Wired LANs: Ethernet

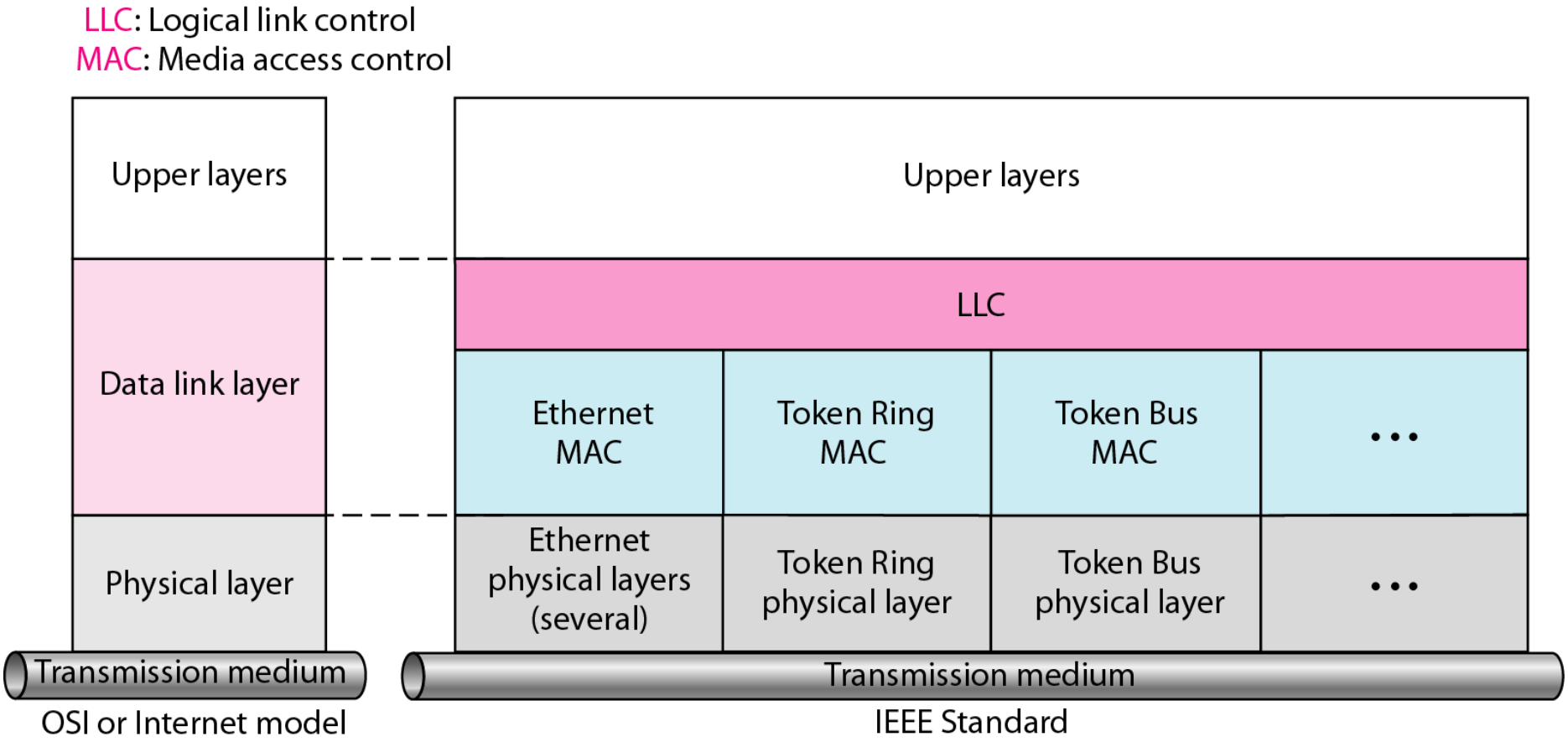
IEEE STANDARDS

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. Project 802 is a way of specifying functions of the physical layer and the data link layer of major LAN protocols.

Topics discussed in this section:

Data Link Layer
Physical Layer

IEEE standard for LANs



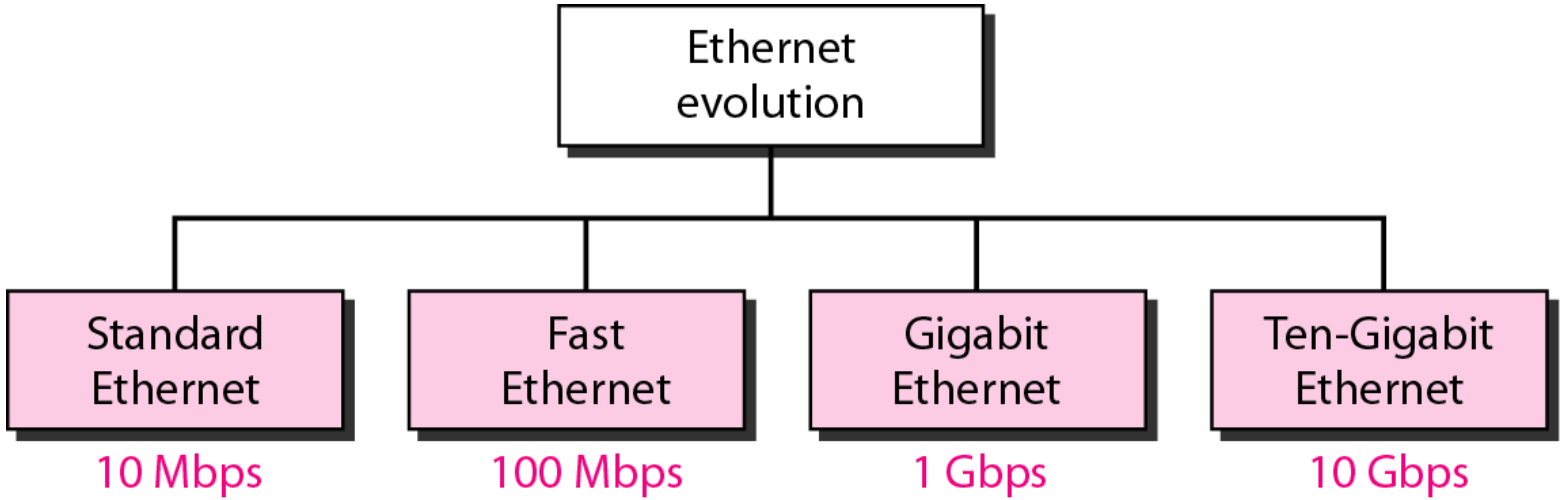
STANDARD ETHERNET

The original Ethernet was created in 1976 at Xerox's Palo Alto Research Center (PARC). Since then, it has gone through four generations. We briefly discuss the Standard (or traditional) Ethernet in this section.

