Chapter 13

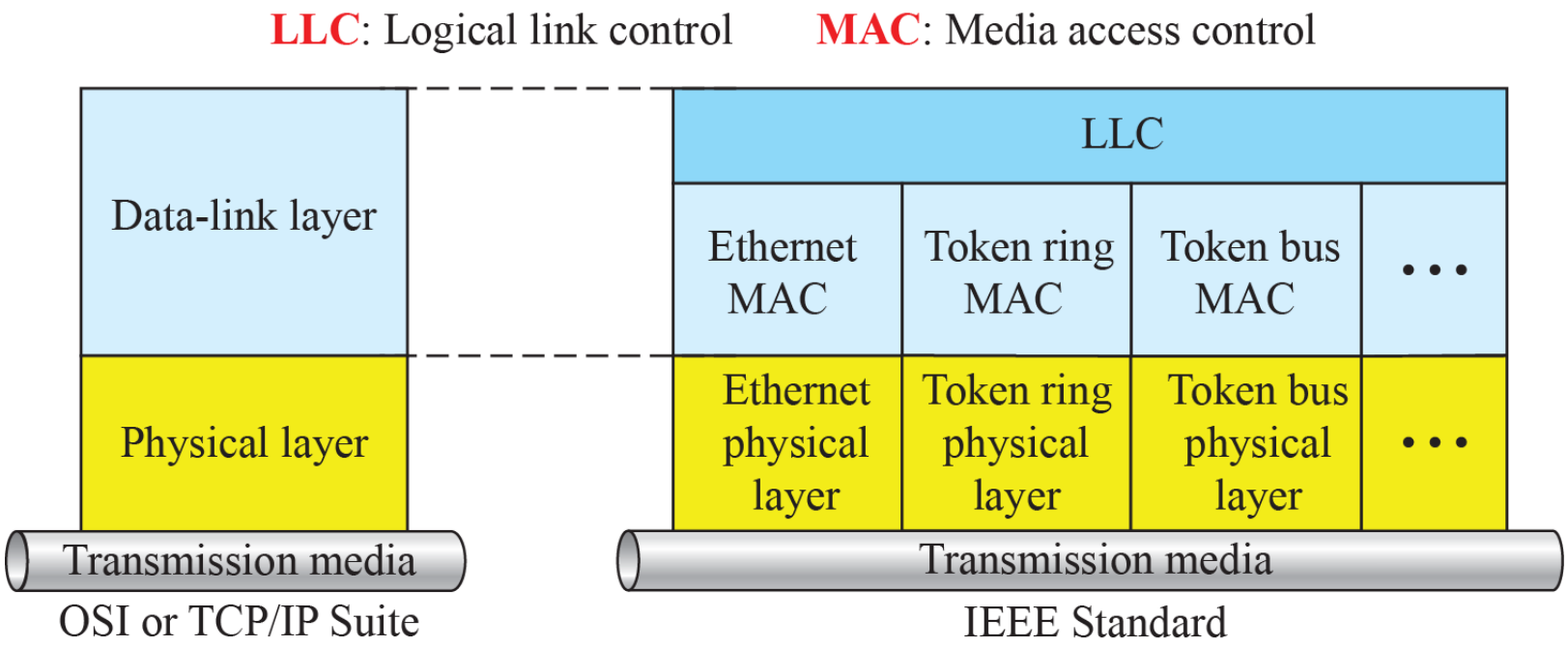
Wired LANs: Ethernet

IEEE Project 802

- **In 1985, the IEEE started a project, called Project 802, to set standards to enable intercommunication among equipment from a variety of manufacturers.**

- **It is a way of specifying functions of the physical layer and the data-link layer of major LAN protocols.**

