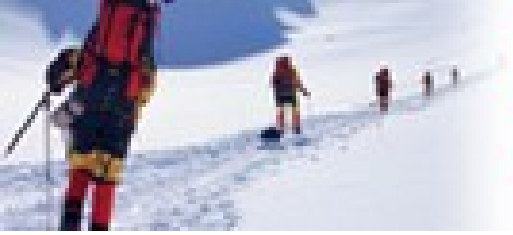


Data Communications and Networking Fourth Edition

Forouzan

Chapter 13

Wired LANs: Ethernet

13-1 IEEE STANDARDS

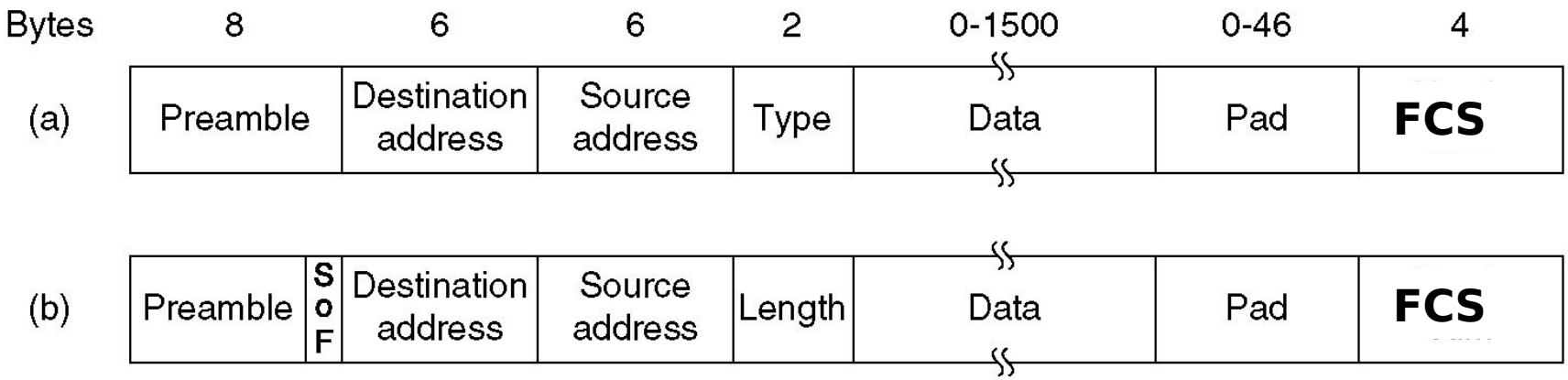
Ethernet: It is a LAN protocol that is used in Bus and Star topologies and implements CSMA/CD as the medium access method

- Original (traditional) Ethernet developed in 1980 by three companies: **D**igital, **I**ntel, **X**erox (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**

