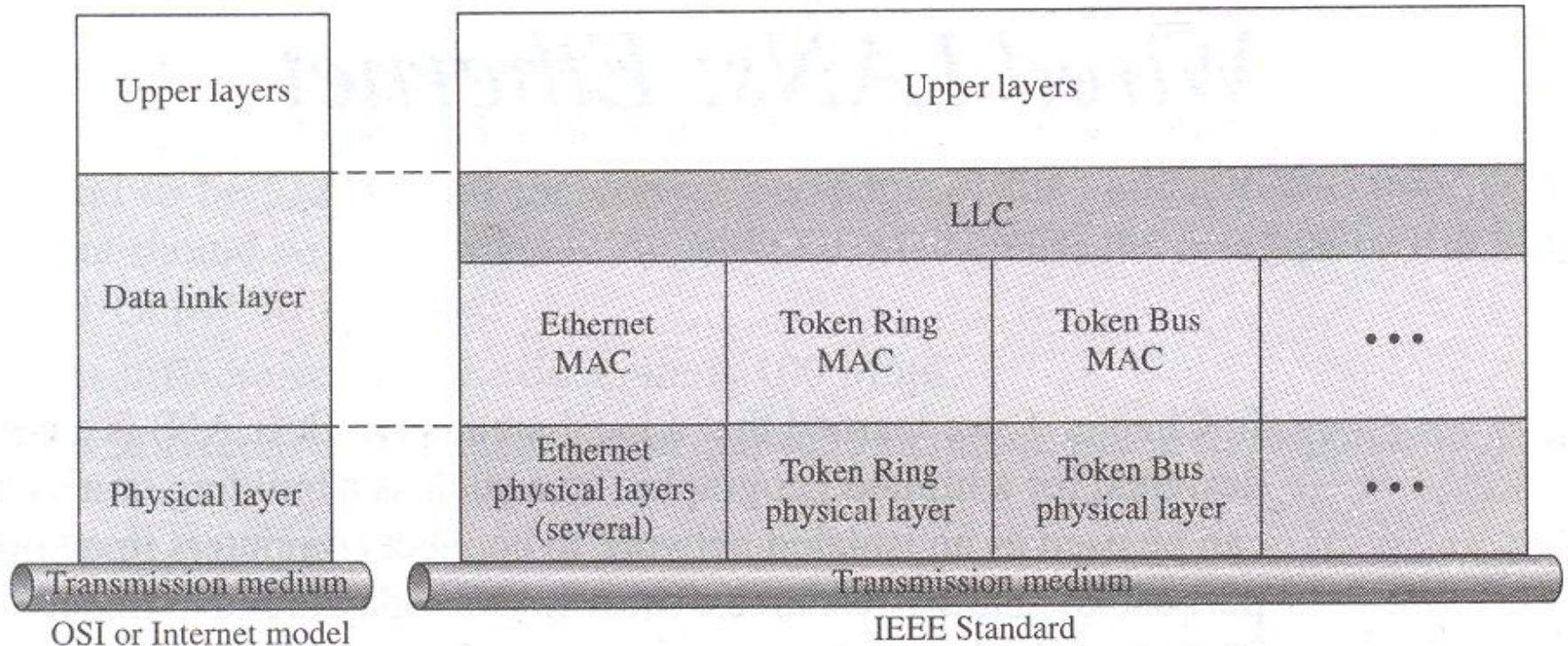
| Upper layers | | Upper layers | | | |
|---|---|---|---|---|---|
| Data link layer | | LLC | | | |
| | | Ethernet MAC | Token Ring MAC | Token Bus MAC | • • • |
| Physical layer | | Ethernet physical layers (several) | Token Ring physical layer | Token Bus physical layer | • • • |
| Transmission medium | | Transmission medium | | | |

OSI or Internet model        IEEE Standard

2

# Figure 13.2 HDLC frame compared with LLC and MAC frames

**DSAP**: Destination service access point
**SSAP**: Source service access point



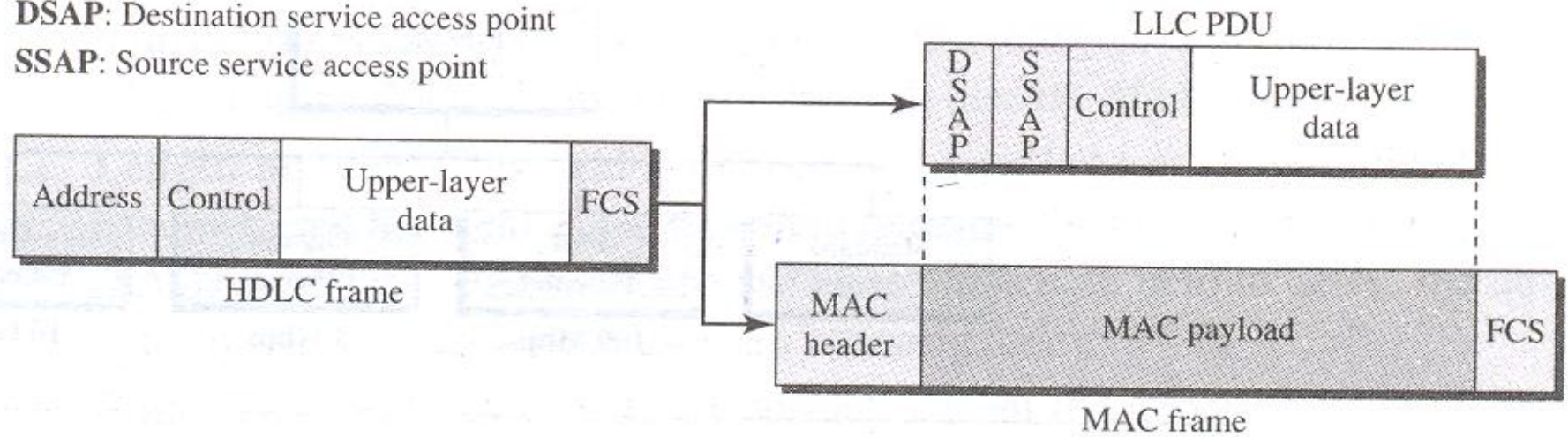LLC PDU

| D S A P | S S A P | Control | Upper-layer data |

| Address | Control | Upper-layer data | FCS |

HDLC frame

| MAC header | MAC payload | FCS |

MAC frame

# Figure 13.3 Ethernet evolution through four generations



| | | | |
|---|---|---|---|
| Standard Ethernet | Fast Ethernet | Gigabit Ethernet | Ten-Gigabit Ethernet |
| 10 Mbps | 100 Mbps | 1 Gbps | 10 Gbps |
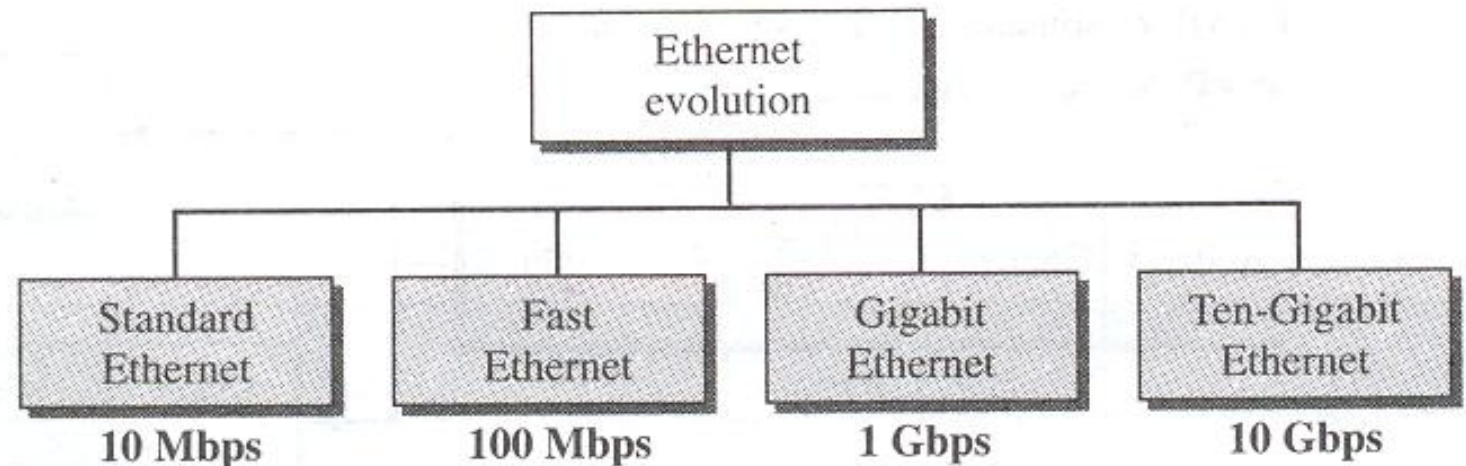
# Figure 13.4 802.3 MAC frame