IEEE standard for LANs

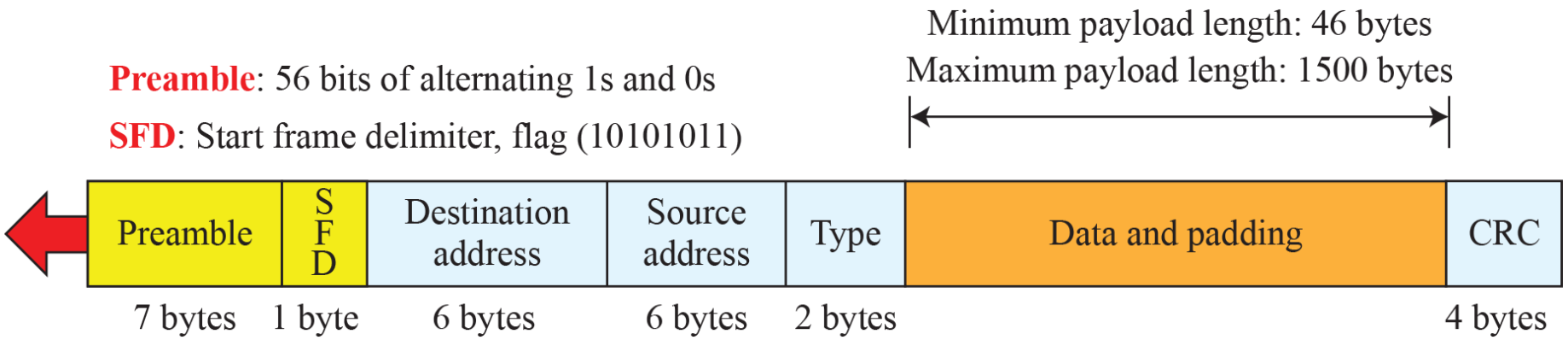


Ethernet Evolution

- **The Ethernet LAN was developed in the 1970s.**

- **Since then, it has gone through four generations:**
  - **Standard Ethernet (10 Mbps)**
  - **Fast Ethernet (100 Mbps)**
  - **Gigabit Ethernet (1 Gbps, 10 Gbps)**

Ethernet frame



Example 13.1

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

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:

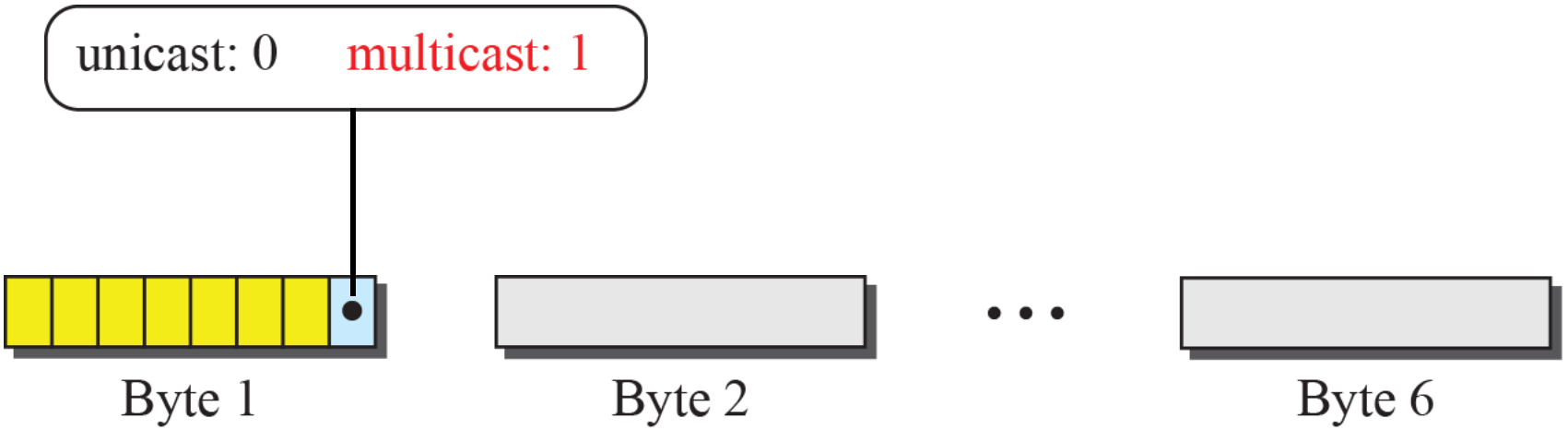
Hexadecimal	47	20	1B	2E	08	EE
Binarys	01000111	00100000	00011011	00101110	00001000	11101110
Transmitted ←	11100010	00000100	11011000	01110100	00010000	01110111

Addressing

- Each station on an Ethernet network (such as a PC, workstation, or printer) has its own network interface card (NIC).
- The NIC fits inside the station and provides the station with a link-layer address.
- The Ethernet address is 6 bytes (48 bits), normally written in hexadecimal notation, with a colon between the bytes. For example, the following shows an Ethernet MAC address:

```
4A:30:10:21:10:1A
```

Unicast and multicast addresses



Example 13.2

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 Fs, the address is broadcast.