Topics discussed in this section:

MAC Sublayer
Physical Layer

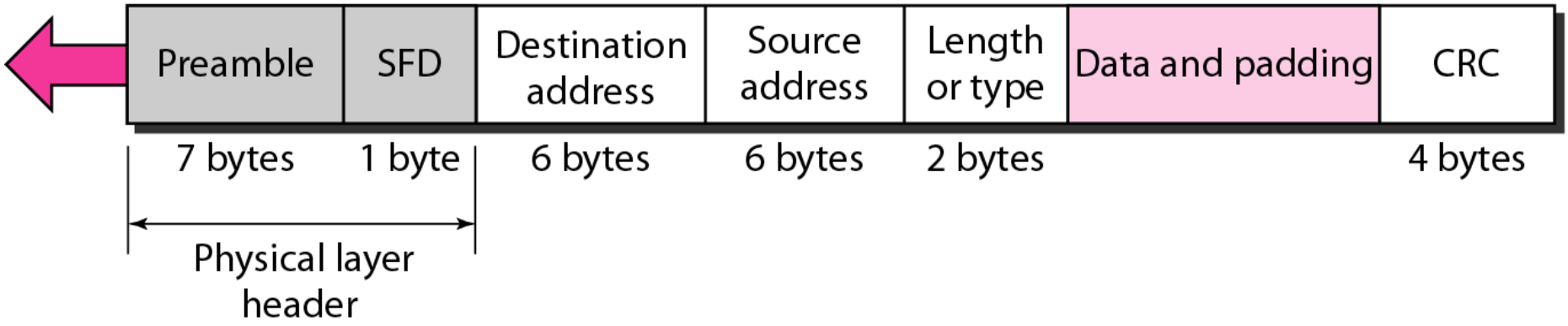
Ethernet evolution through four generations



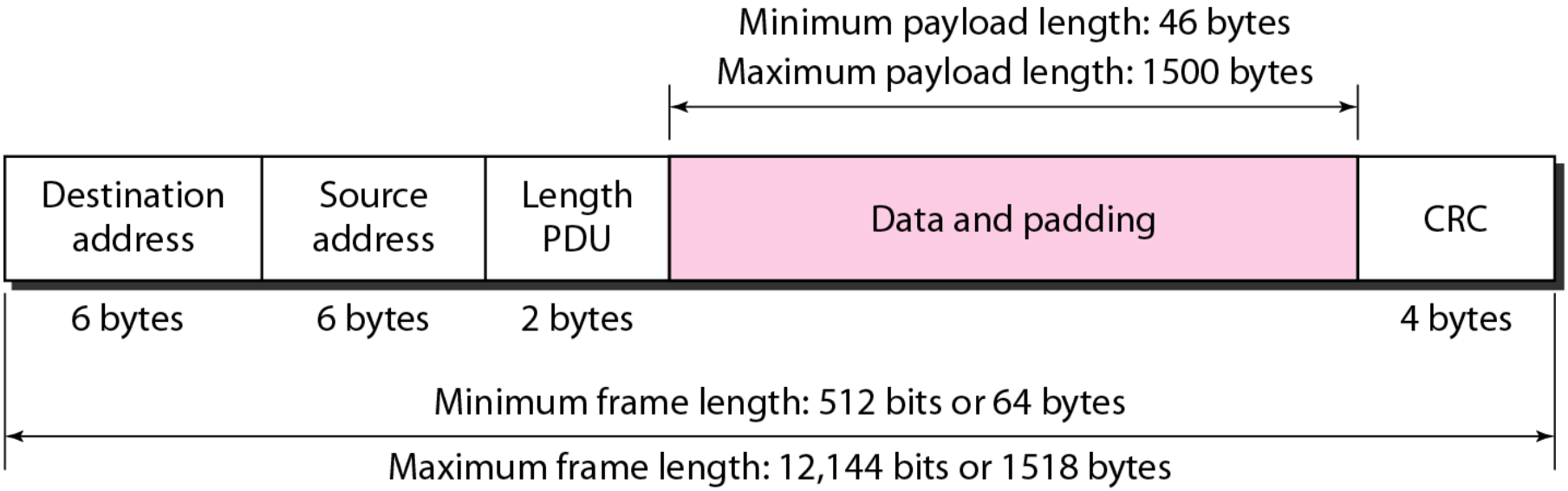
802.3 MAC frame

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

SFD: Start frame delimiter, flag (10101011)



Minimum and maximum lengths



Note

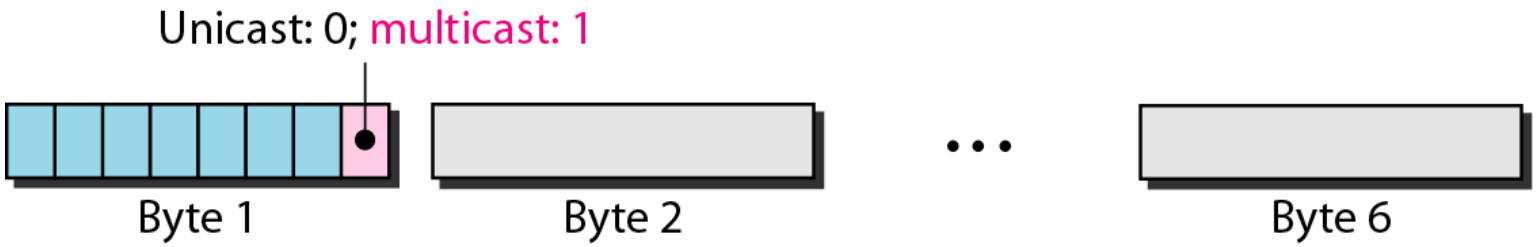
Frame length:

Minimum: 64 bytes (512 bits)

Maximum: 1518 bytes (12,144 bits)

Example of an Ethernet address in hexadecimal notation

Unicast and multicast addresses



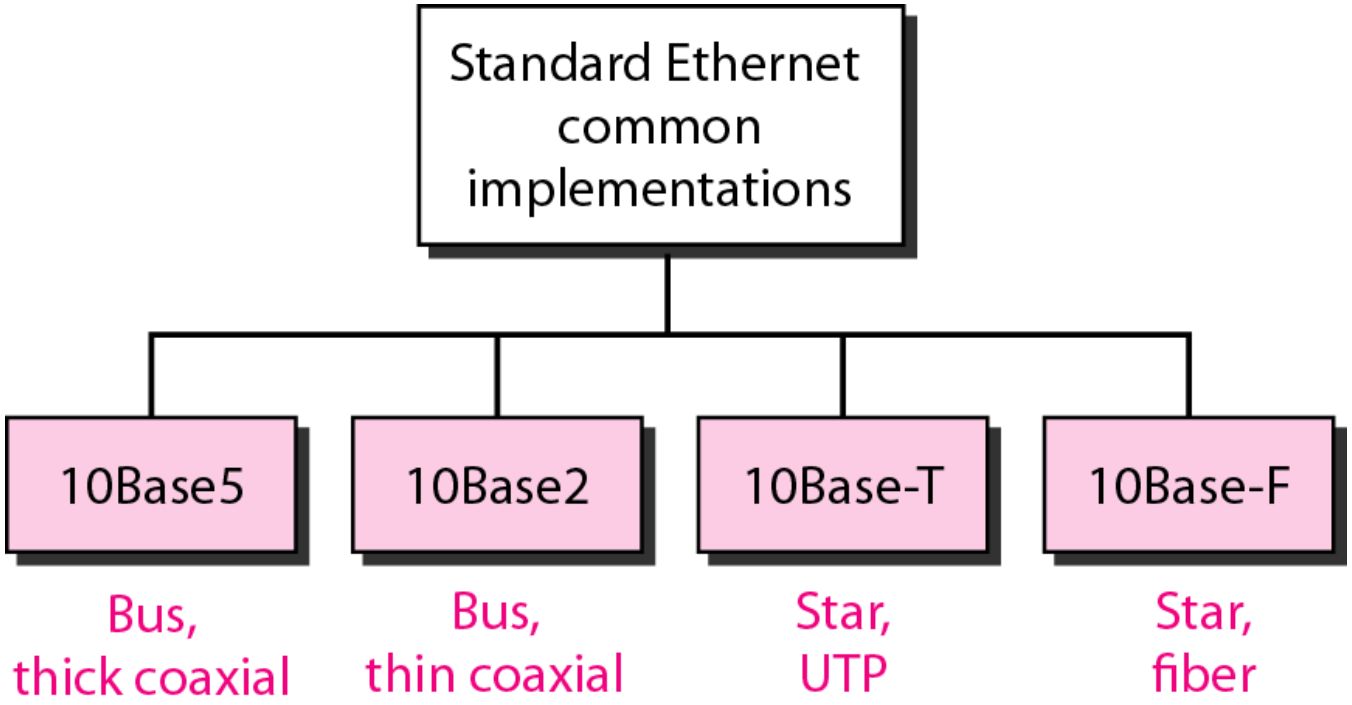
Note

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.