**Preamble**: 56 bits of alternating 1s and 0s.

**SFD**: Start frame delimiter, flag (10101011)



| Preamble | SFD | Destination address | Source address | Length or type | Data and padding | CRC |
|---|---|---|---|---|---|---|
| 7 bytes | 1 byte | 6 bytes | 6 bytes | 2 bytes | | 4 bytes |

Physical layer header
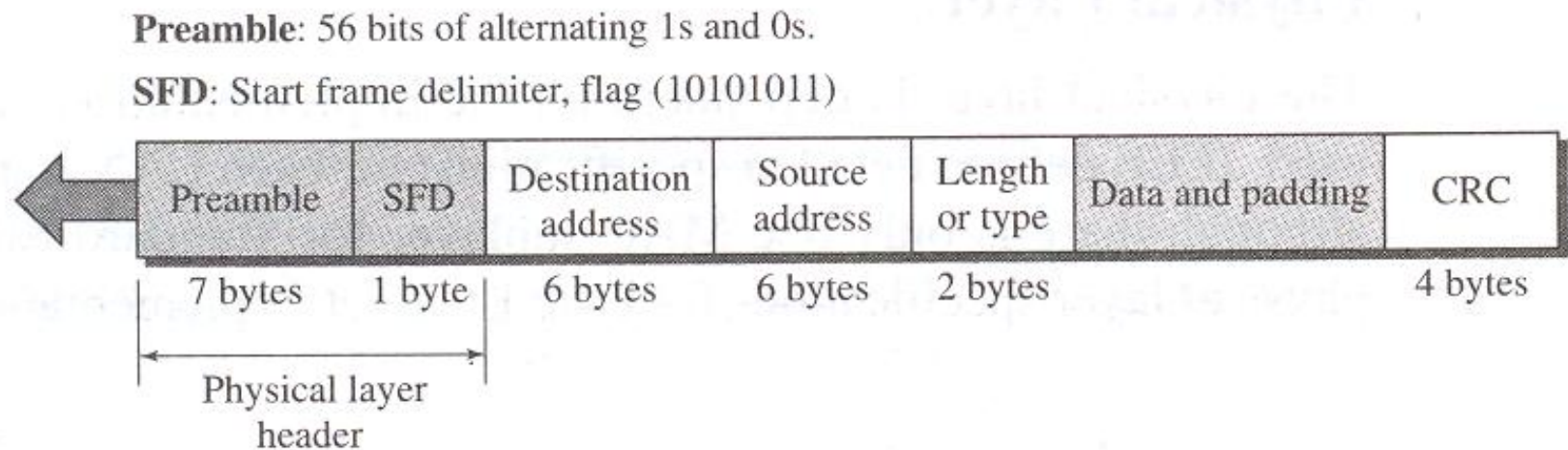
# Figure 13.5 Minimum and maximum lengths

Minimum payload length: 46 bytes
Maximum payload length: 1500 bytes

| Destination address | Source address | Length PDU | Data and padding | CRC |
|---|---|---|---|---|
| 6 bytes | 6 bytes | 2 bytes | | 4 bytes |

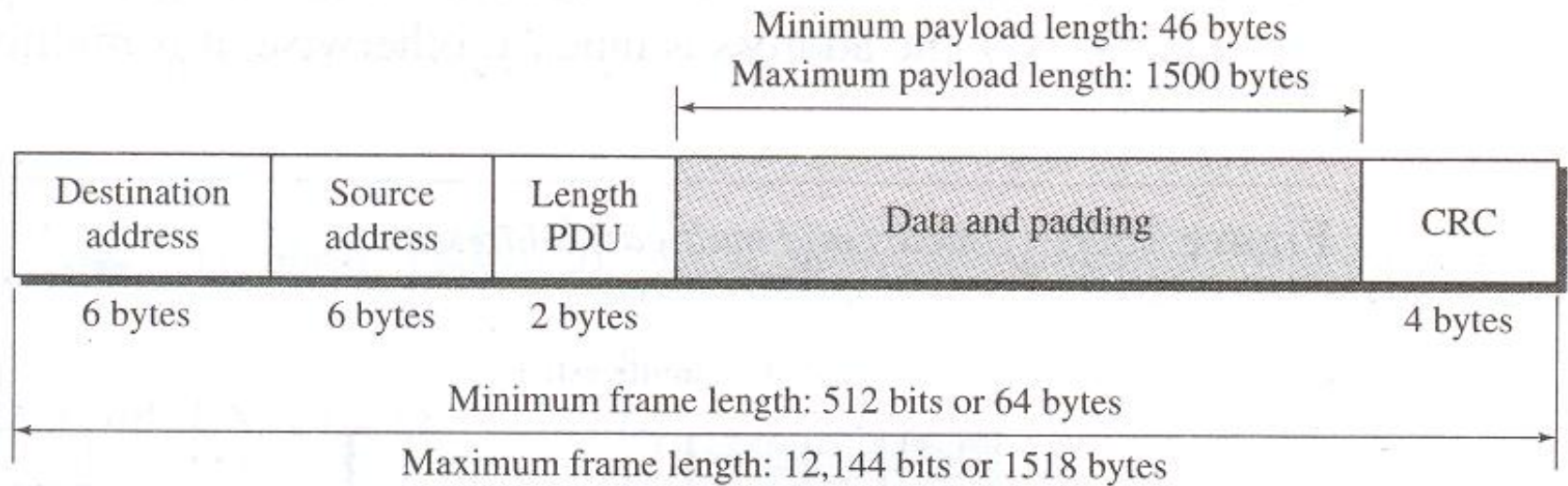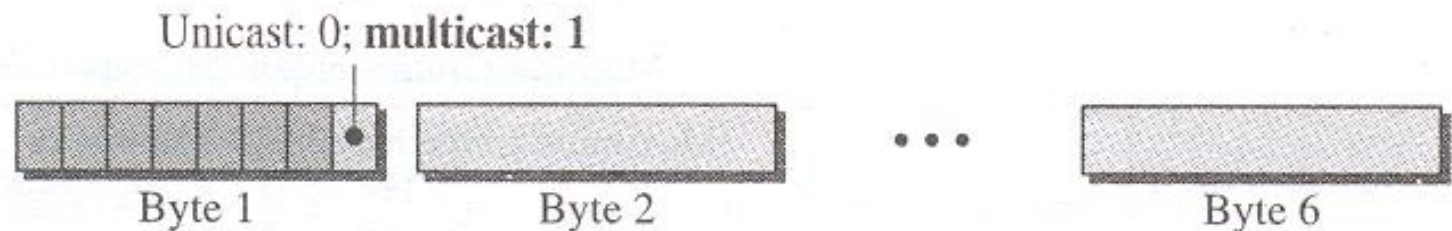Minimum frame length: 512 bits or 64 bytes
Maximum frame length: 12,144 bits or 1518 bytes

**Figure 13.6** *Example of an Ethernet address in hexadecimal notation*

$$06 : 01 : 02 : 01 : 2C : 4B$$

6 bytes = 12 hex digits = 48 bits

**Figure 13.7** *Unicast and multicast addresses*

Unicast: 0; **multicast: 1**

Byte 1          Byte 2          • • •          Byte 6

## Example 13.1

Define the type of the following destination addresses:

    a.  4A:30:10:21:10:1A

    b.  47:20:1B:2E:08:EE

    c.  FF:FF:FF:FF:FF:FF

## Solution

To find the type of the address, we need to look at the second hexadecimal digit from the left. If it is even, the address is unicast. If it is odd, the address is multicast. If all digits are F's, the address is broadcast. Therefore, we have the following:

    a.  This is a unicast address because A in binary is 1010 (even).

    b.  This is a multicast address because 7 in binary is 0111 (odd).

    c.  This is a broadcast address because all digits are F's.