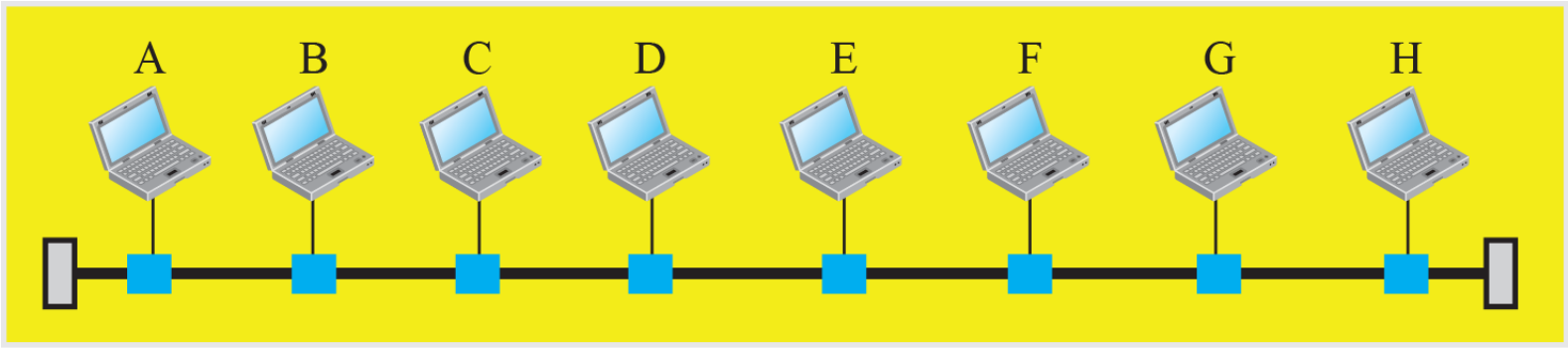
Example 13.2 (continued)

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

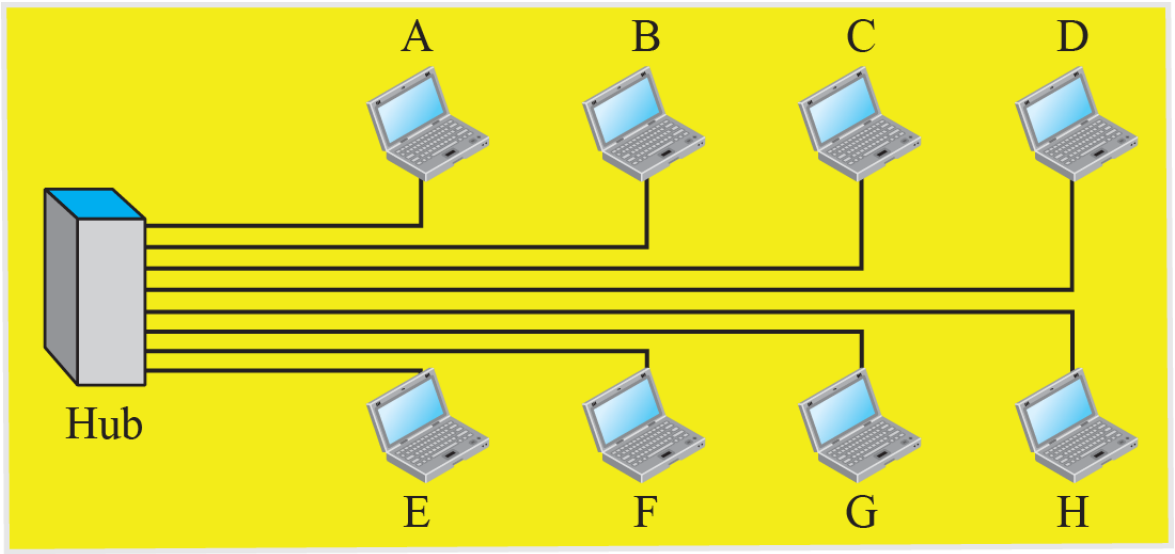
b. This is a multicast address because 7 in binary is 0111 (odd).

c. This is a broadcast address because all digits are Fs in hexadecimal.