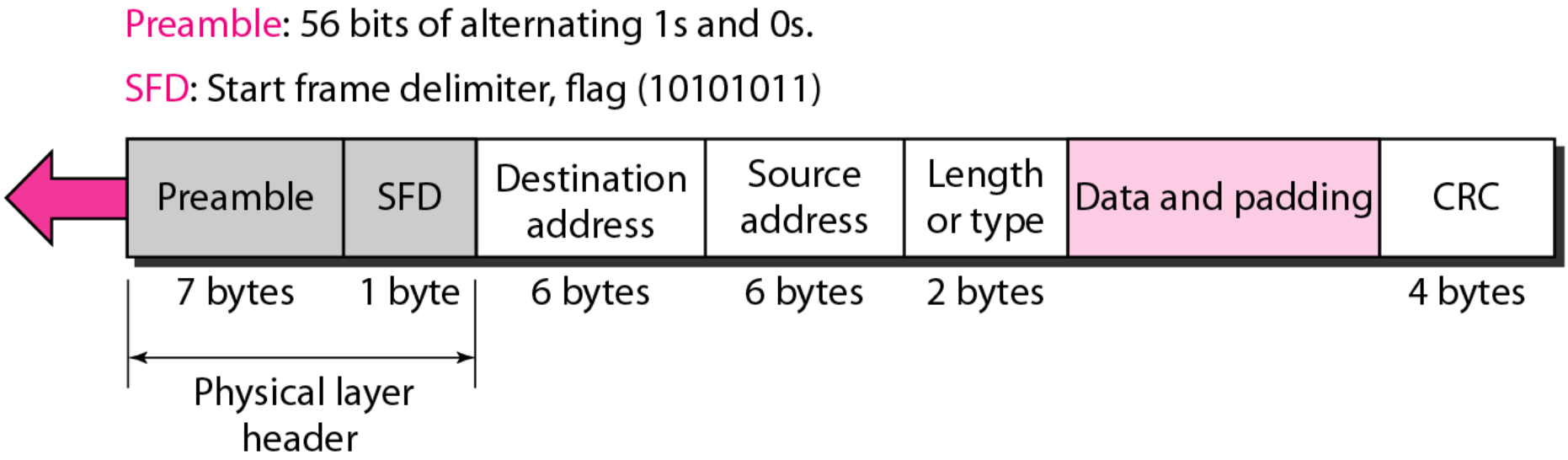
Ethernet

- **Ethernet Frame format**



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

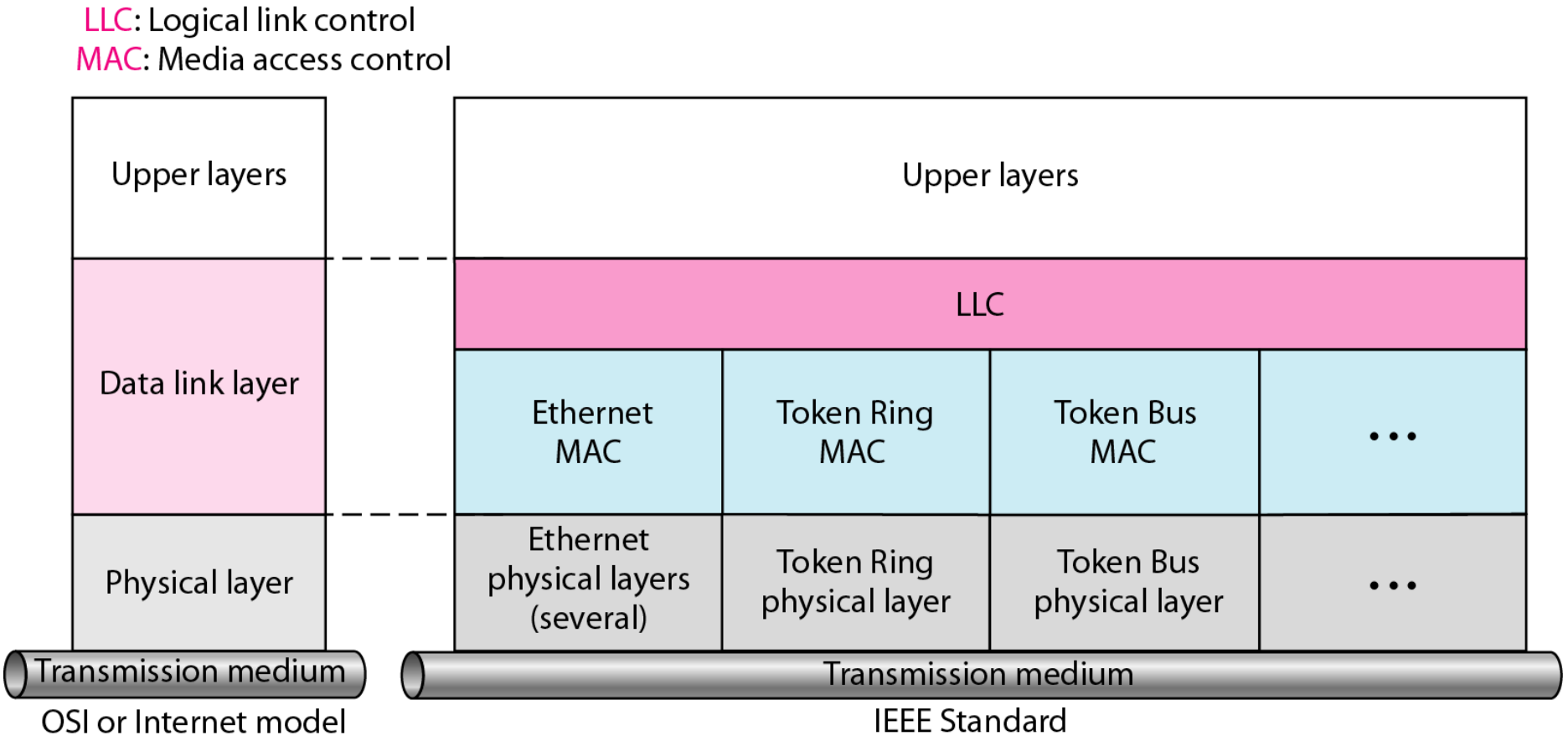
Figure 13.4 *802.3 MAC frame*



IEEE 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**

Figure 13.1 *IEEE standard for LANs*



Ethernet Provides Unreliable, connectionless Service

- **Ethernet data** link layer protocol provides **connectionless service** to the network layer
  - No handshaking between sending and receiving adapter.
- **Ethernet protocol provides *Unreliable* service to the network layer :**
  - Receiving adapter doesn't send ACK or NAK to sending adapter
  - This means stream of datagrams passed to network layer can have gaps (missing data)
    - Gaps will be filled if application is using reliable transport layer protocol
      - Otherwise, application will see the gaps

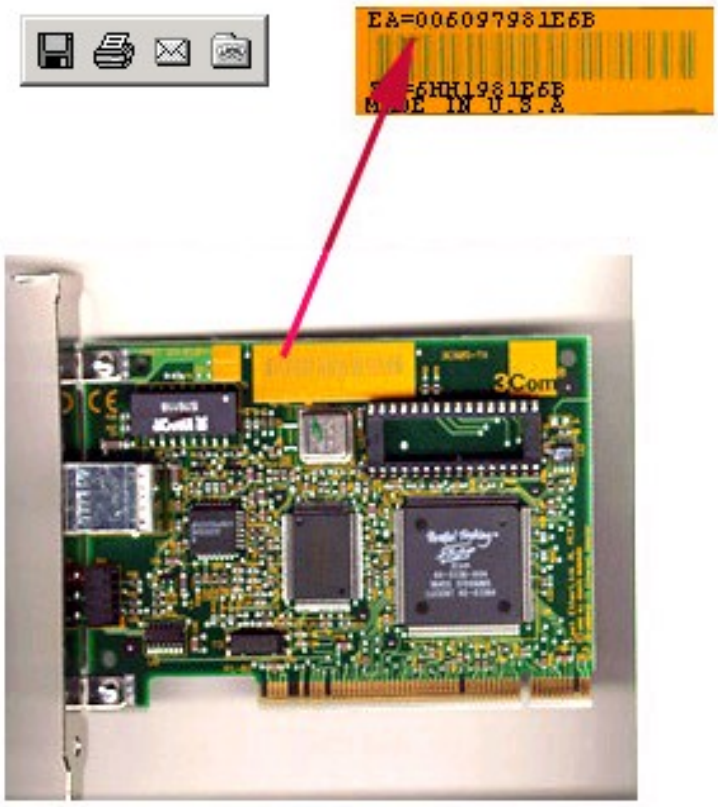
Ethernet Frame

- Preamble:
  - 8 bytes with pattern 10101010 used to synchronize receiver, sender clock rates.
  - In IEEE 802.3, eighth byte is start of frame (10101011)
- Addresses: 6 bytes (explained latter)
- Type (DIX)
  - Indicates the type of the **Network layer protocol** being carried in the **payload (data)** field, **mostly IP** but others may be supported such as IP (**0800**), Novell IPX (**8137**) and AppleTalk (**809B**), ARP (**0806**))
  - Allow **multiple network layer** protocols to be supported on a single machine (multiplexing)
  - Its value starts at **0600h (=1536 in decimal)**
- Length (IEEE 802.3): number of bytes in the **data field**.
  - Maximum 1500 bytes **(= 05DCh)**
- CRC: checked at receiver, if error is detected, the frame is **discarded**
  - CRC-32
- Data: carries data encapsulated from the upper-layer protocols
- Pad: Zeros are added to the data field to make the **minimum data length = 46 bytes**

Ethernet address

- **Six bytes = 48 bits** 06-01-02-01-2C-4B
- **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



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

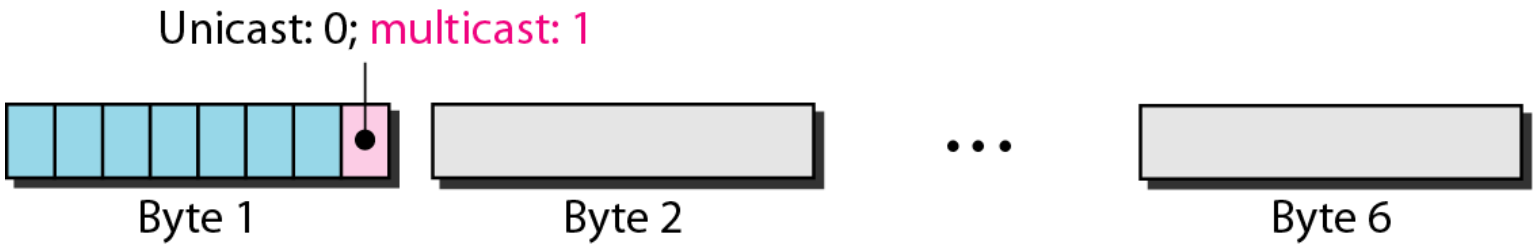
Note

The least significant bit of the first byte defines the type of address. If the bit is 0, the address is unicast; otherwise, it is multicast.

Note

The broadcast destination address is a special case of the multicast address in which all bits are 1s.