The way the addresses are sent out on line is different from the way they are written in hexadecimal notation. The transmission is left-to-right, byte by byte; however, for each byte, the least significant bit is sent first and the most significant bit is sent last. This means that the bit that defines an address as unicast or multicast arrives first at the receiver.

## Example 13.2

Show how the address 47:20:1B:2E:08:EE is sent out on line.

## Solution

The address is sent left-to-right, byte by byte; for each byte, it is sent right-to-left, bit by bit, as shown below:

⟵  11100010 00000100 11011000 01110100 00010000 01110111

## Access Method: CSMA/CD

Standard Ethernet uses 1-persistent CSMA/CD (see Chapter 12).

**Slot Time**   In an Ethernet network, the round-trip time required for a frame to travel from one end of a maximum-length network to the other plus the time needed to send the jam sequence is called the slot time.

Slot time = round-trip time + time required to send the jam sequence

## Example 13.2

Show how the address 47:20:1B:2E:08:EE is sent out on line.

## Solution

The address is sent left-to-right, byte by byte; for each byte, it is sent right-to-left, bit by bit, as shown below:

⟵  11100010  00000100  11011000  01110100  00010000  01110111

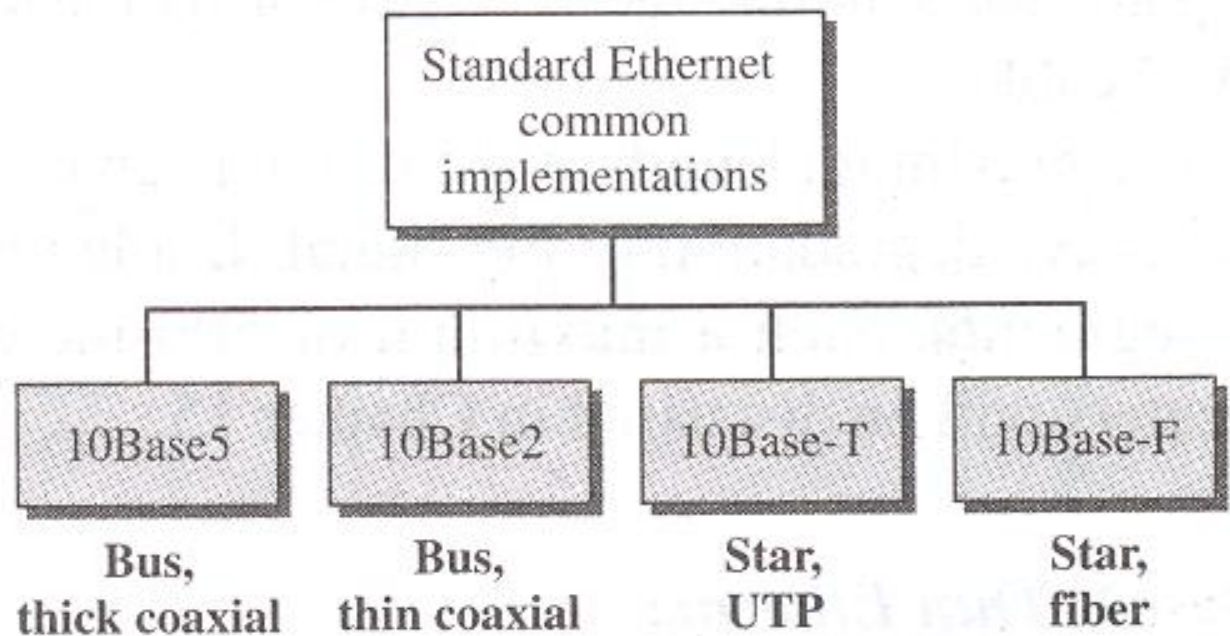# Figure 13.8   Categories of Standard Ethernet

```
                        ┌──────────────────────┐
                        │   Standard Ethernet   │
                        │        common         │
                        │    implementations    │
                        └───────────┬──────────┘
          ┌─────────────────┬───────┴───────┬─────────────────┐
    ┌───────────┐     ┌───────────┐   ┌───────────┐    ┌───────────┐
    │  10Base5  │     │  10Base2  │   │ 10Base-T  │    │ 10Base-F  │
    └───────────┘     └───────────┘   └───────────┘    └───────────┘
       Bus,              Bus,            Star,             Star,
    thick coaxial     thin coaxial       UTP               fiber
```

# Figure 13.9  Encoding in a Standard Ethernet implementation

10 Mbps data

Manchester
encoder

10 Mbps data

Manchester
decoder

Station

Twisted pairs or fibers
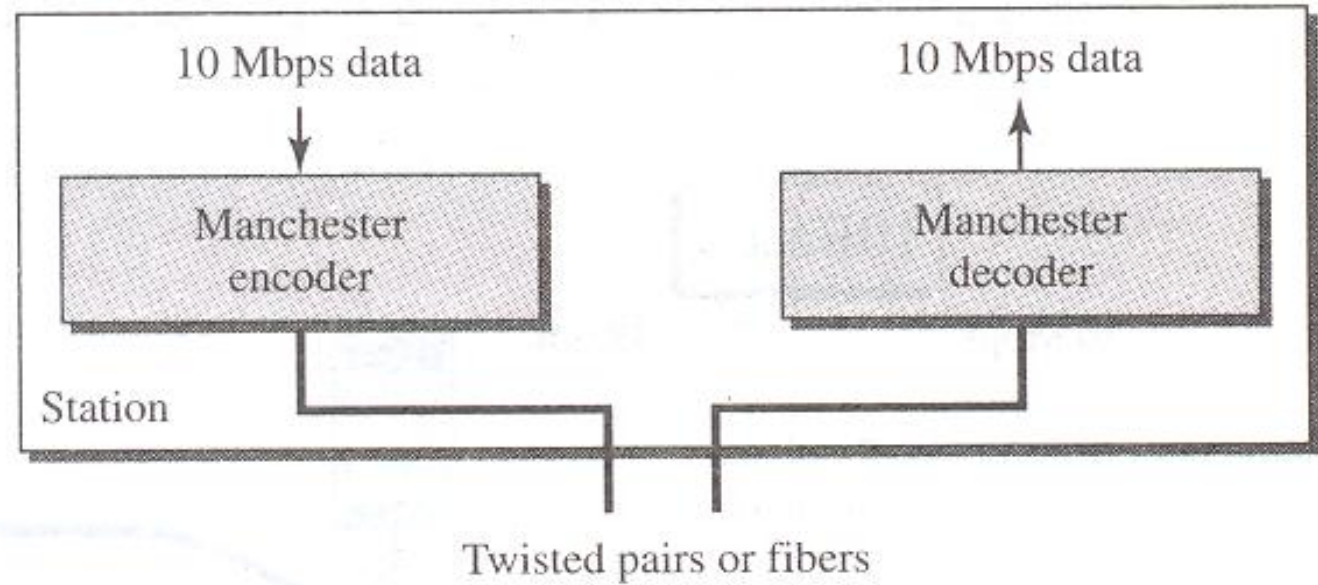
# Figure 13.10    10Base5 implementation
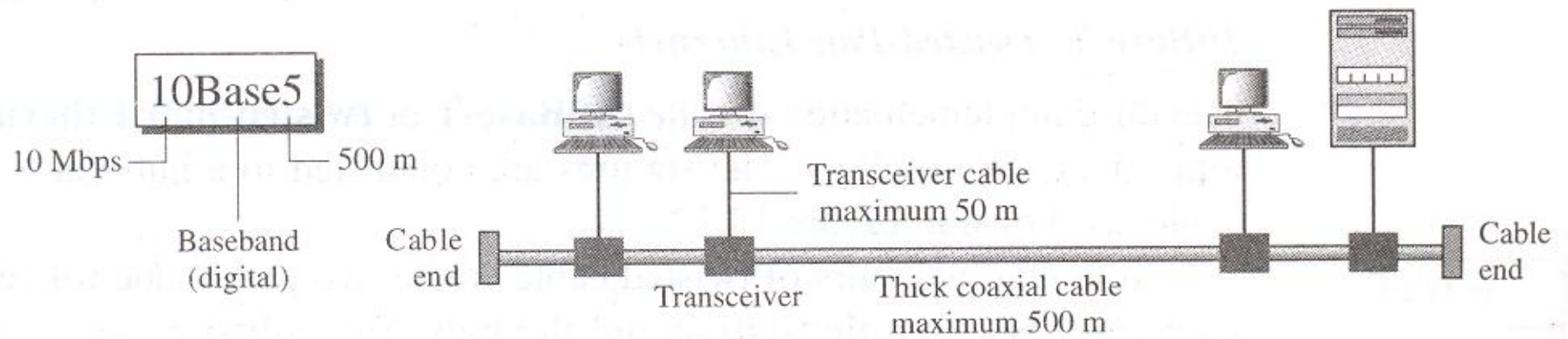
# Figure 13.11 *10Base2 implementation*