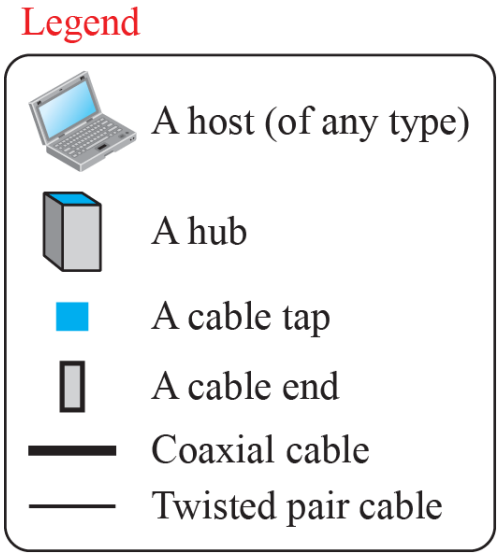
Implementation of standard Ethernet



a. A LAN with a bus topology using a coaxial cable



b. A LAN with a star topology using a hub



Access Method

- **Since the network that uses the standard Ethernet protocol is a broadcast network**

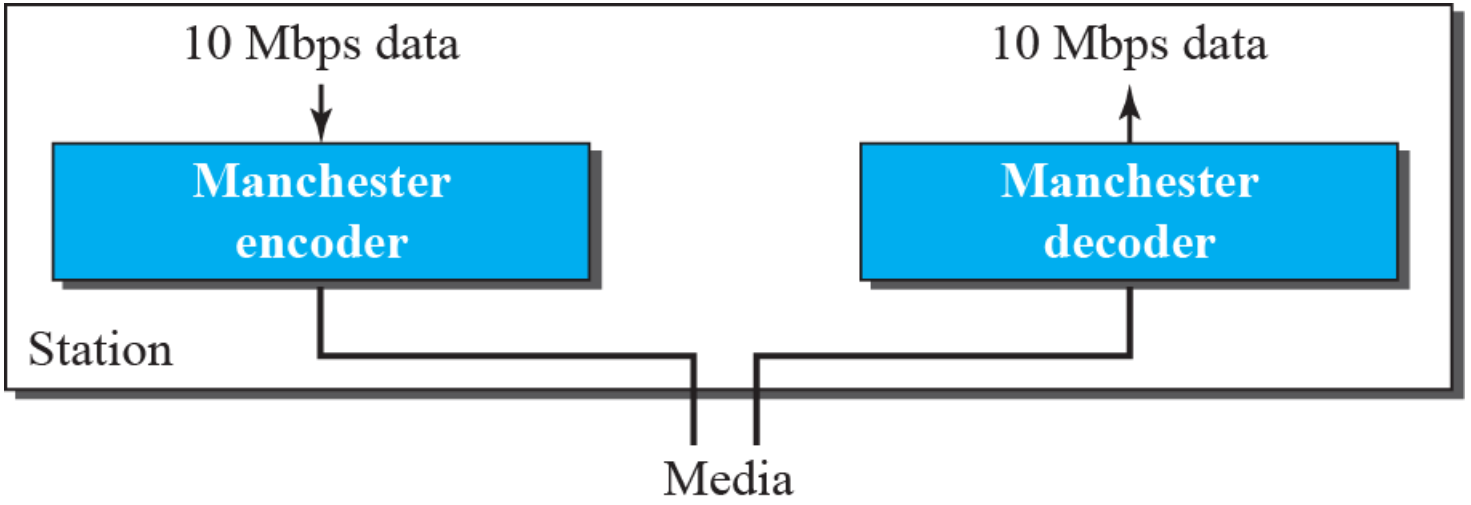
- **We need to use an access method to control access to the sharing medium.**