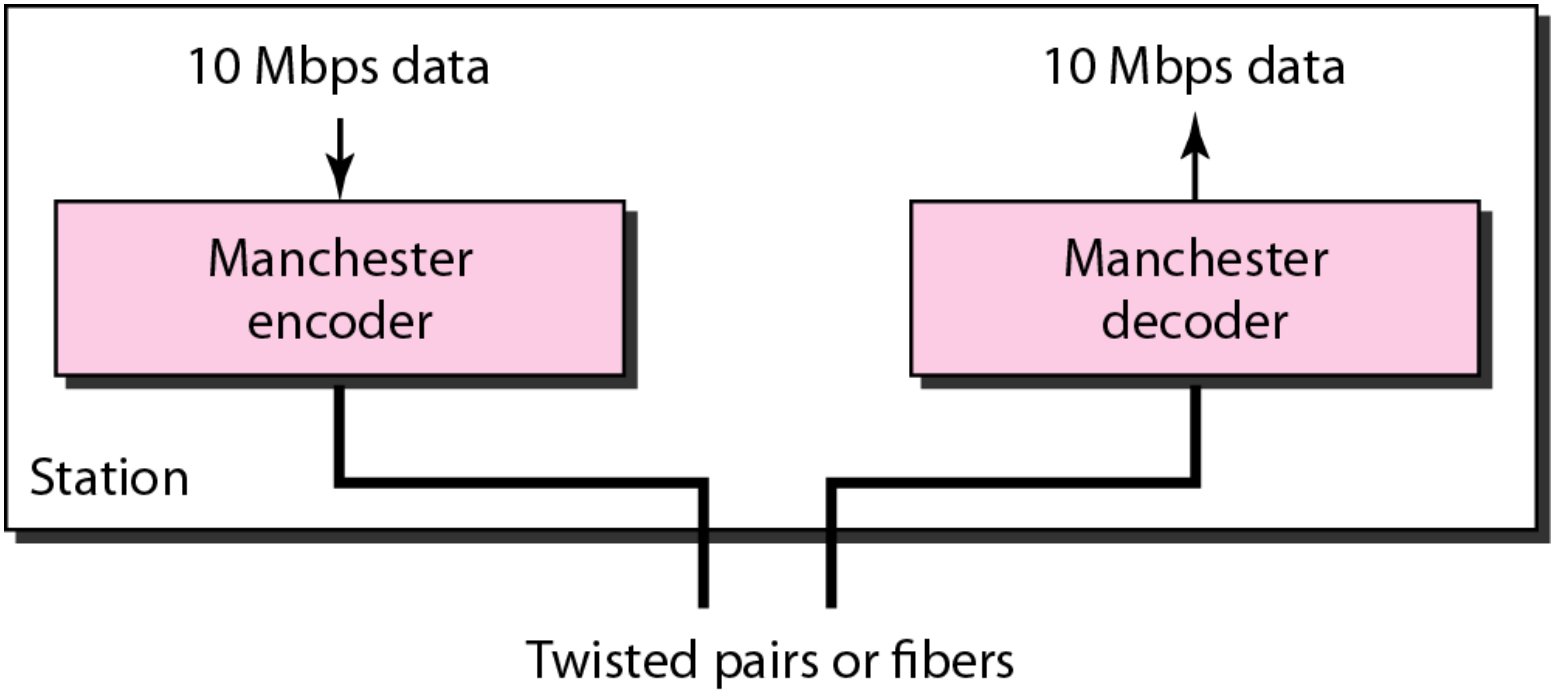
Note

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

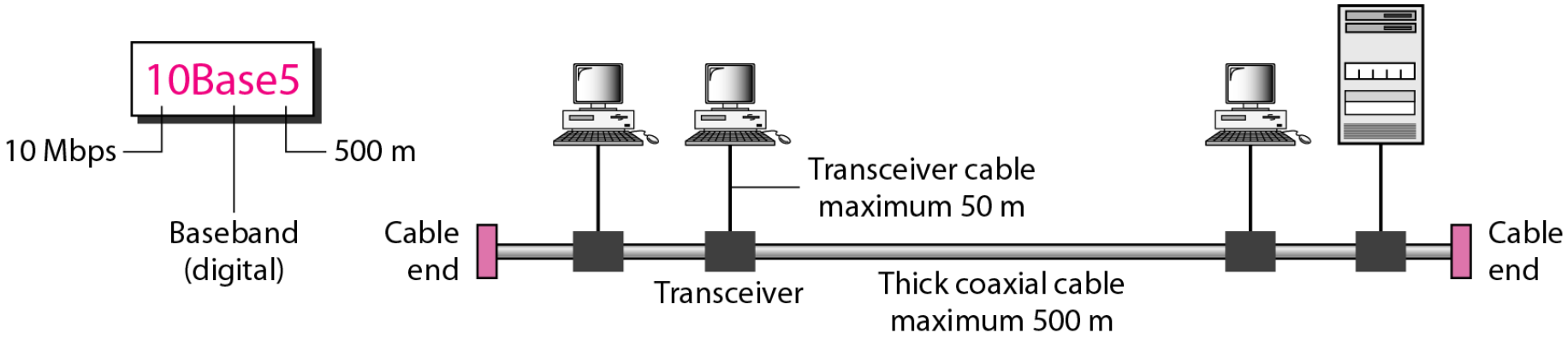
Categories of Standard Ethernet



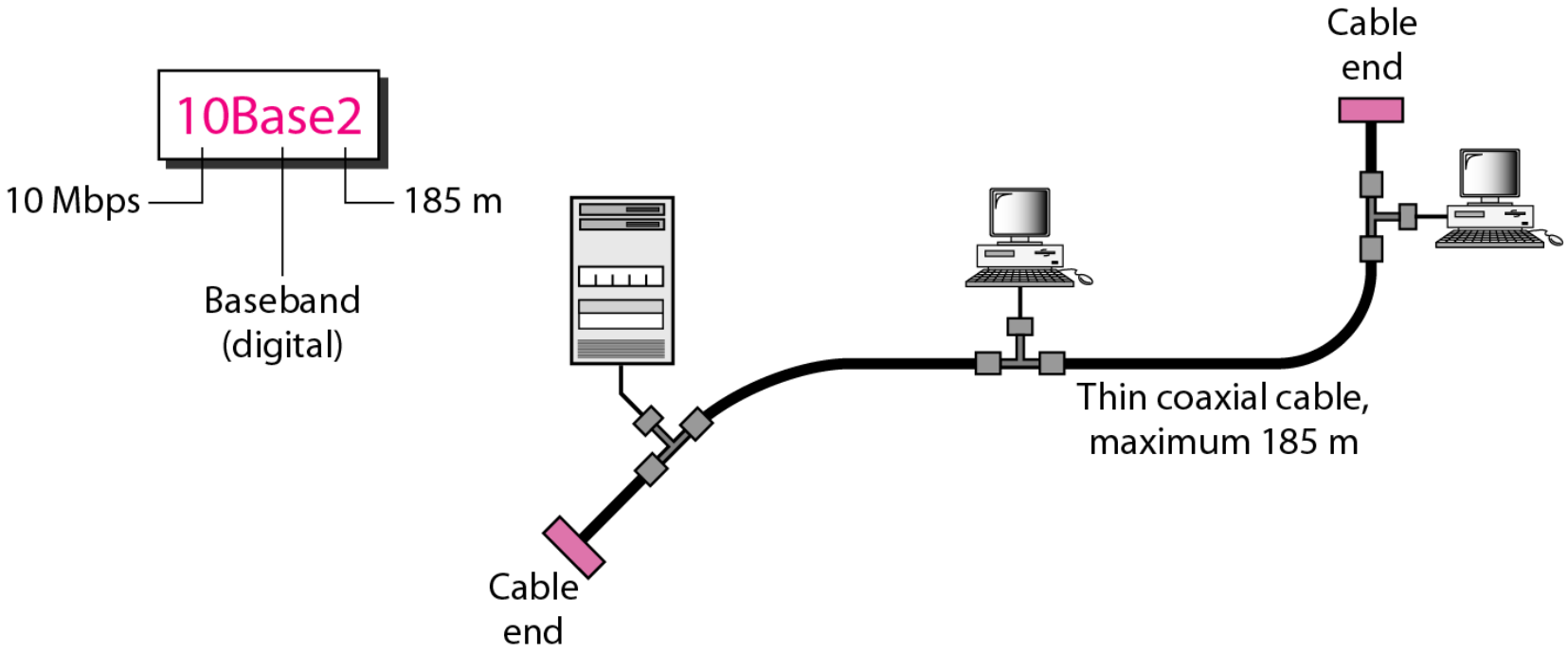
Encoding in a Standard Ethernet implementation