Figure 13.7 *Unicast and multicast addresses*



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:

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

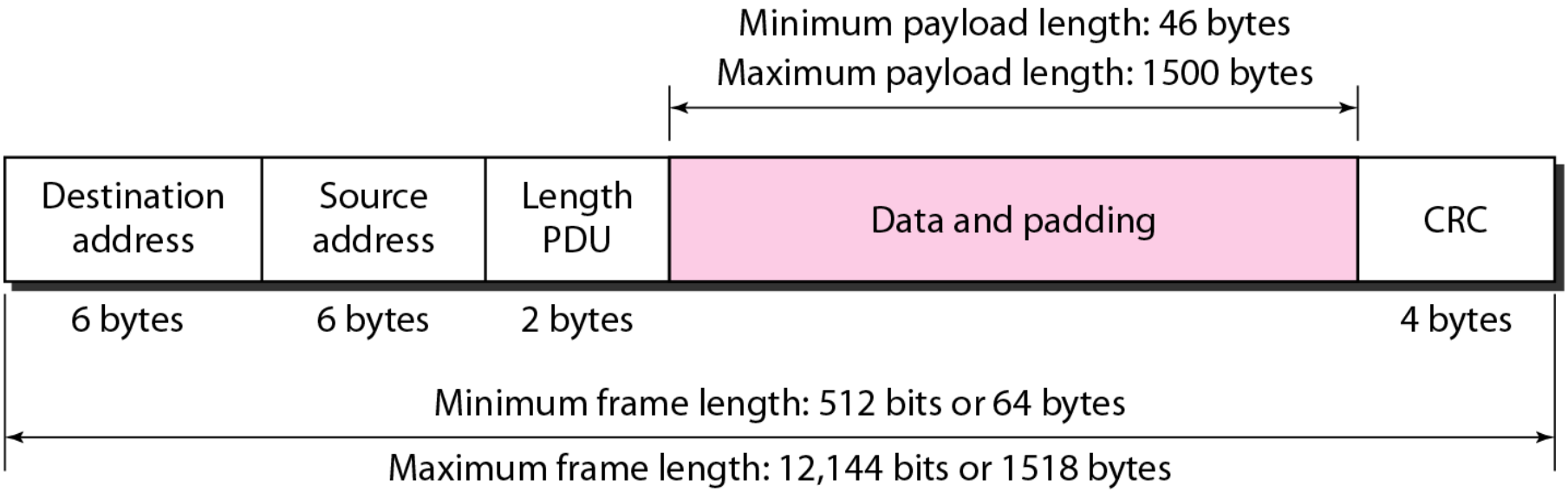
To find the type of the address, we need to look at the second hexadecimal digit from the left. If it is even, the address is unicast. If it is odd, the address is multicast. If all digits are F's, the address is broadcast. Therefore, we have the following:

a. This is a unicast address because A in binary is 1010.

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

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

Figure 13.5 *Minimum and maximum lengths*



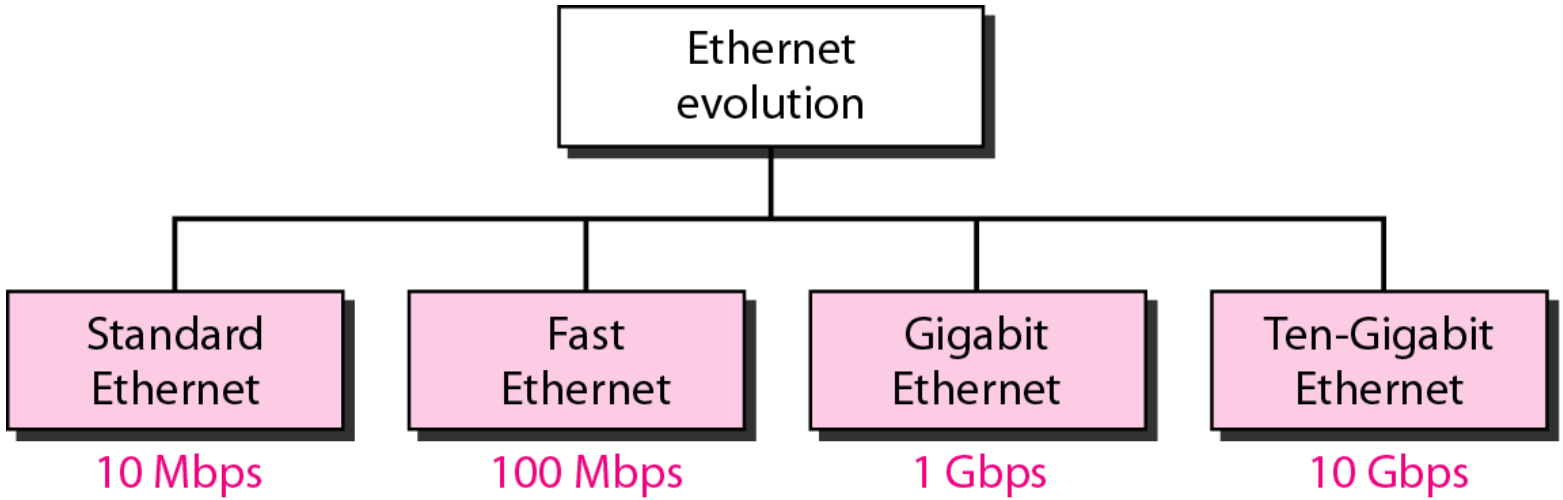
Note

Frame length:

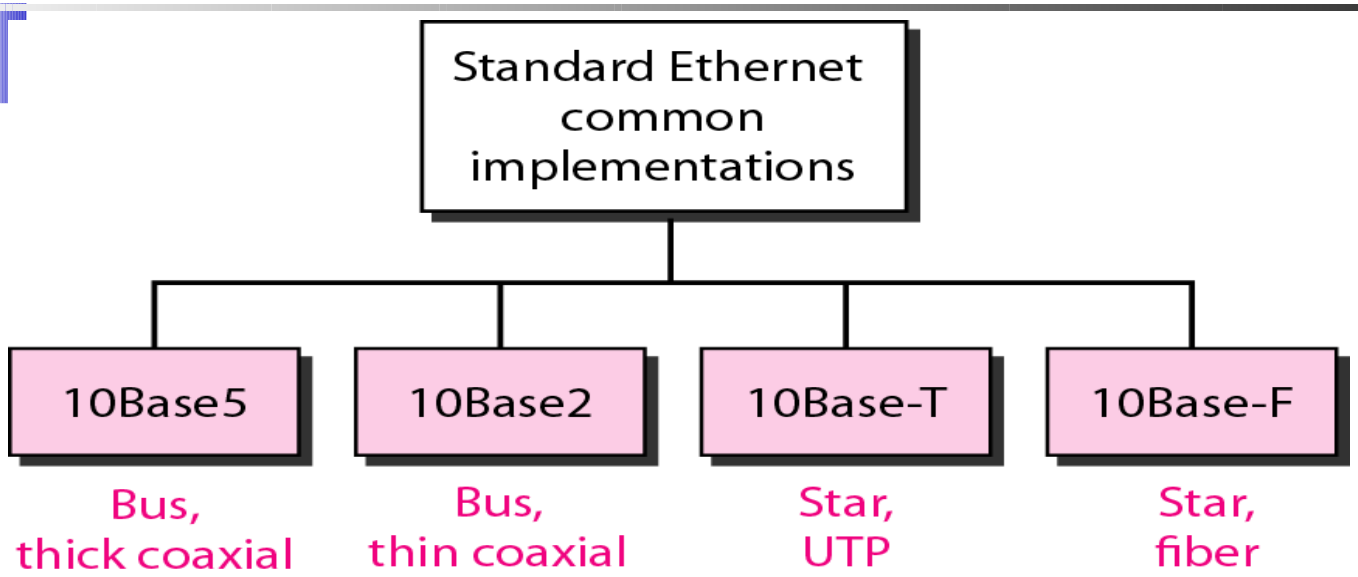
Minimum: 64 bytes (512 bits)