10Base2

10 Mbps — 185 m

Baseband
(digital)

Cable
end

Thin coaxial cable,
maximum 185 m
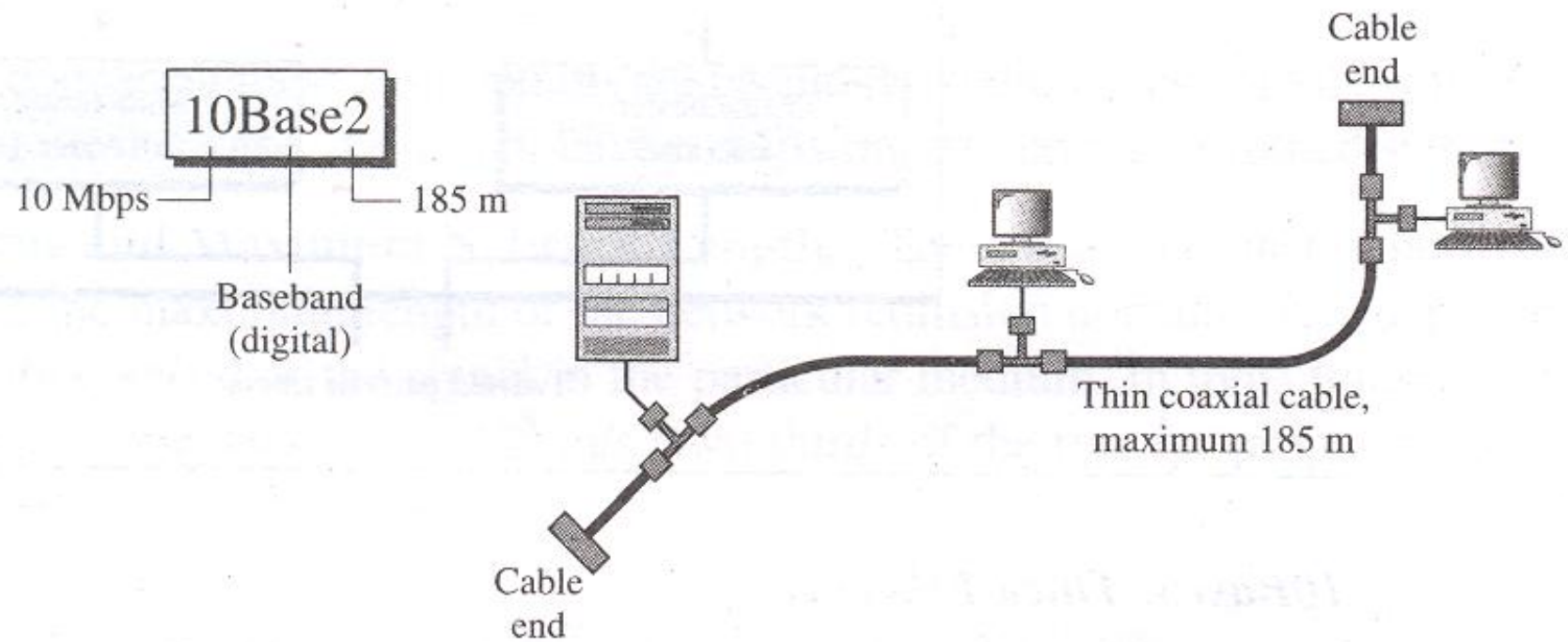
Cable
end

# Figure 13.12   10Base-T implementation

**10Base-T**

10 Mbps — Twisted pair

Baseband (digital)

Two pairs of UTP cable

10Base-T hub
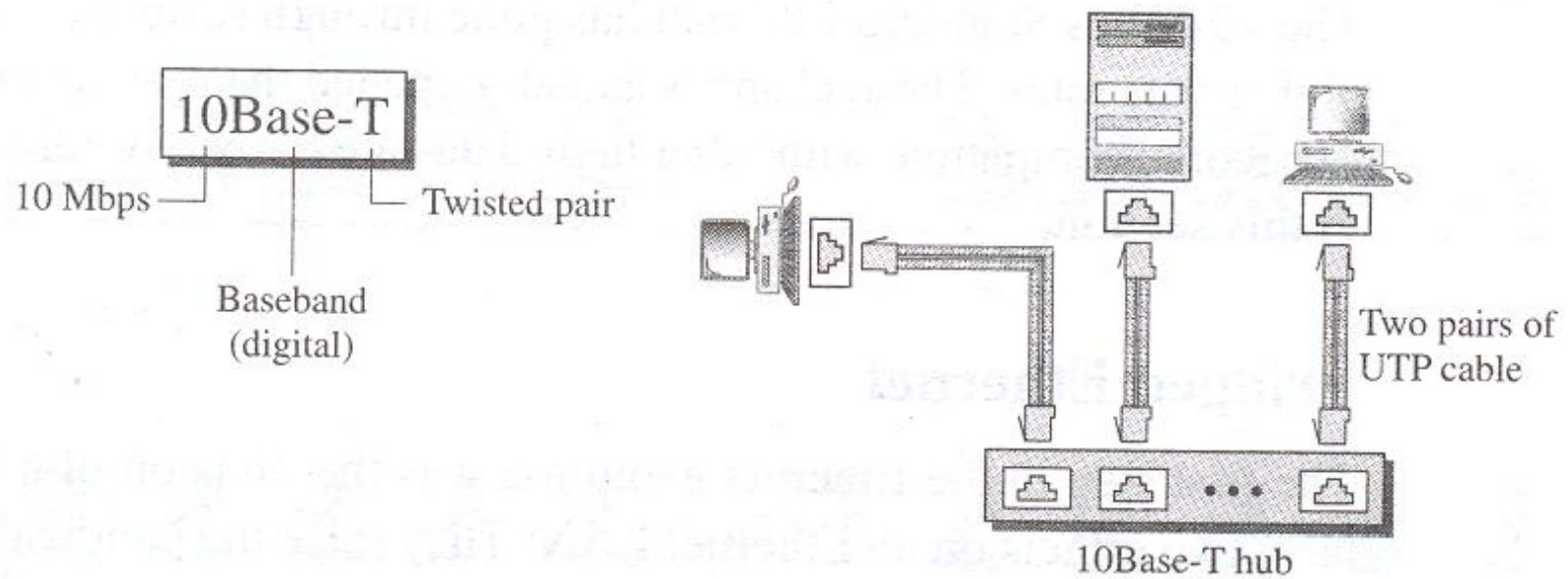
# Figure 13.13  10Base-F implementation



10Base-F

10 Mbps — | — Fiber

Baseband (digital)