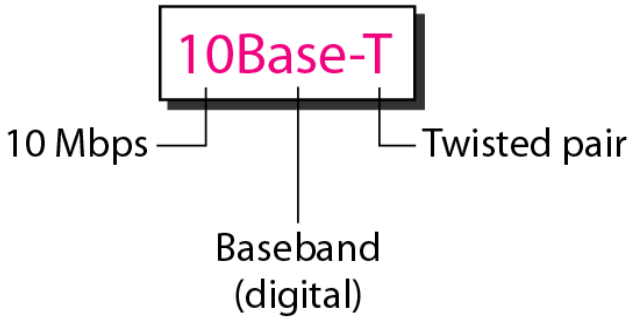
10Base5 implementation

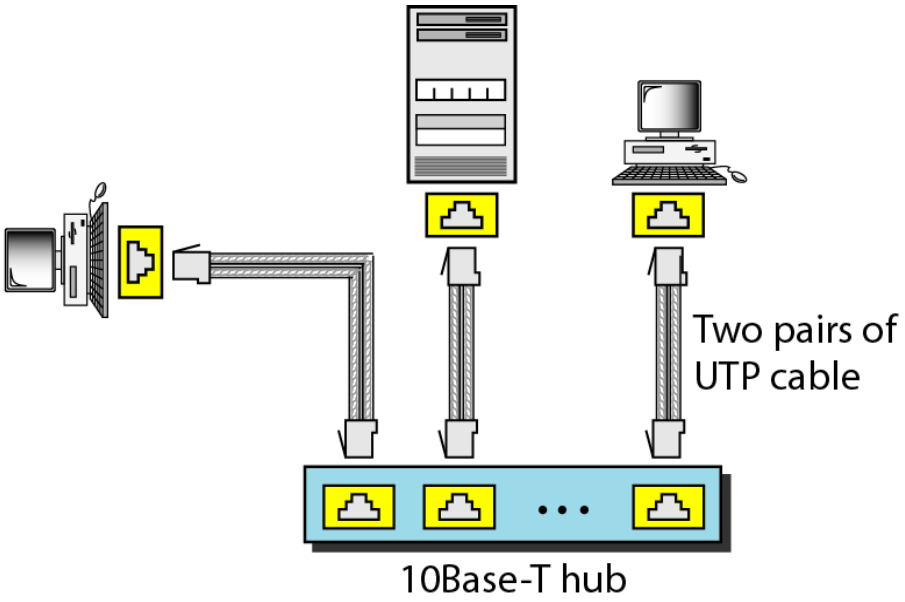


10Base2 implementation

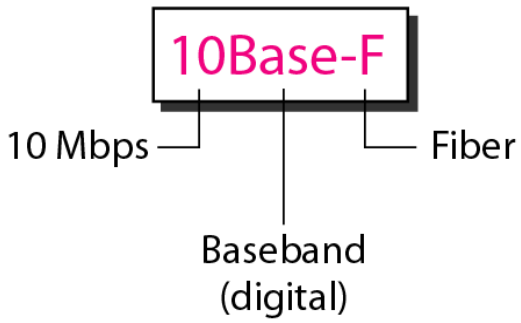


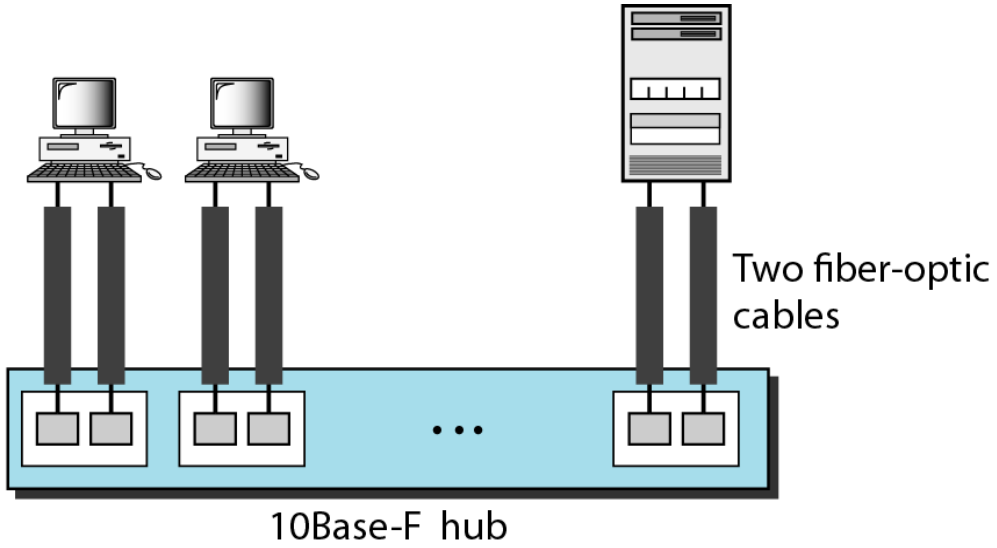
10Base-T implementation





10Base-F implementation





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

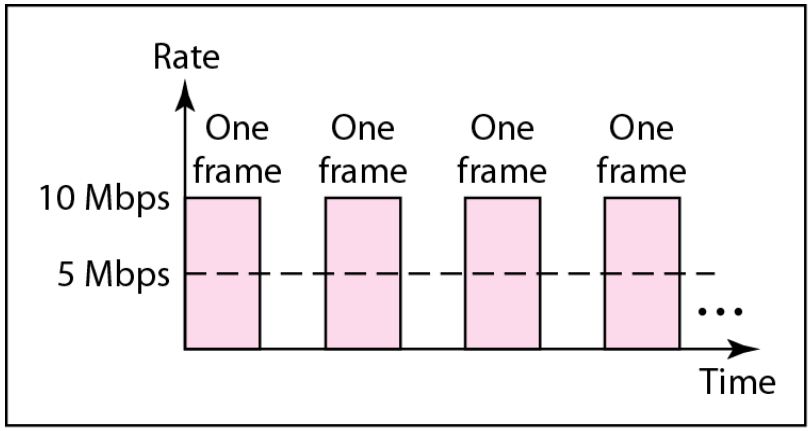
CHANGES IN THE STANDARD

The 10-Mbps Standard Ethernet has gone through several changes before moving to the higher data rates. These changes actually opened the road to the evolution of the Ethernet to become compatible with other high-data-rate LANs.