- **The standard Ethernet chose CSMA/CD with 1-persistent method,**

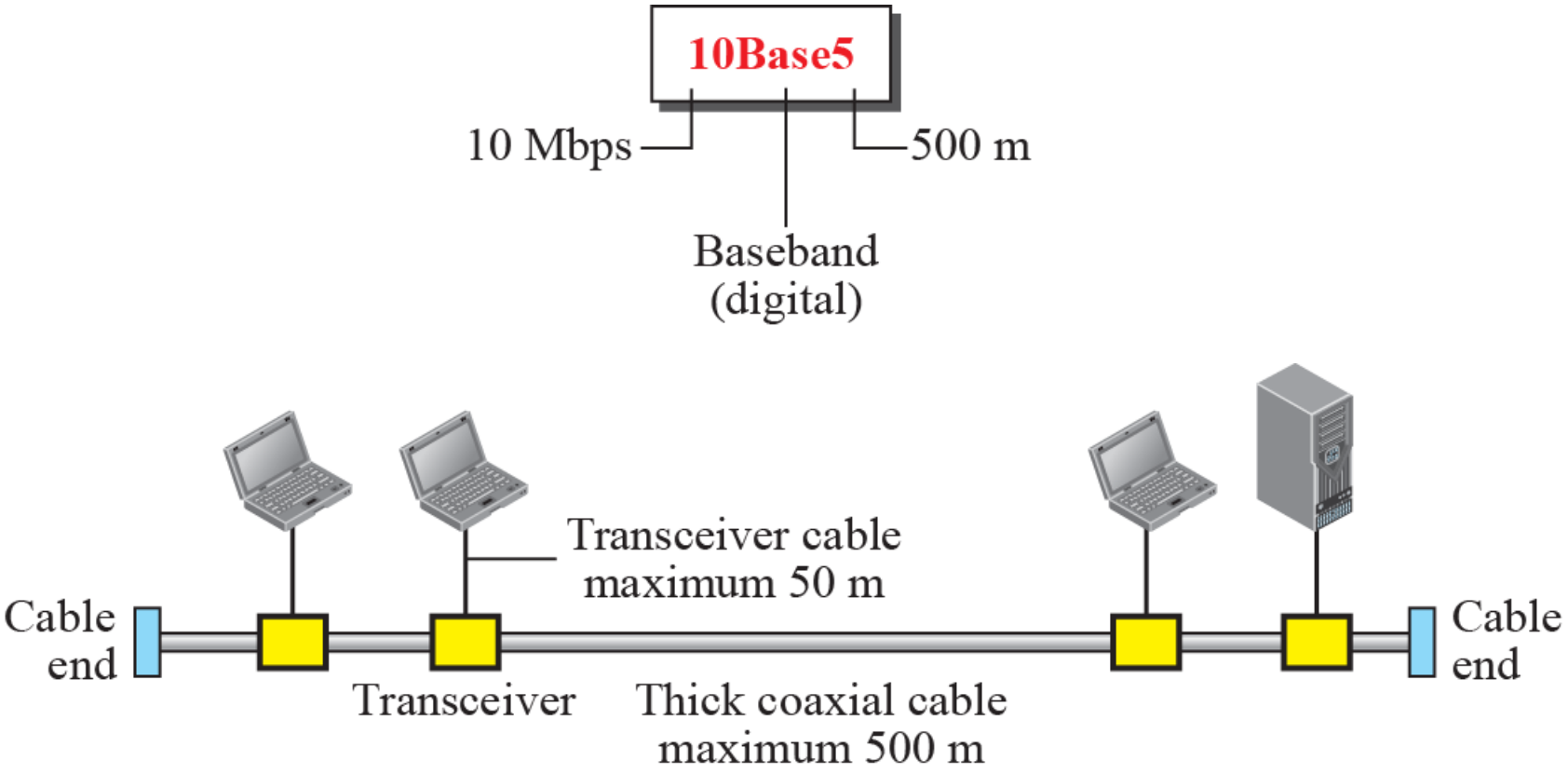
Summary of Standard Ethernet implementations

Implementation	*Medium*	*Medium Length*	*Encoding*
10Base5	Thick coax	500 m	Manchester
10Base2	Thin coax	185 m	Manchester
10Base-T	2 UTP	100 m	Manchester
10Base-F	2 Fiber	2000	Manchester