Two fiber-optic cables

10Base-F  hub
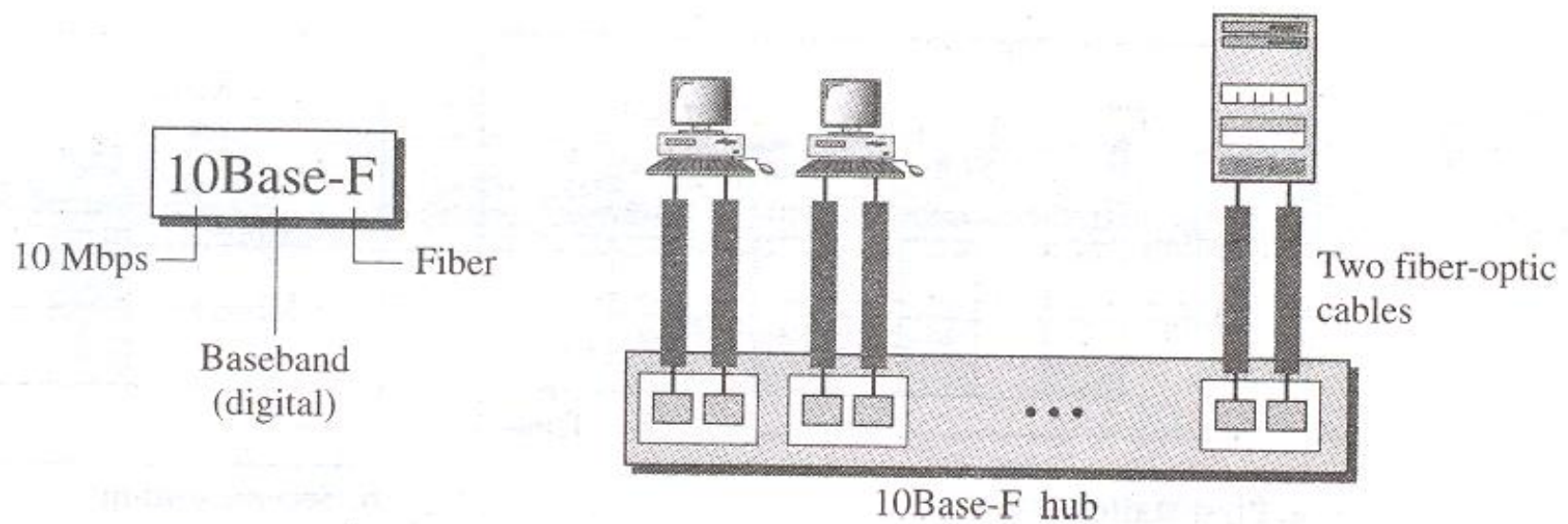
**Table 13.1** *Summary of Standard Ethernet implementations*

| 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 |

# Figure 13.14  *Sharing bandwidth*
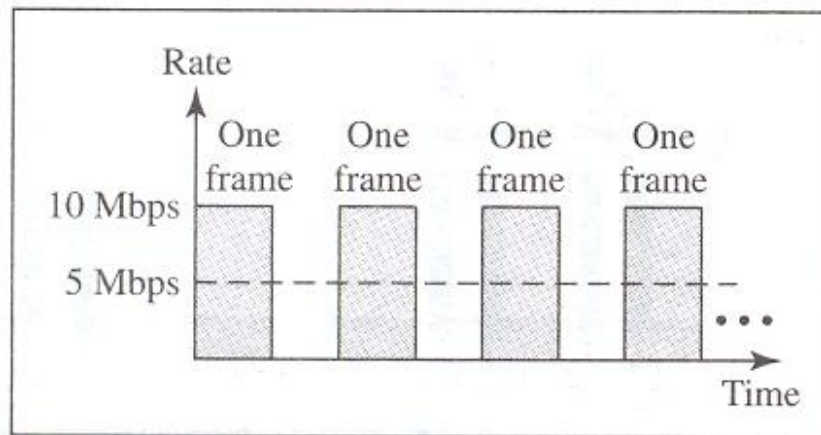


a. First station
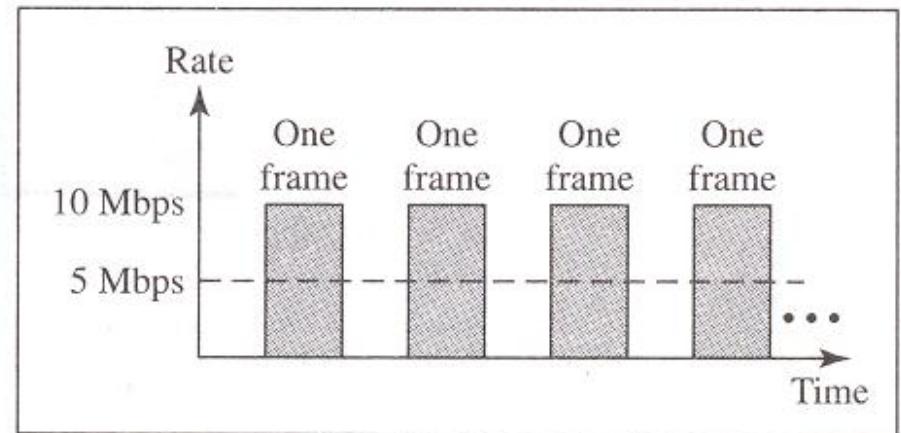
b. Second station

## Figure 13.15 A network with and without a bridge
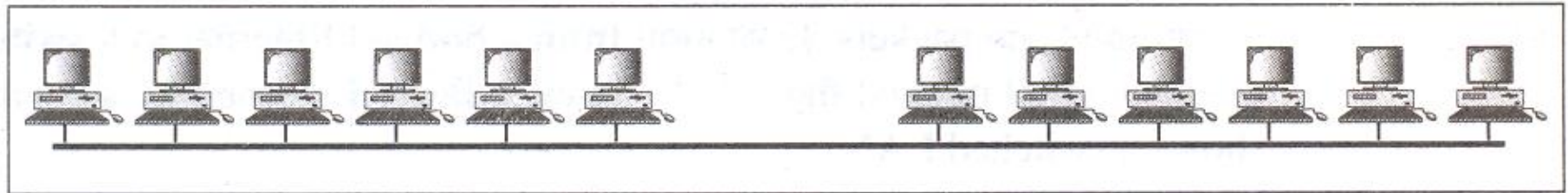


a. Without bridging
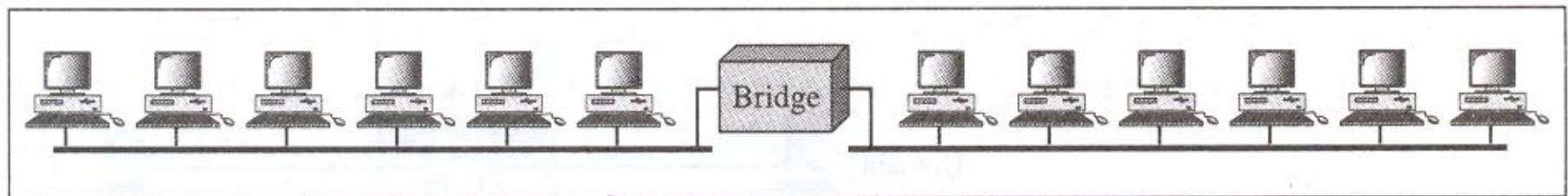
b. With bridging

**Figure 13.16** *Collision domains in an unbridged network and a bridged network*



Domain

**a. Without bridging**

Domain   Domain

Domain   Bridge   Domain
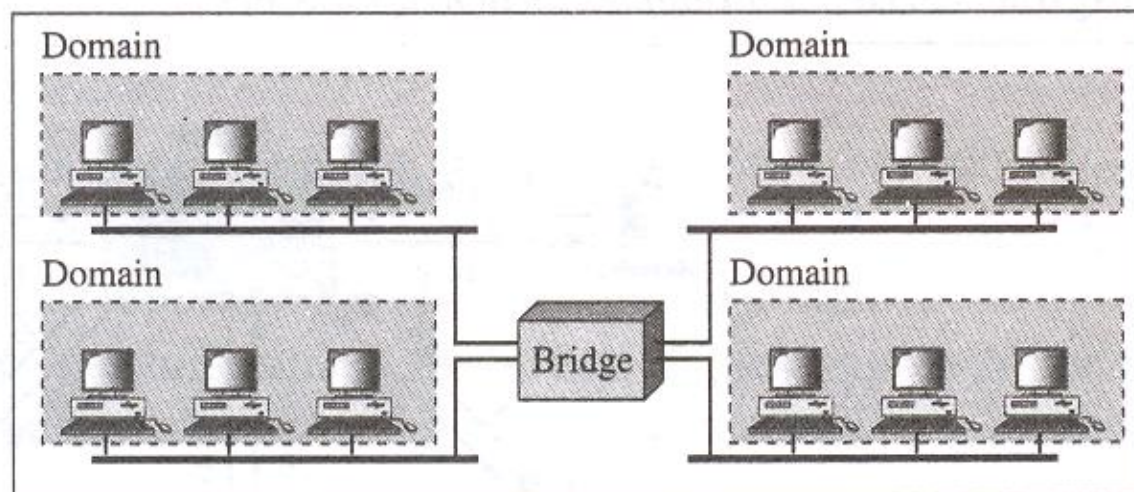
**b. With bridging**