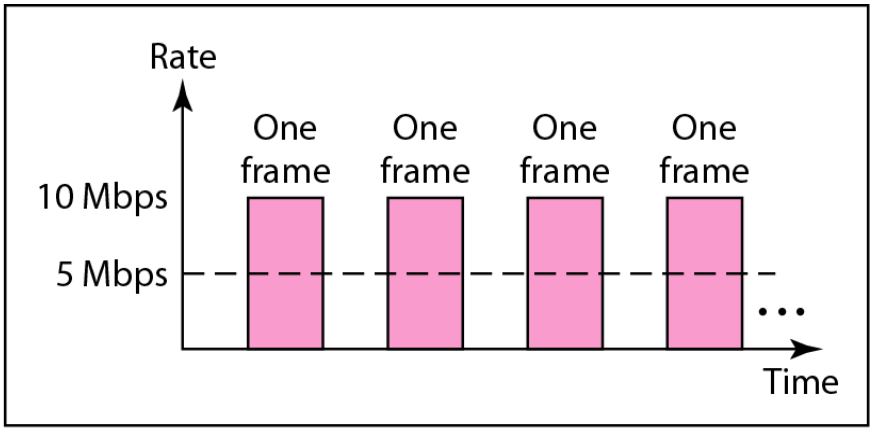
Topics discussed in this section:

Bridged Ethernet
Switched Ethernet
Full-Duplex Ethernet

Sharing bandwidth



a. First station



b. Second station

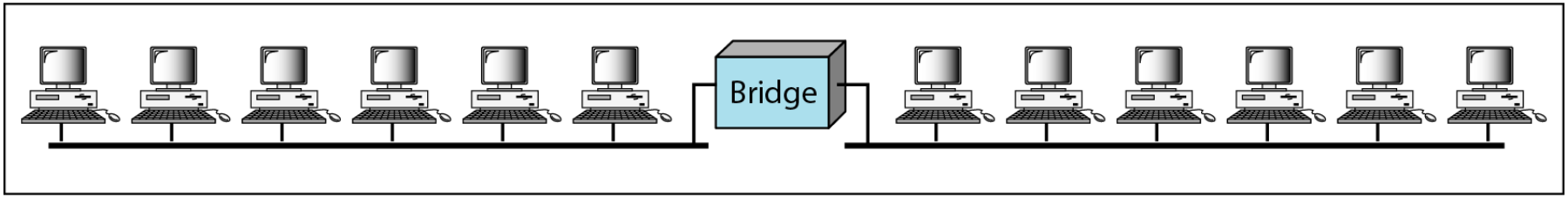
A network with and without a bridge

A bridge divides the network into two or more networks. Bandwidth-wise, each network is independent.

Example :

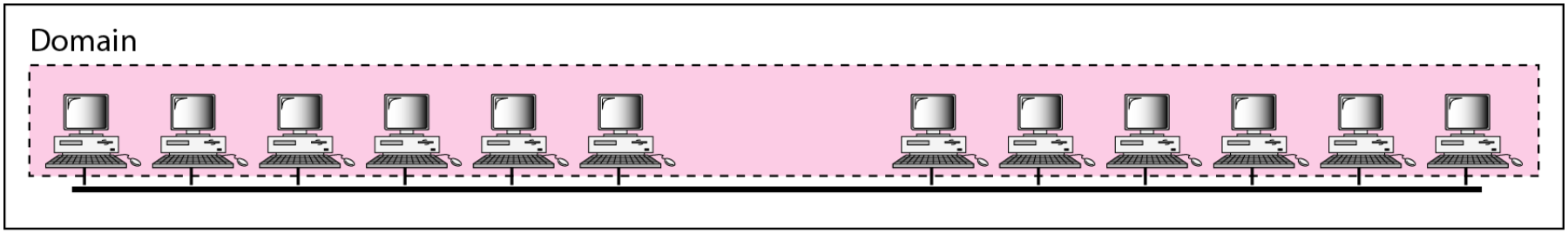
- A network with 12 stations is divided into two networks, each with 6 stations**.**
- Each network has a capacity of 10 Mbps.
- The 10-Mbps capacity in each segment is now shared between 6 stations
- In a network with a heavy load, each station theoretically is offered 10/6 Mbps instead of 10/12 Mbps, assuming that the traffic is not going through the bridge**.**