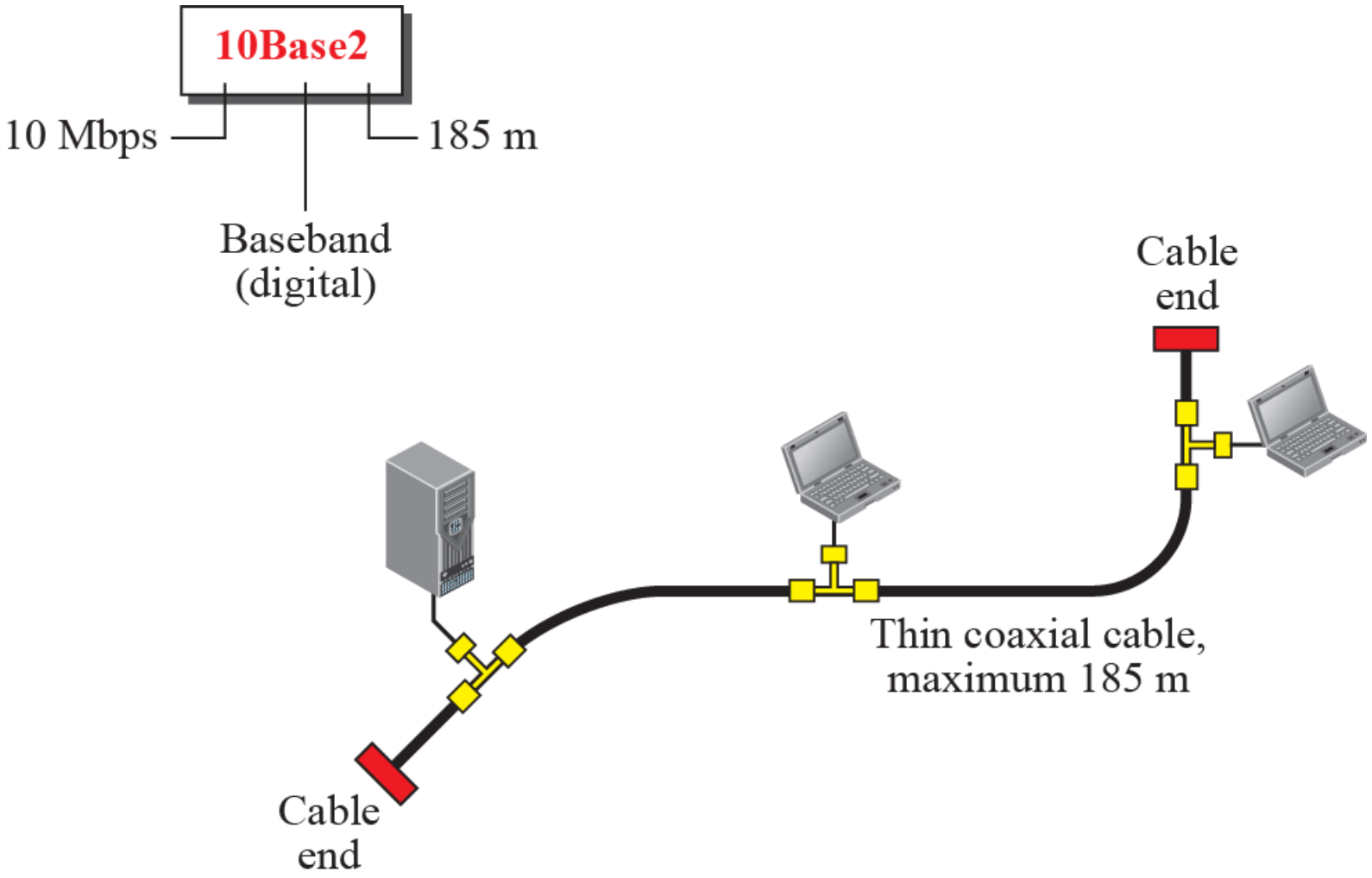
Encoding in a Standard Ethernet



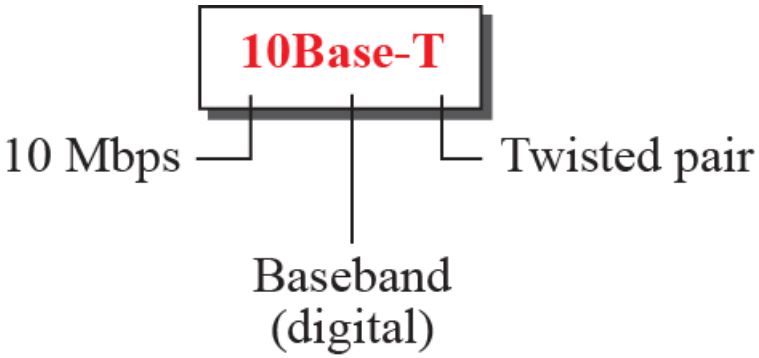
10Base5 implementation

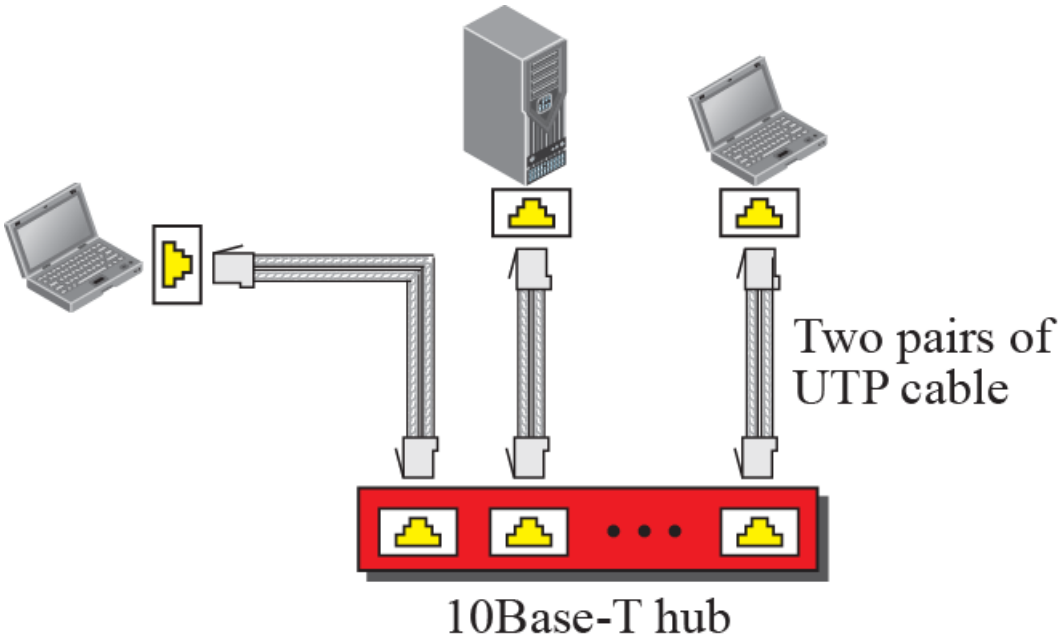


10Base2 implementation

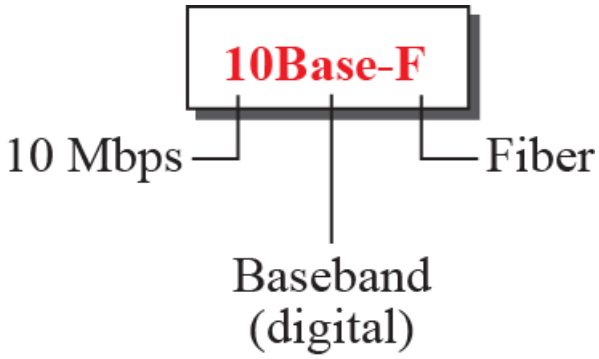