# Figure 13.17  *Switched Ethernet*
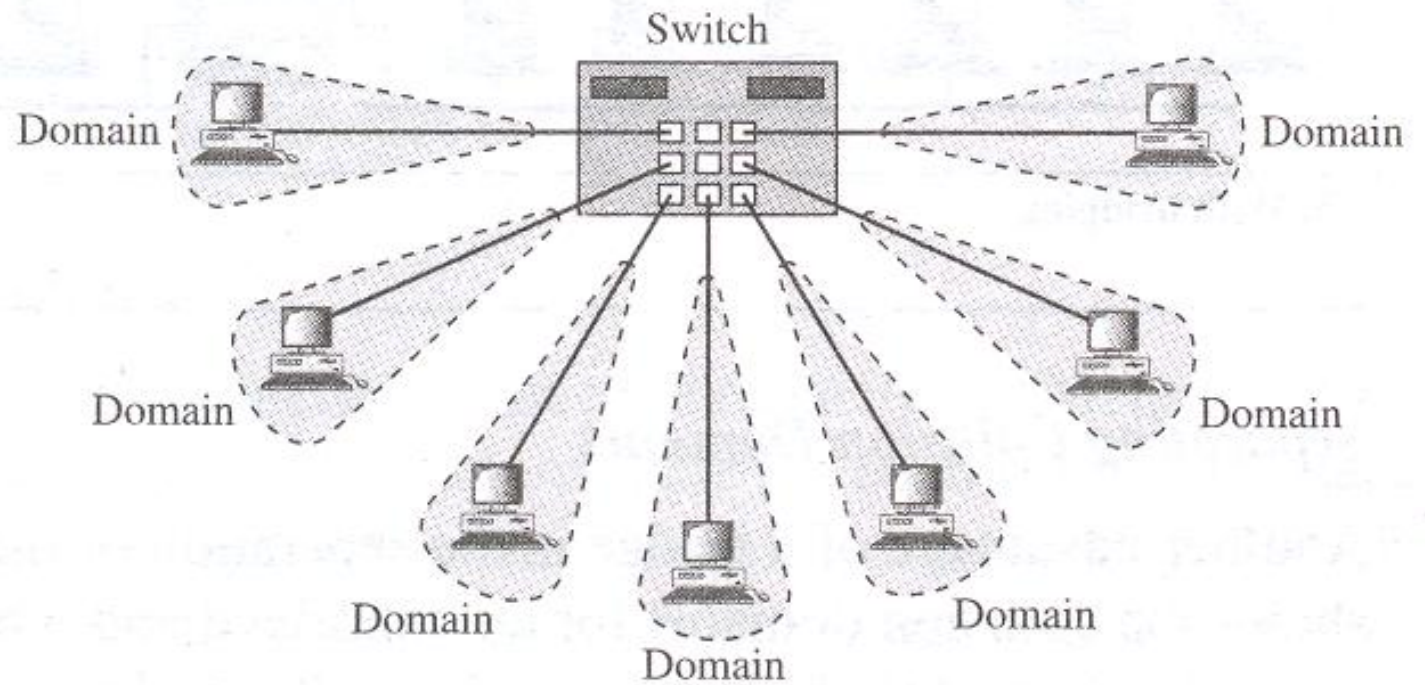
# Figure 13.18  *Full-duplex switched Ethernet*
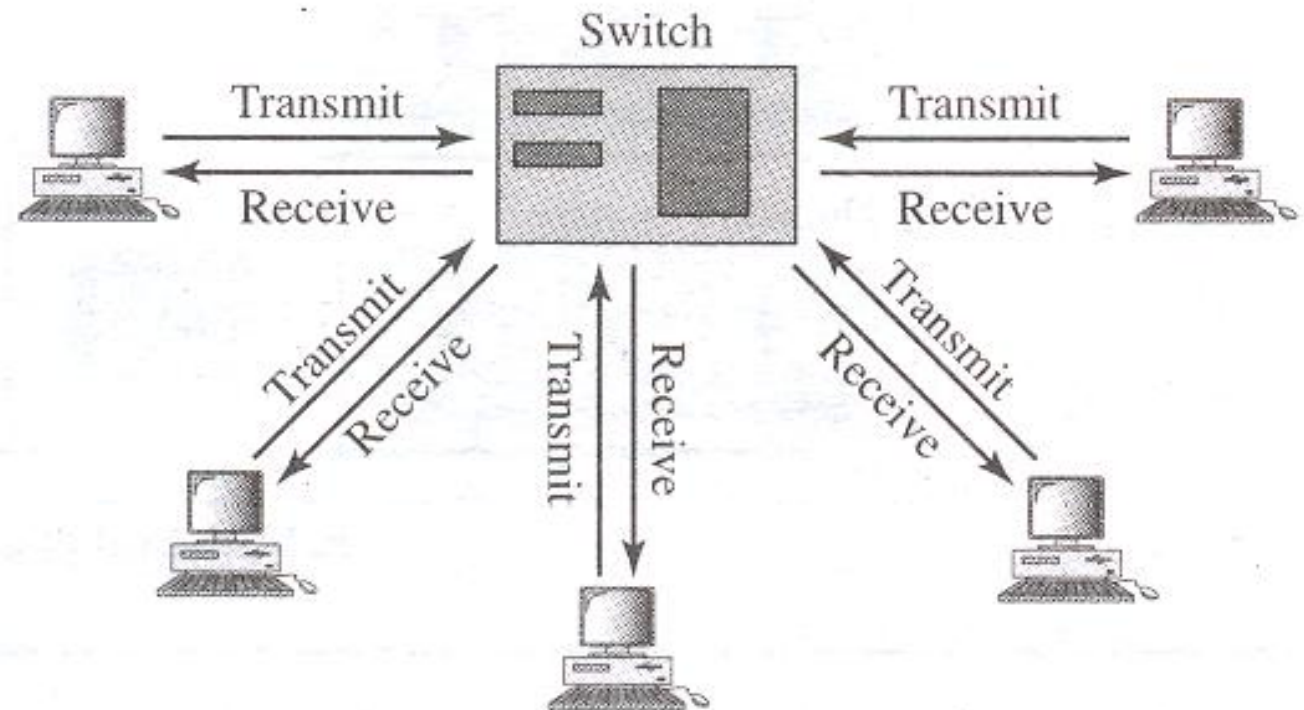
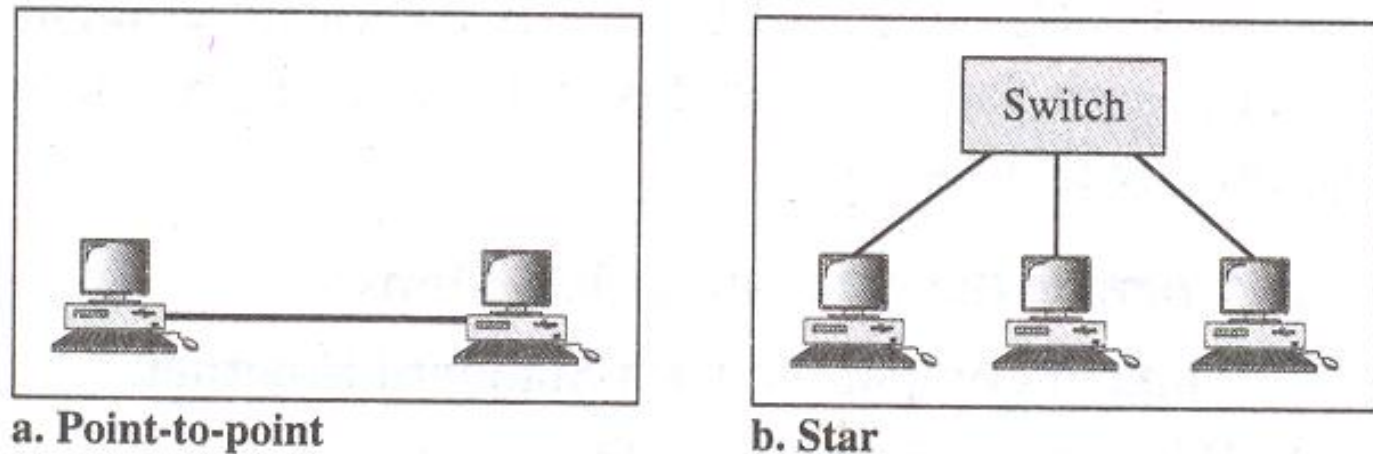**Figure 13.19** *Fast Ethernet topology*