a. Without bridging

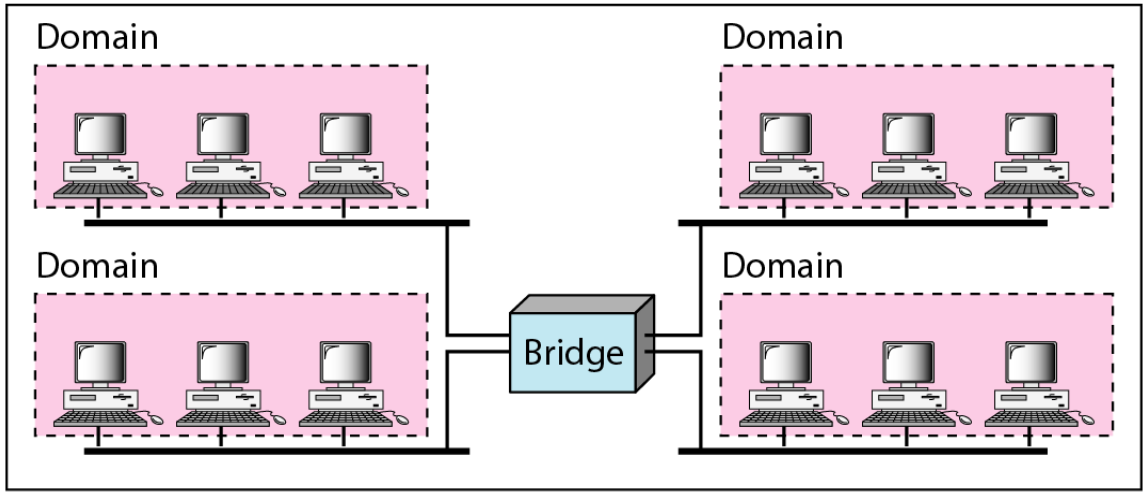


b. With bridging

Collision domains in an unbridged network and a bridged network

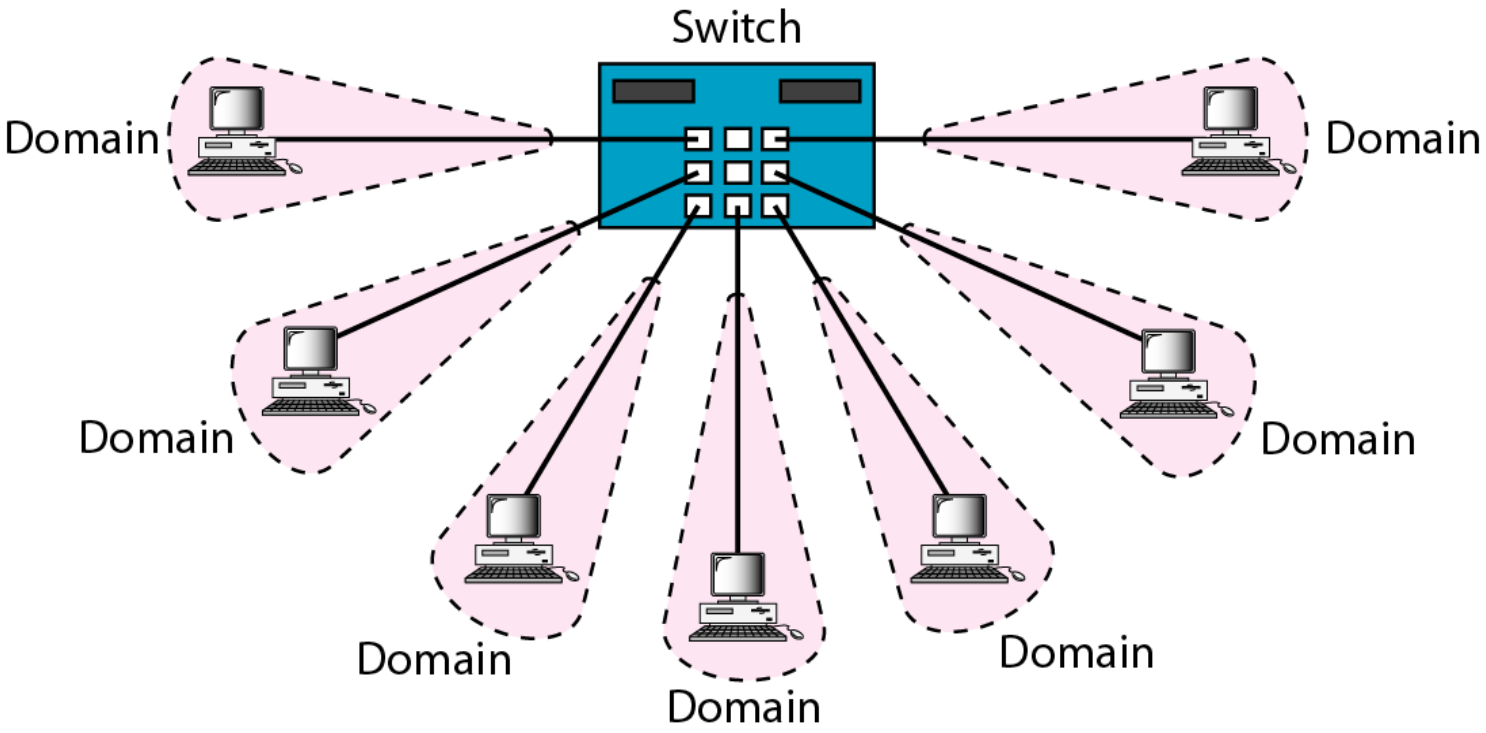


a. Without bridging



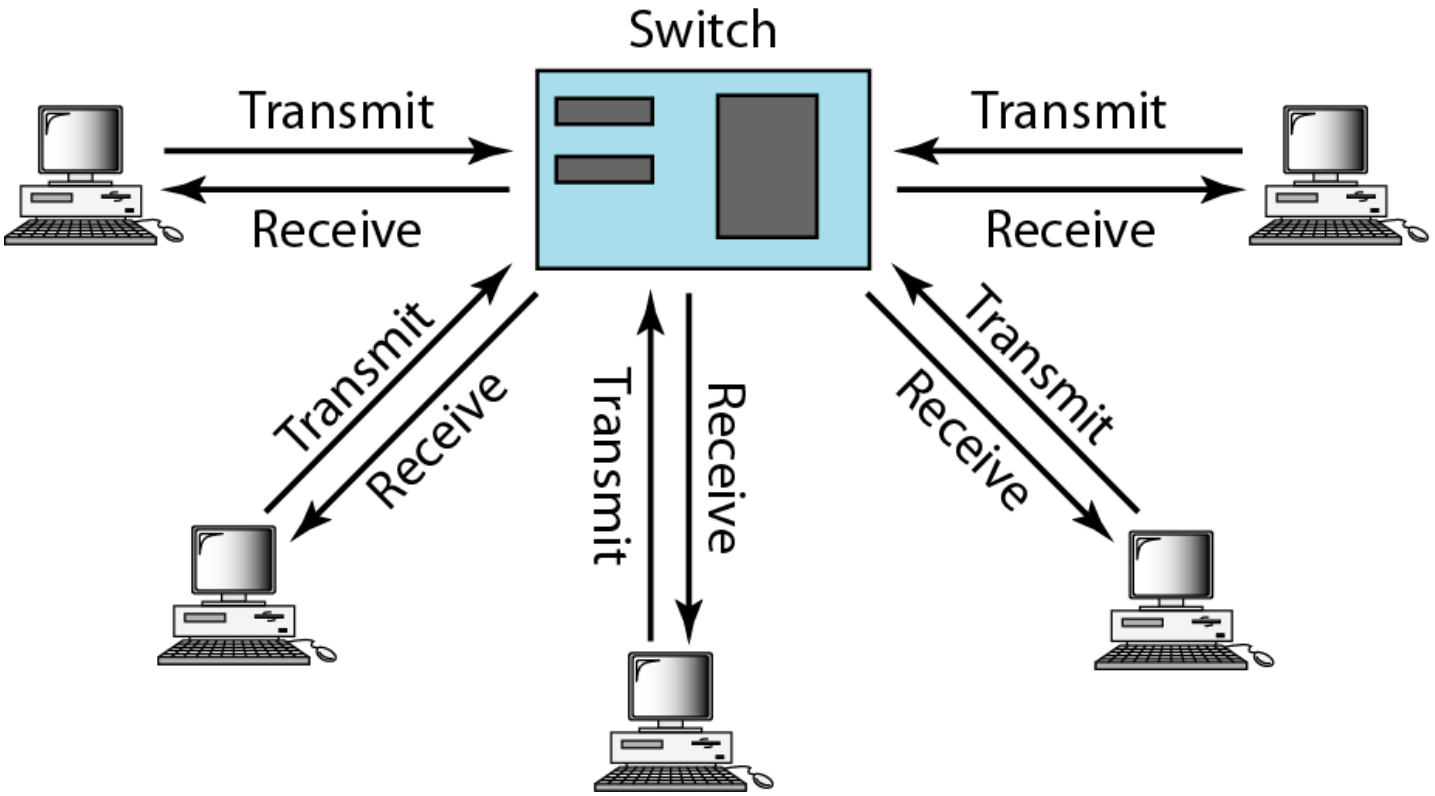
b. With bridging

Switched Ethernet



Full-duplex switched Ethernet

One of the limitations of 10Base5 and 10Base2 is that communication is half-duplex And 10Base-T is always full-duplex.



FAST ETHERNET

Fast Ethernet was designed to compete with LAN protocols such as FDDI or Fiber Channel. IEEE created Fast Ethernet under the name 802.3u. Fast Ethernet is backward-compatible with Standard Ethernet, but it can transmit data 10 times faster at a rate of 100 Mbps.

The goal of Fast Ethernet

1. **Upgrade the data rate to 100 Mbps.**
2. **Make it compatible with Standard Ethernet**
3. **Keep the same 48-bit address**
4. **Keep the same frame format**
5. **Keep the same Min and Max frame length**

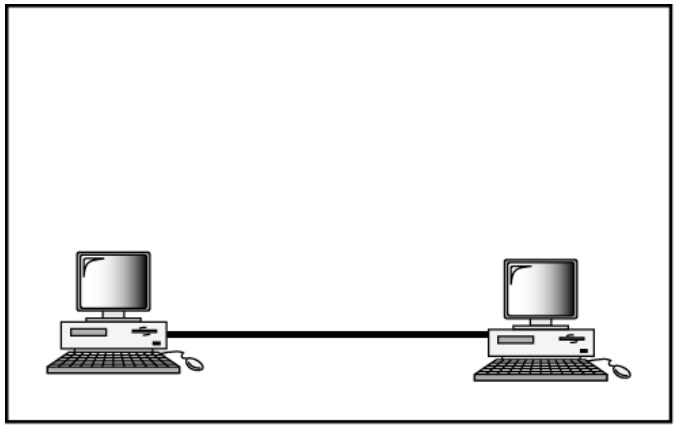
Autonegotiation

A new feature added Fast Ethernet is called autonegotiation. It allow two devices to negotiate the mode Or data rate of operation.