Maximum: 1518 bytes (12,144 bits)

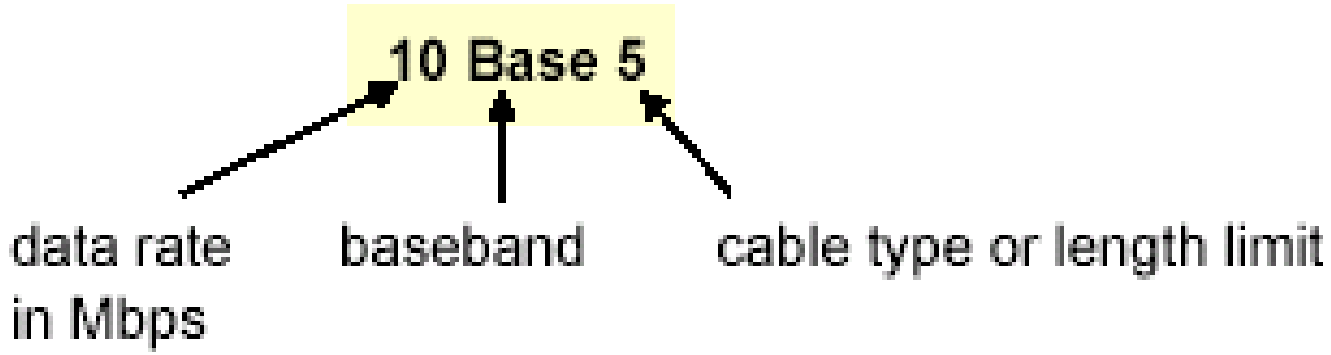
Figure 13.3 *Ethernet evolution through four generations*



Categories of traditional Ethernet



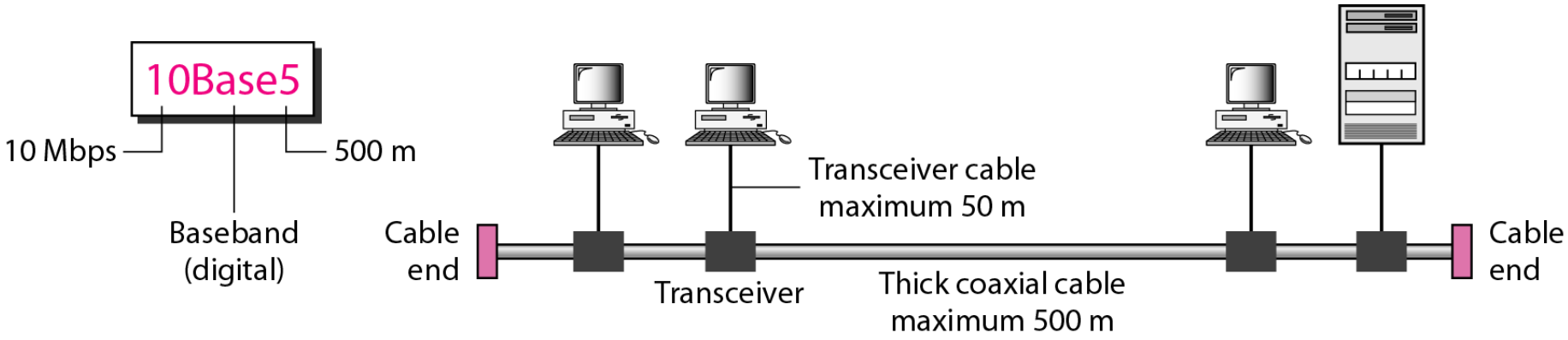
- <data rate><Signaling method><Max segment length or cable type>



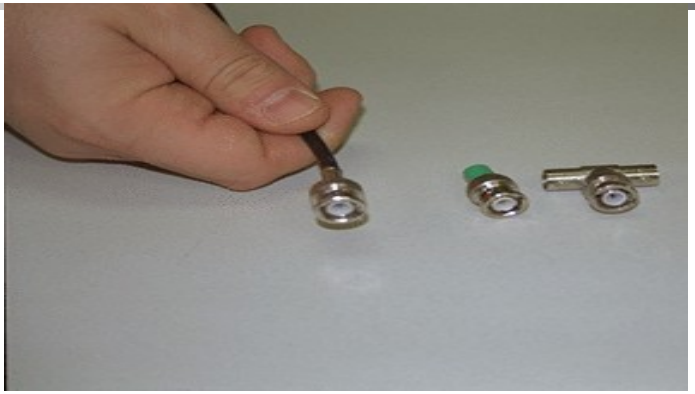
IEEE 802.3 Cable Types

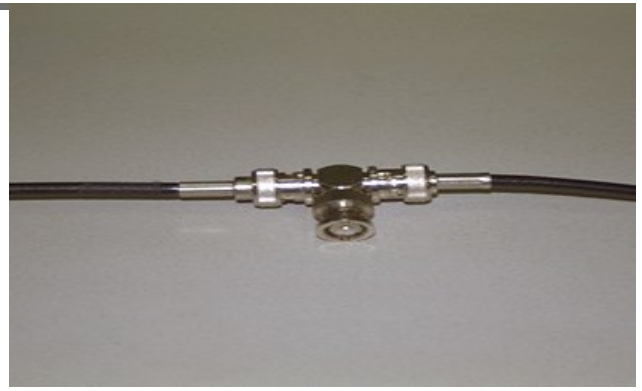
Name	Cable Max.	Max Cable Segment Length	Nodes /segment	Toplogy
10Base5	thick coax	500 meters	100	**Bus**
10Base2	thin coax	185 meters	30	**Bus**
10BaseT	twisted pair	100 meters	1	**Star**
10BaseF	Fiber Optic	2Km	1	**Star**