a. Point-to-point

b. Star

**Figure 13.20** *Fast Ethernet implementations*



Common Fast Ethernet implementations

| 100Base-TX | 100Base-FX | 100Base-T4 |
| --- | --- | --- |
| Two wires category 5 UTP | Two wires fiber | Four wires category 3 UTP |
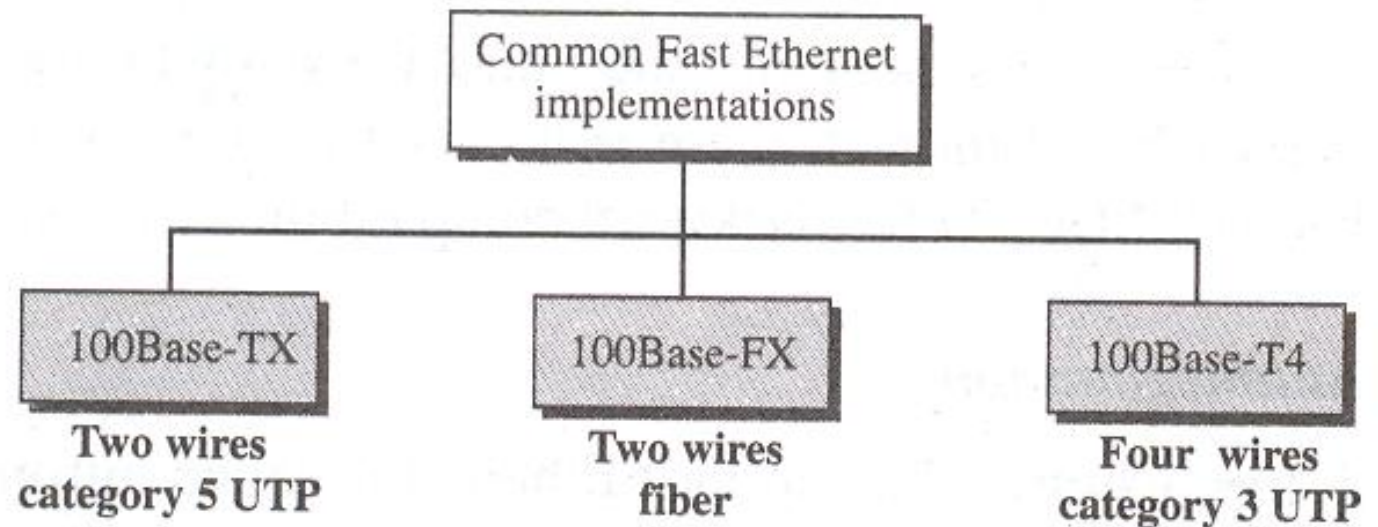
**Figure 13.21** *Encoding for Fast Ethernet implementation*



100Base-TX

4 × 25 Mbps    4 × 25 Mbps

4B/5B encoder    4B/5B decoder

125 Mbps    125 Mbps

MLT-3 encoder    MLT-3 decoder

Station

Two UTP category 5

100Base-FX

4 × 25 Mbps    4 × 25 Mbps

4B/5B encoder    4B/5B decoder

125 Mbps    125 Mbps

NRZ-I encoder    NRZ-I decoder

Station

Two fibers

100Base-T4

100 Mbps    100 Mbps

8B/6T encoder    8B/6T decoder

Station

4 category 3 UTP
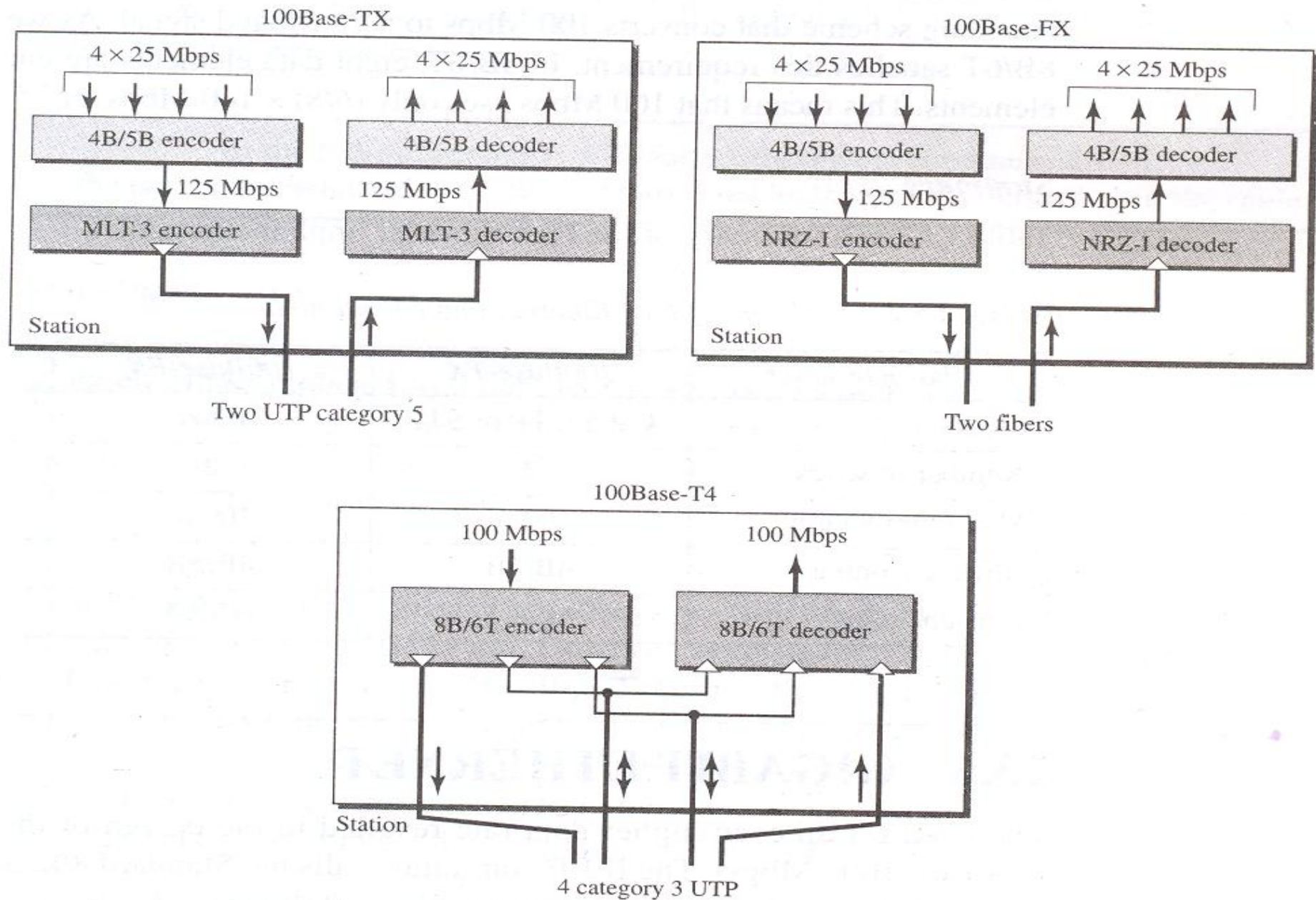
**Table 13.2**  *Summary of Fast Ethernet implementations*