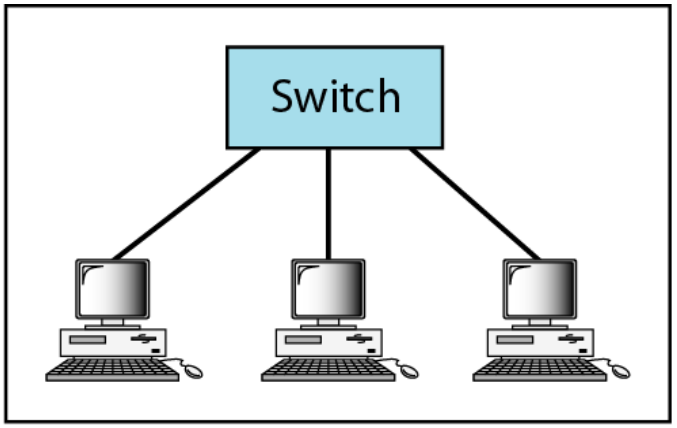
It was designed particularly for the following purposes:

1. To allow incompatible devices to connect to one another.
2. To allow one devices to have multiple capabilities.
3. To allow a station to check a hub's capabilities.

Fast Ethernet topology

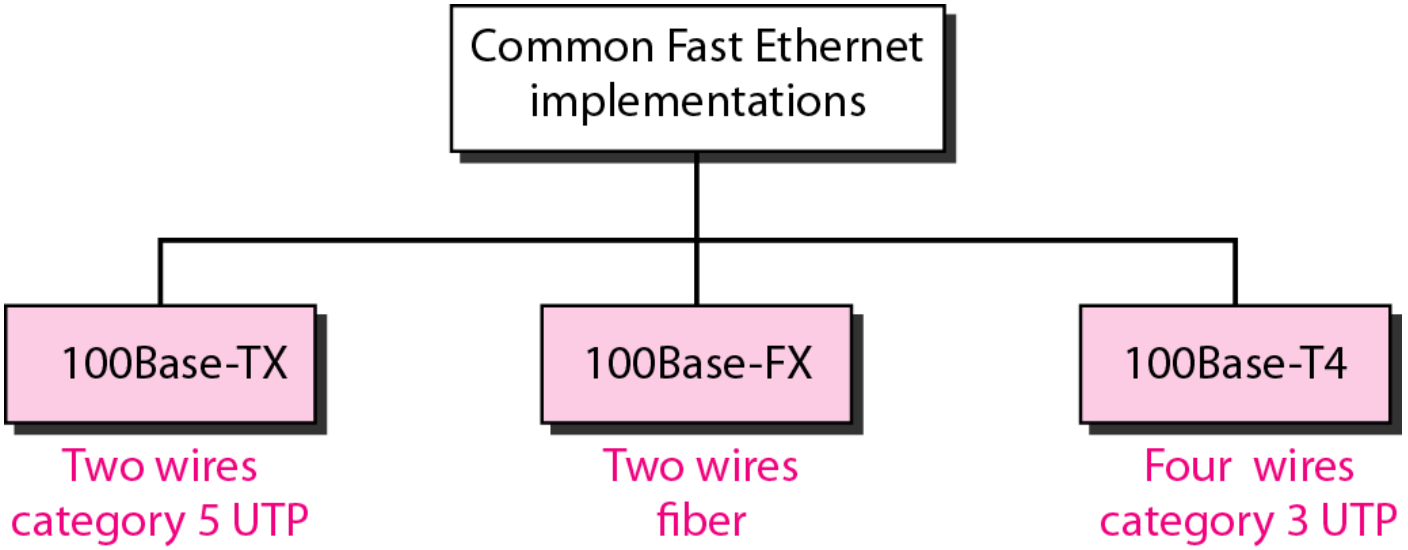


a. Point-to-point

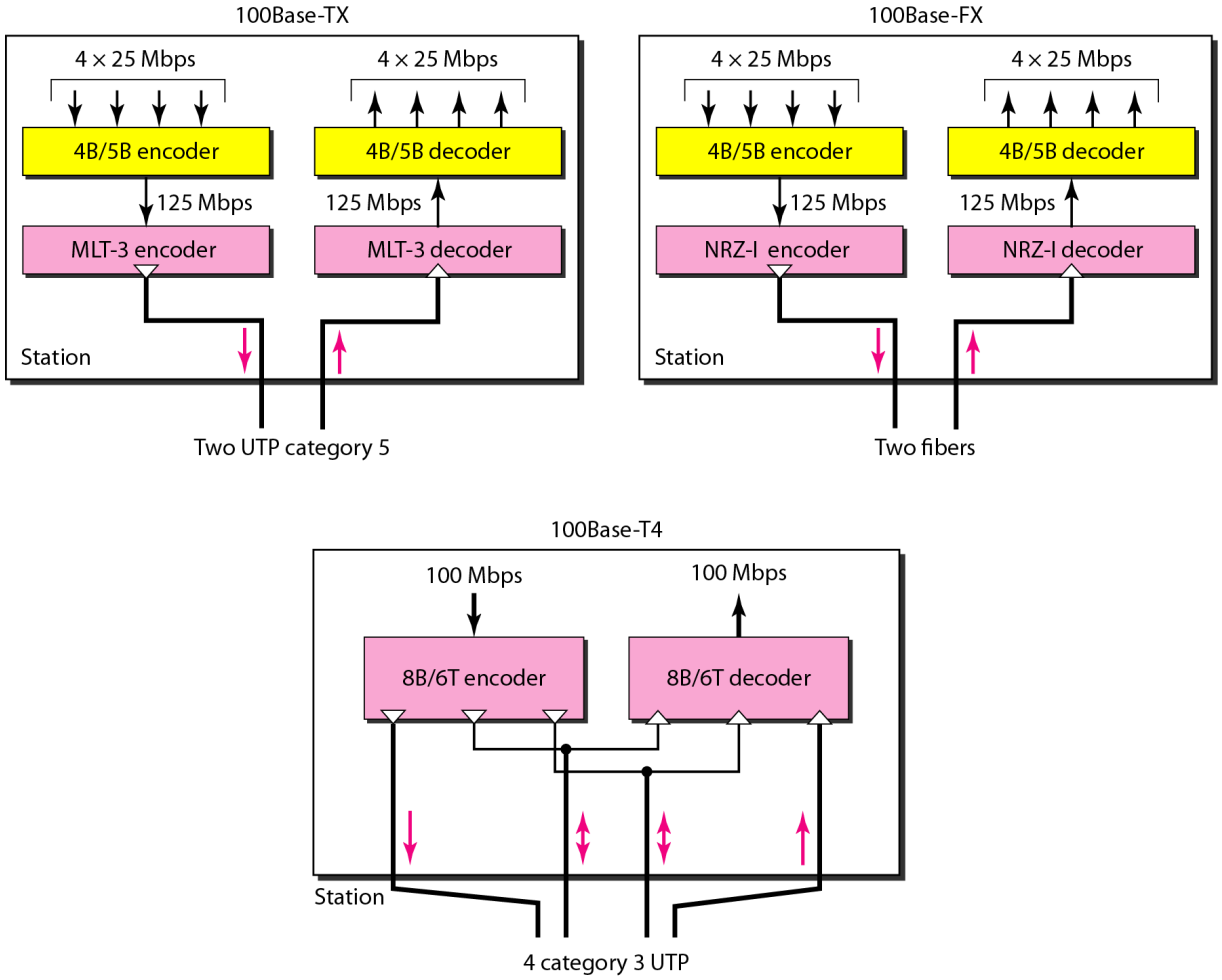


b. Star

Figure 13.20 *Fast Ethernet implementations*



Encoding for Fast Ethernet implementation



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

13-5 GIGABIT ETHERNET

The need for an even higher data rate resulted in the design of the Gigabit Ethernet protocol (1000 Mbps). The IEEE committee calls the standard 802.3z.