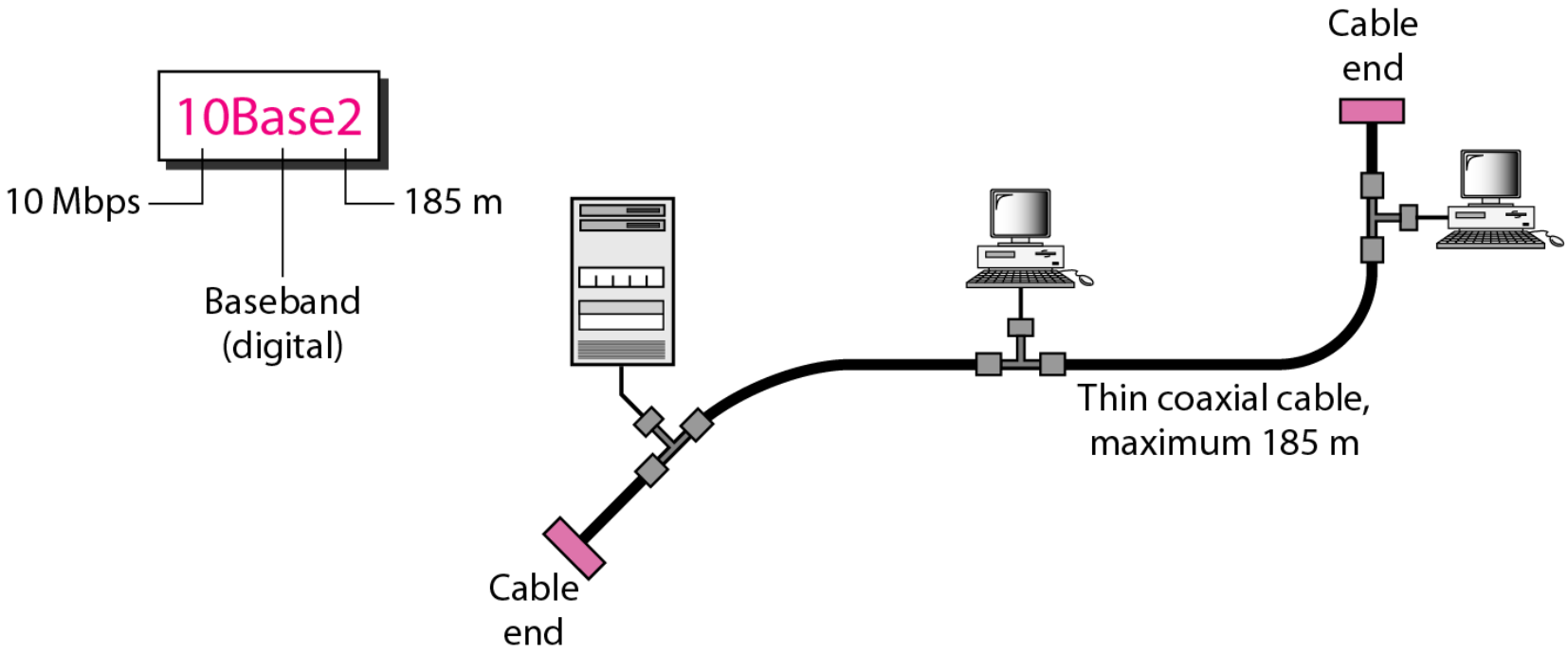
Figure 13.10 *10Base5 implementation*



Connection of stations to the medium using 10Base2







10BaseT

- Uses twisted pair **Cat3** cable
  - Star-wire topology
- A hub functions as a **repeater** with additional functions
- Fewer cable problems, easier to troubleshoot than coax
- Cable length at most 100 meters

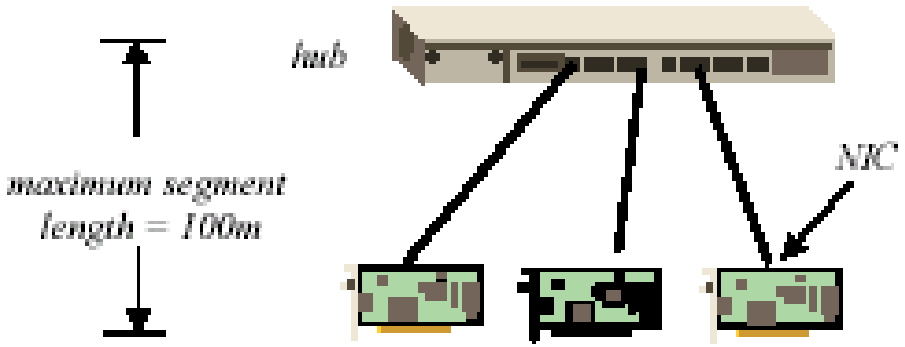


Figure 13.12 *10Base-T implementation*

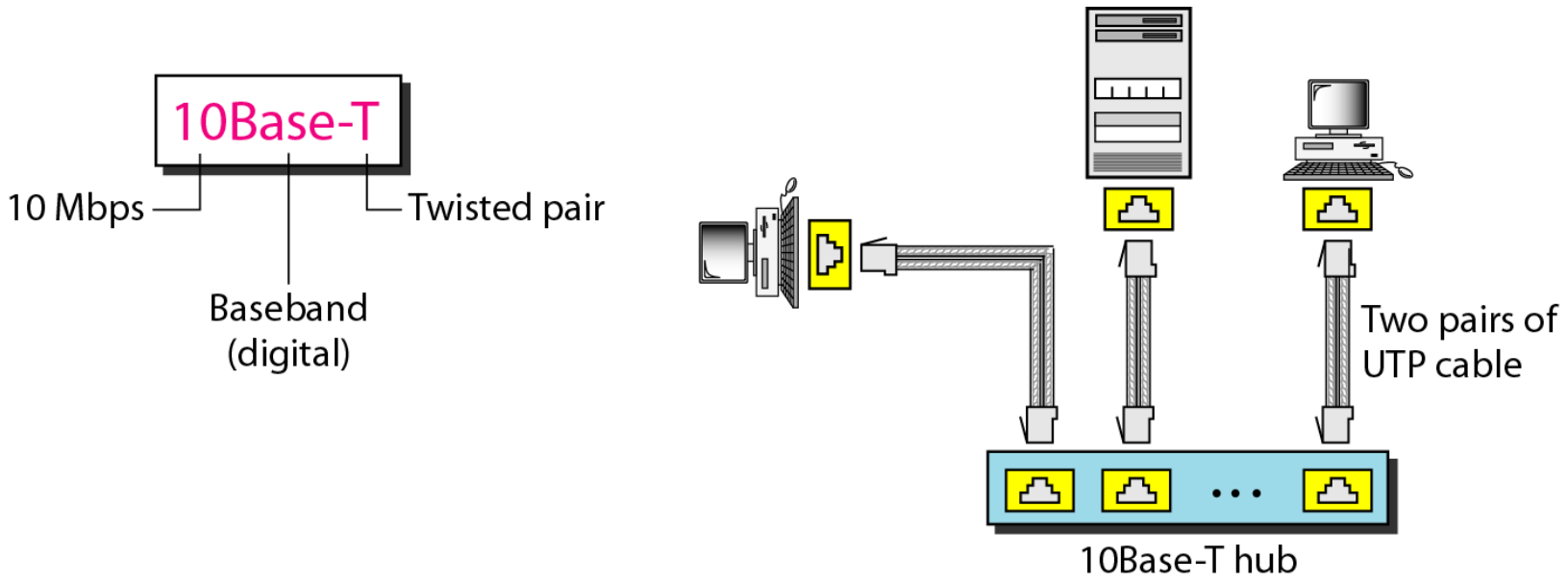
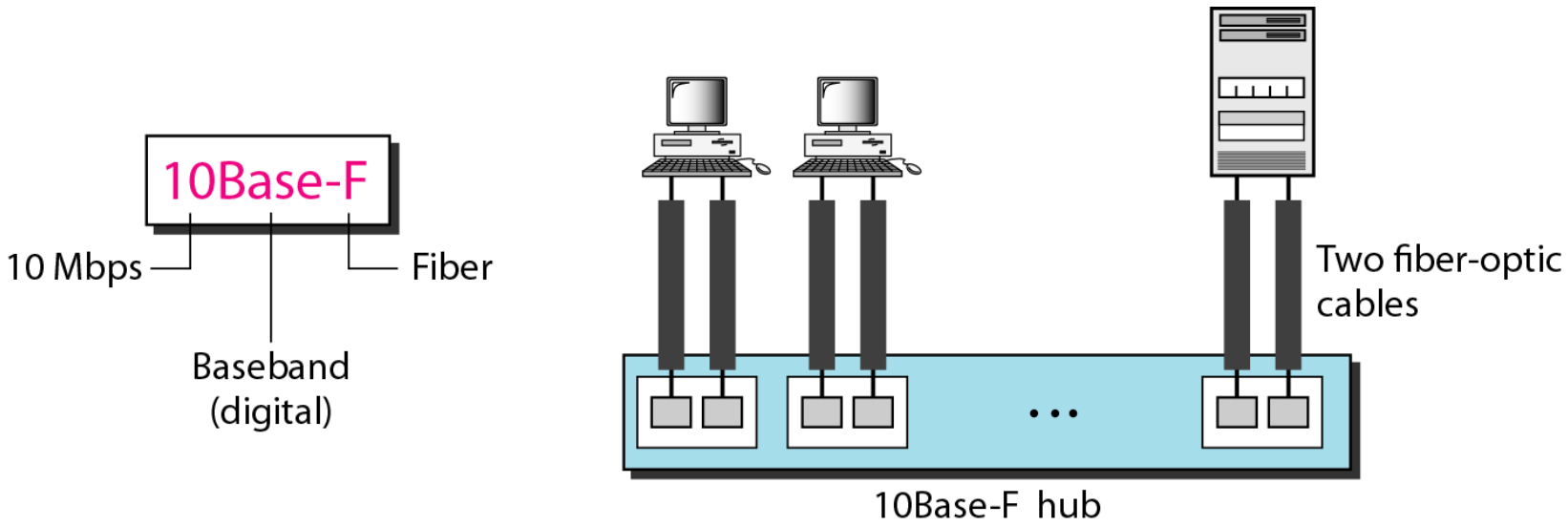