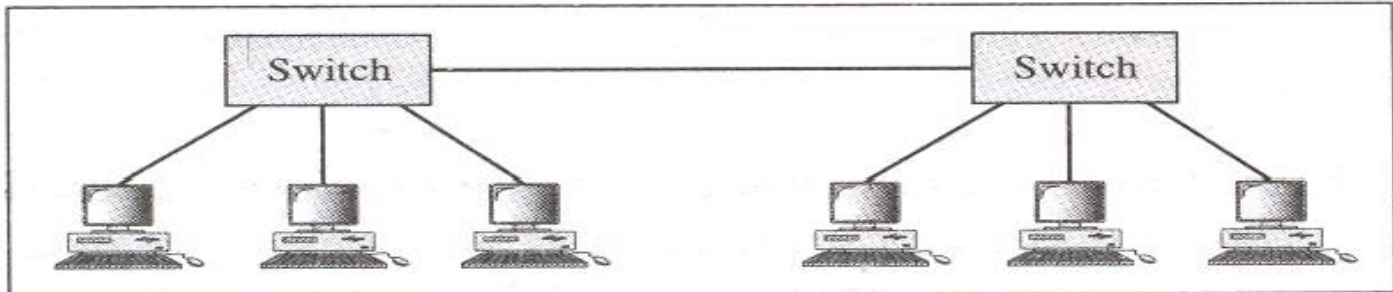| Characteristics | 100Base-TX | 100Base-FX | 100Base-T4 |
|---|---|---|---|
| Media | Cat 5 UTP or STP | Fiber | Cat 4 UTP |
| Number of wires | 2 | 2 | 4 |
| Maximum length | 100 m | 100 m | 100 m |
| Block encoding | 4B/5B | 4B/5B | |
| Line encoding | MLT-3 | NRZ-I | 8B/6T |

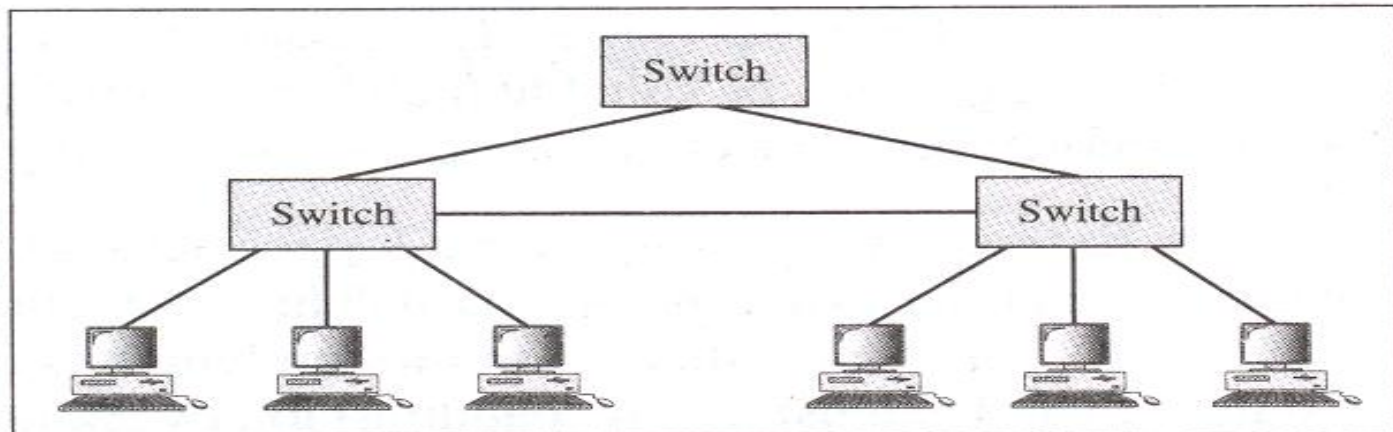**Figure 13.22** *Topologies of Gigabit Ethernet*
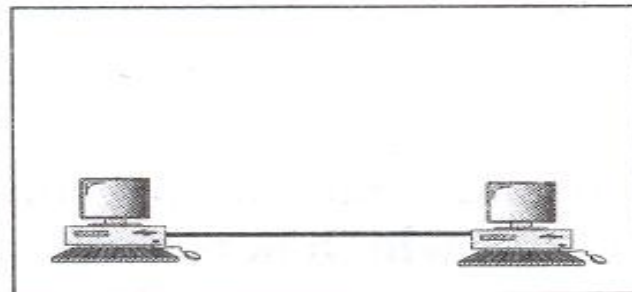


a. Point-to-point
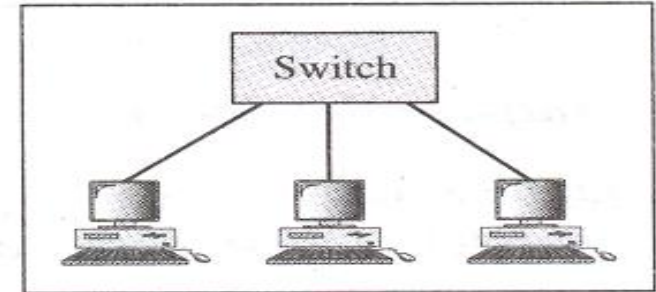
b. Star

c. Two stars

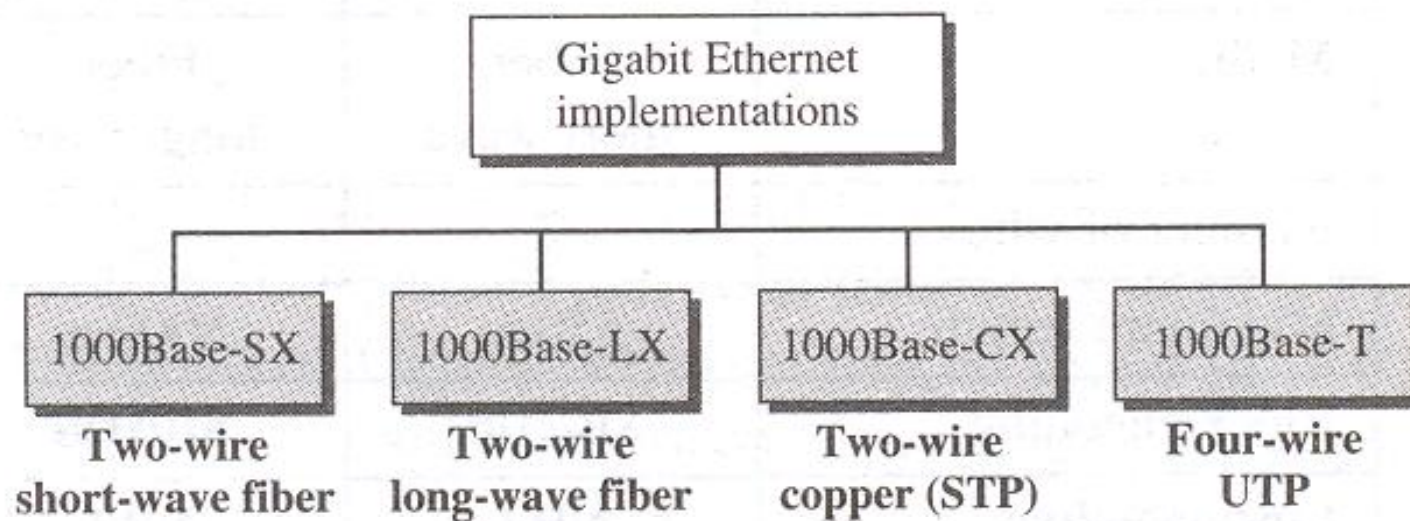d. Hierarchy of stars

# Figure 13.23  *Gigabit Ethernet implementations*

# Figure 13.24 *Encoding in Gigabit Ethernet implementations*

1000Base-SX, 1000Base-LX, and 1000Base-CX

1000Base-T

8 × 125 Mbps

8 × 125 Mbps

8 × 125 Mbps

8 × 125 Mbps

8B/10B block encoder

8B/10B block decoder

4D-PAM5 encoder

4D-PAM5 decoder

1.25 Gbps

1.25 Gbps

NRZ line encoder

NRZ line decoder

Station

Station

Two fibers or two STPs

4 UTP cables