Topics discussed in this section:

MAC Sublayer
Physical Layer
Ten-Gigabit Ethernet

GIGABIT ETHERNET

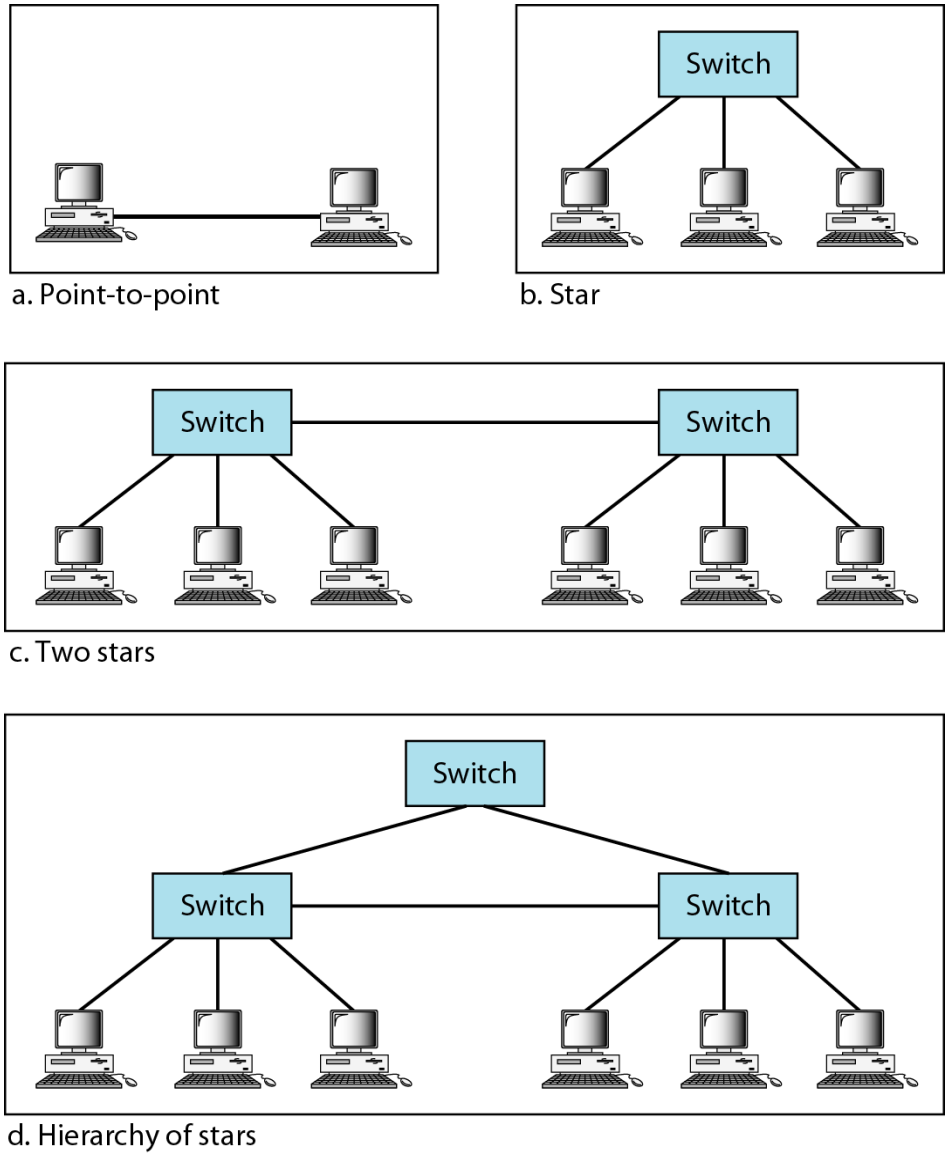
The goal of Gigabit Ethernet

1. **Upgrade the data rate to 1 Gbps.**
2. **Make it compatible with Standard Ethernet & Fast Ethernet**
3. **Keep the same 48-bit address**
4. **Keep the same frame format**
5. **Keep the same Min and Max frame length**
6. **To Support autonegotiation as define in Fast Ethernet**

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*

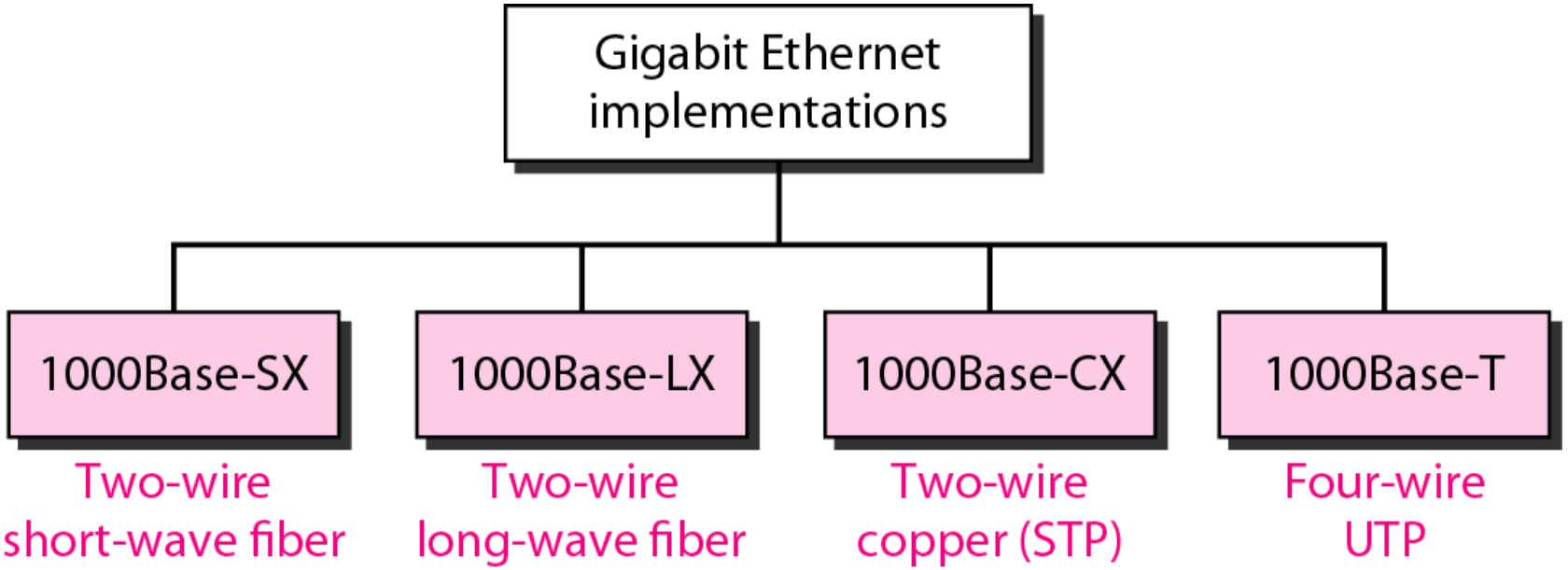


Table 13.3 *Summary of Gigabit Ethernet implementations*

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

The goal of Ten-Gigabit Ethernet

1. **Upgrade the data rate to 10 Gbps.**
2. **Make it compatible with Standard Ethernet, Fast Ethernet, Gigabit Ethernet**
3. **Keep the same 48-bit address**
4. **Keep the same frame format**
5. **Keep the same Min and Max frame length**
6. **Allow the interconnection of existing LANs into a MAN or WAN**
7. **Make Ethernet compatible with technologies such as Frame Relay and ATM.**

Summary of Ten-Gigabit Ethernet implementations

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