Figure 13.13 *10Base-F implementation*

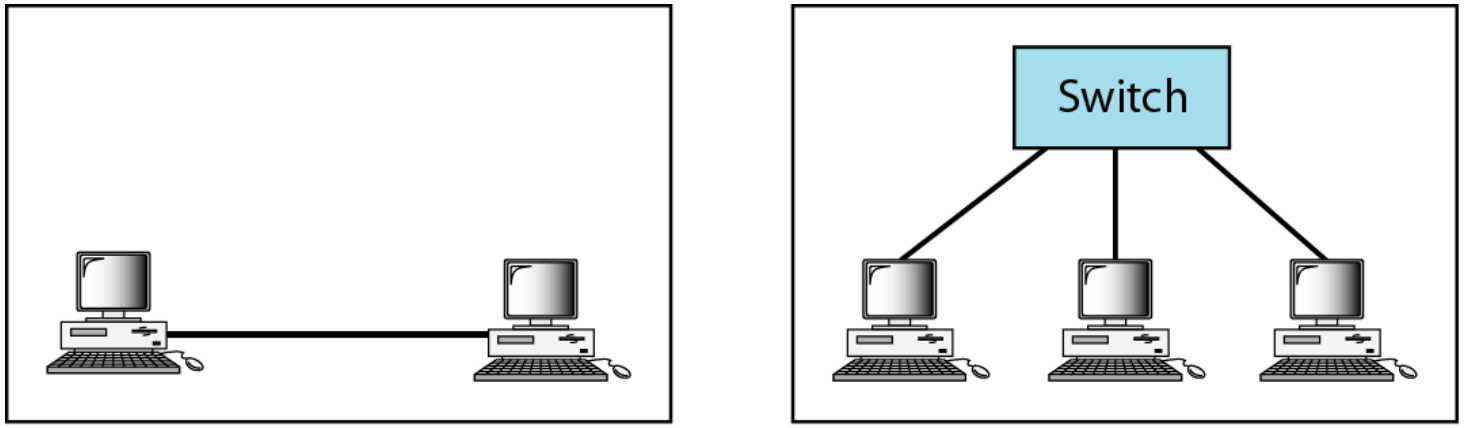


13.4 Fast Ethernet

- 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	

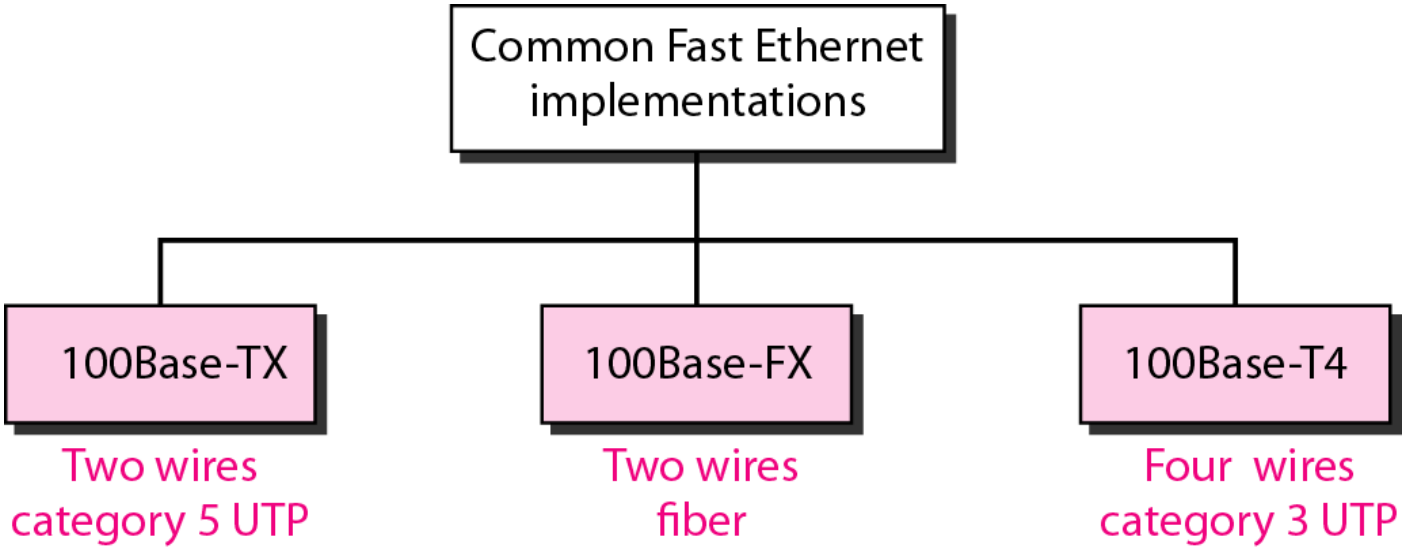
Figure 13.19 *Fast Ethernet topology*



a. Point-to-point

b. Star

Figure 13.20 *Fast Ethernet implementations*



Full Duplex Operation

- Traditional Ethernet is half duplex
  - Either transmit or receive but not both **simultaneously**
- With full-duplex, station can transmit and receive *data* **simultaneously**
- With full duplex, **Throughput** (actual transmission rate) is doubled.
  - 10-Mbps Ethernet in full-duplex mode, theoretical transfer rate becomes 20 Mbps
  - 100-Mbps Ethernet in full-duplex mode, theoretical transfer rate becomes 200 Mbps
- **Changes that should be made with any computer in order to operate in Full-Duplex Mode**
  1) Attached stations must have **full-duplex NIC** cards
  2) Must use **two pairs** of wire one pair for transmitting from host to switch (inbound) and the other pair for transmitting from switch to host (outbound)
  3) Must use **a switch as a central** device **not a hub**
  4) Devices must be connected point-to-point (**dedicated**) to the **switch**
  - Each station constitutes separate collision domain
    - CSMA/CD algorithm **no longer needed (no collision)**
    - No limit on the segment length
    - Same 802.3 MAC frame format used

Figure 13.18 *Full-duplex switched Ethernet*

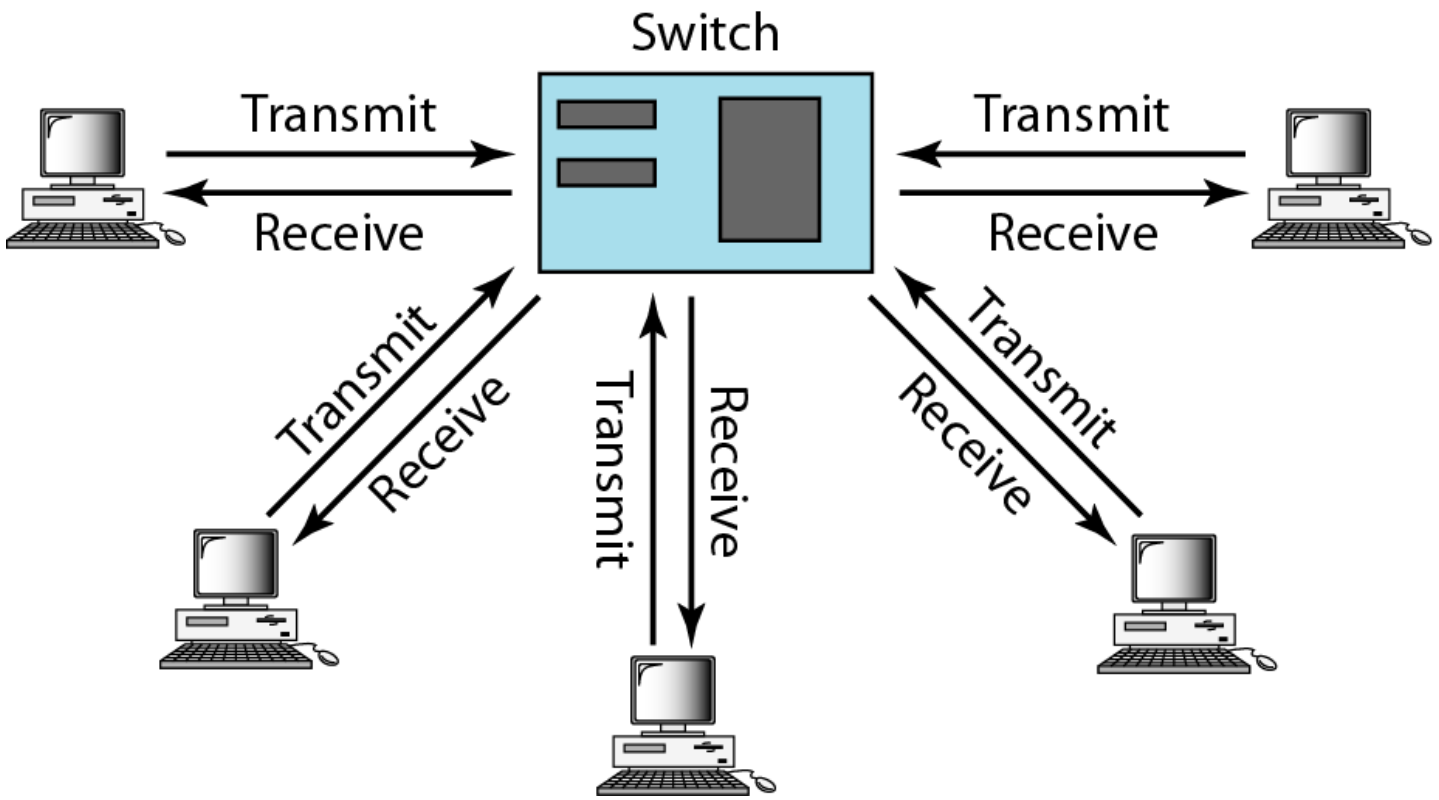
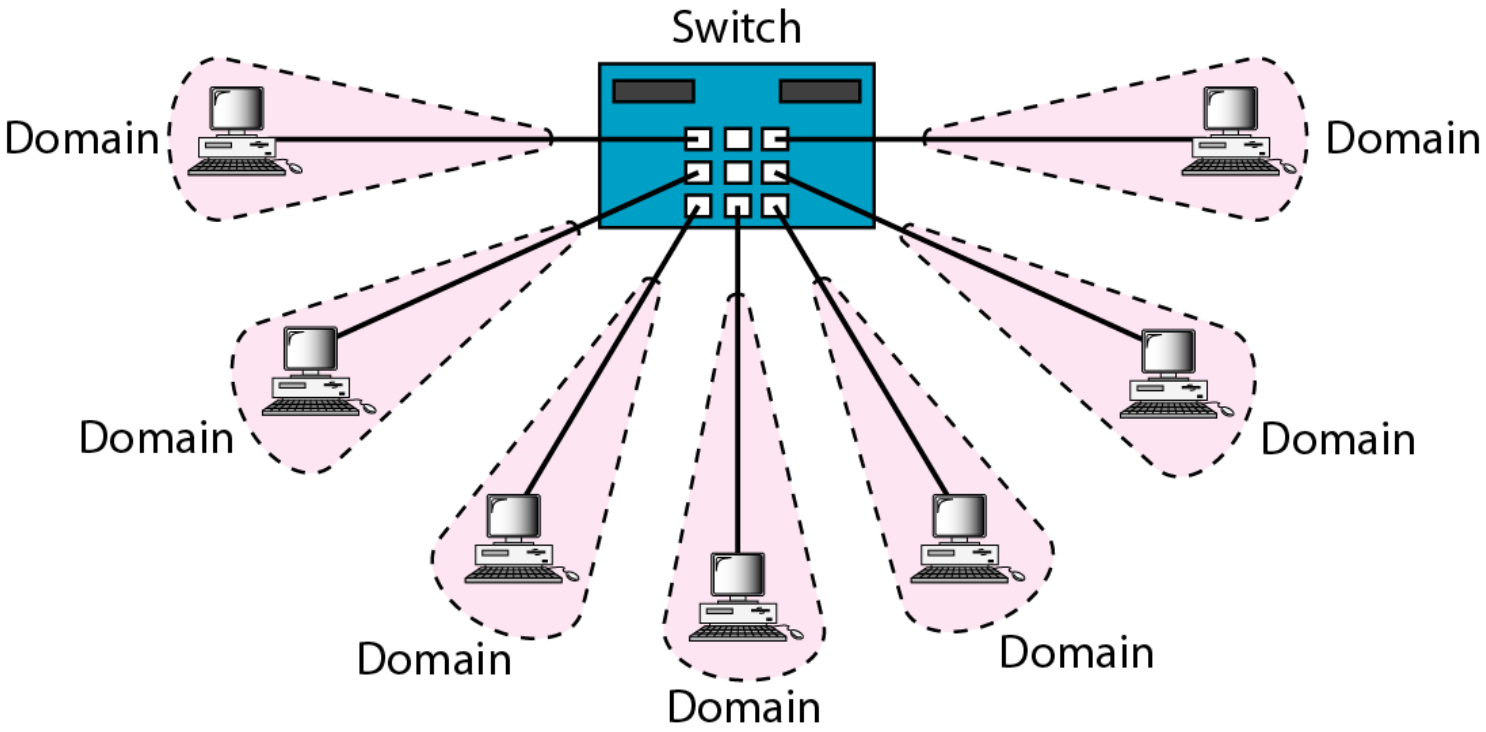


Figure 13.17 *Switched Ethernet*



13.5 Gigabit Ethernet

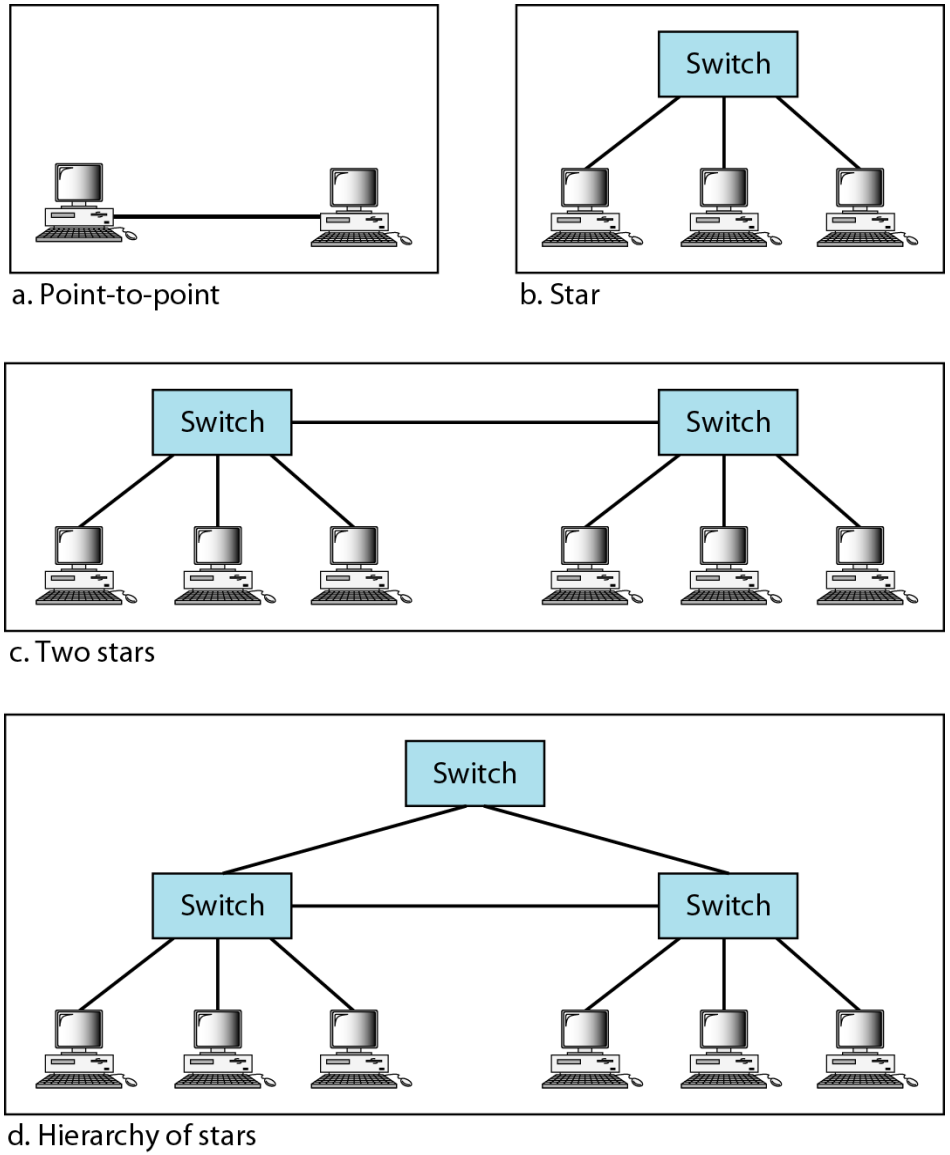
- Speed 1Gpbs
- Minimum frame length is 512 bytes
- Operates in full/half duplex modes mostly full duplex

Name	Cable	Max. segment
1000Base-SX	Fiber optics	550 m
1000Base-LX	Fiber optics	5000 m
1000Base-CX	2 Pairs of STP	25 m
1000Base-T	4 Pairs of UTP	100 m

Note

In the full-duplex mode of Gigabit Ethernet, there is no collision; the maximum length of the cable is determined by the signal attenuation in the cable.

Figure 13.22 *Topologies of Gigabit Ethernet*



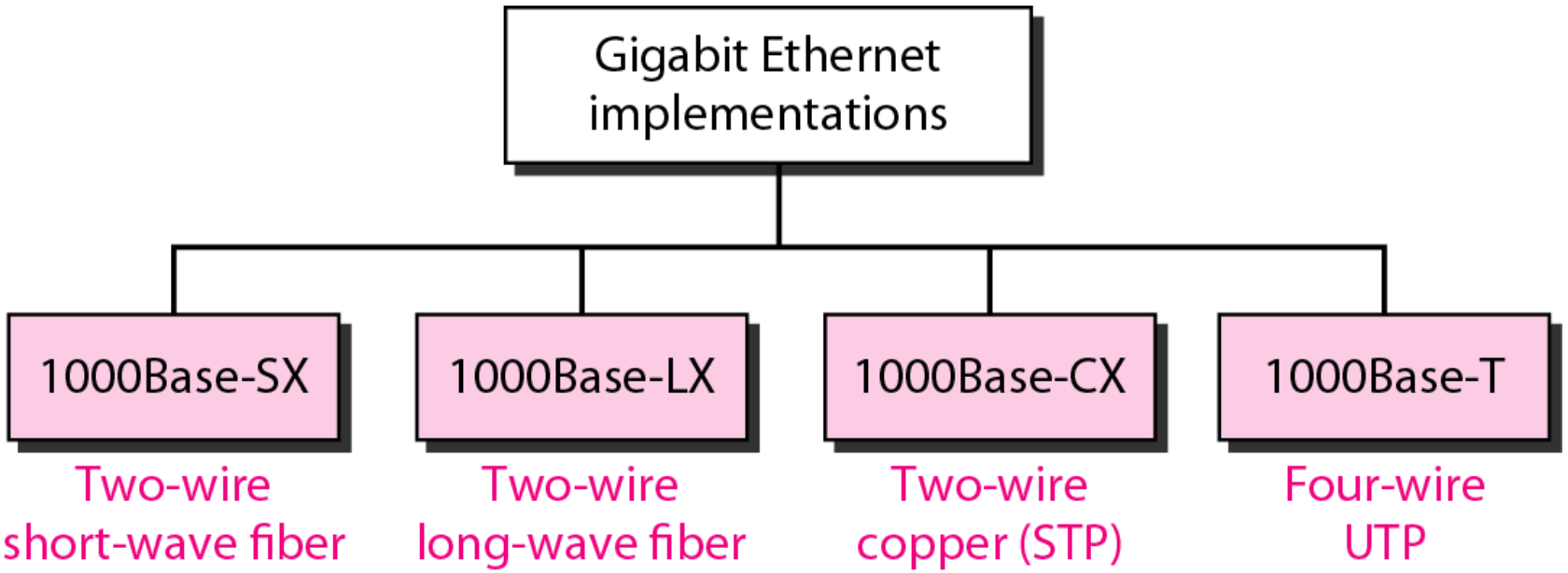
a. Point-to-point

b. Star

c. Two stars

d. Hierarchy of stars

Figure 13.23 *Gigabit Ethernet implementations*



10Gbps Ethernet

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