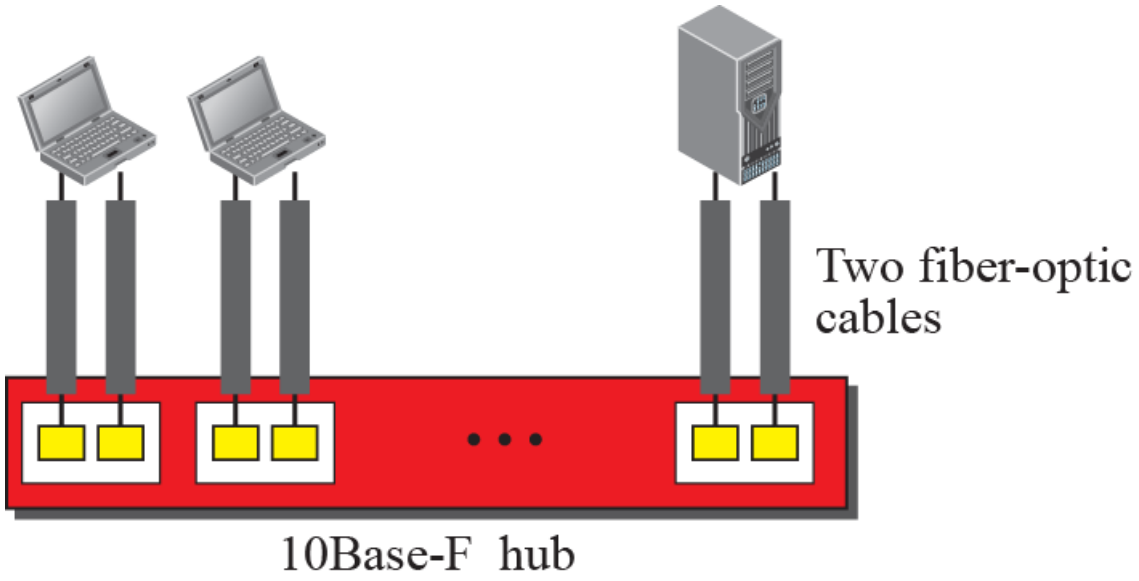
10Base-T implementation





10Base-F implementation

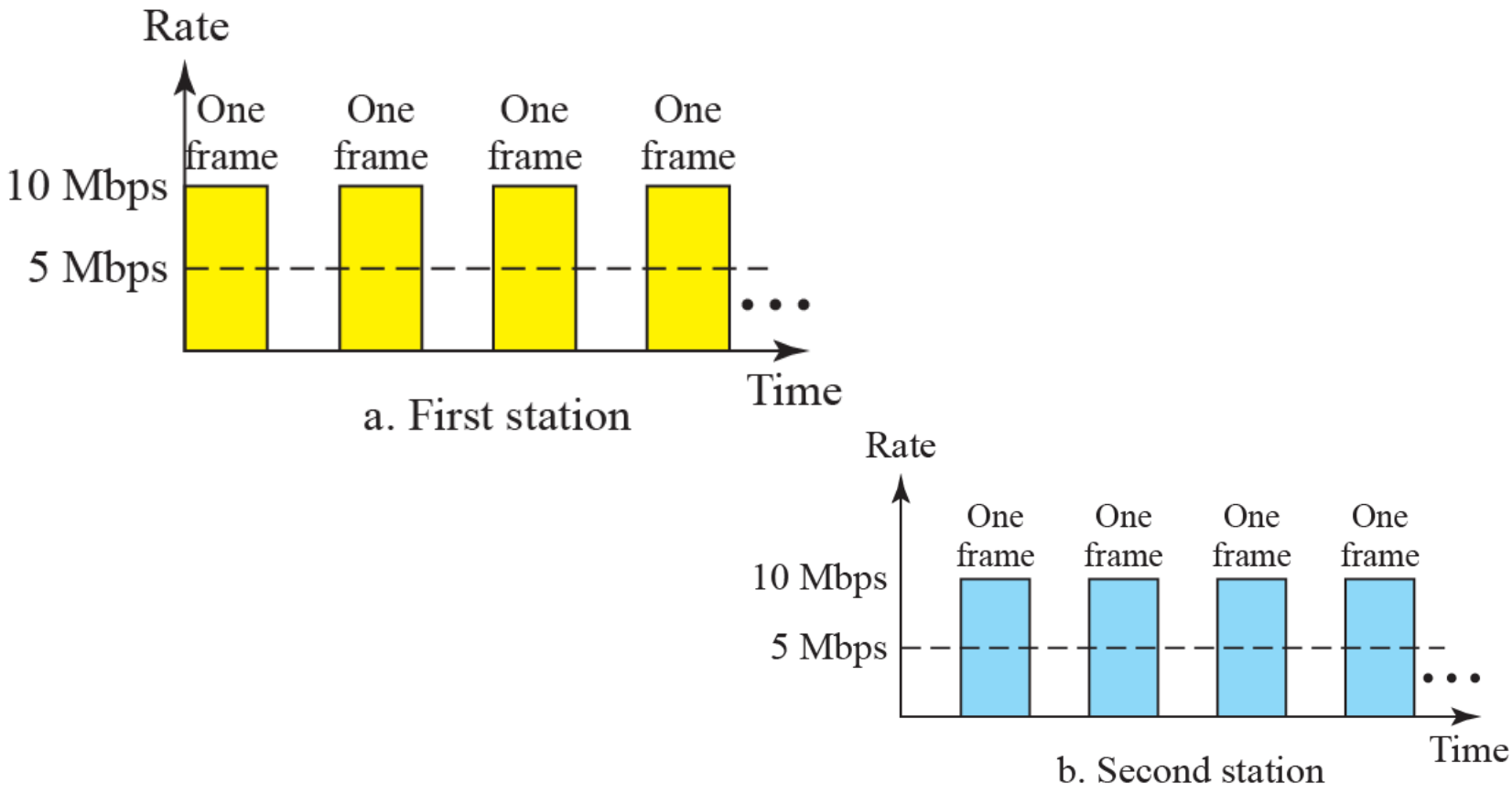




Changes in the Standard

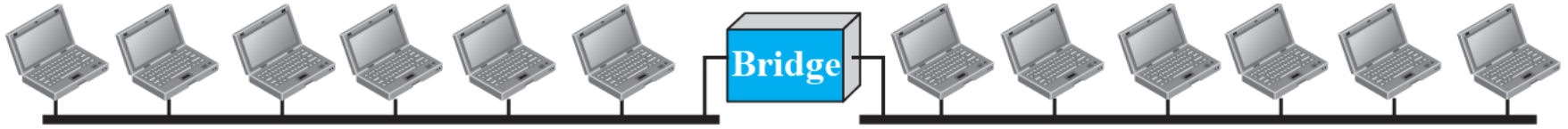
Before we discuss higher-rate Ethernet protocols, we need to discuss the changes that occurred to the 10-Mbps Standard Ethernet. These changes actually opened the road to the evolution of the Ethernet to become compatible with other high-data-rate LANs.

Sharing bandwidth



A network with and without bridging

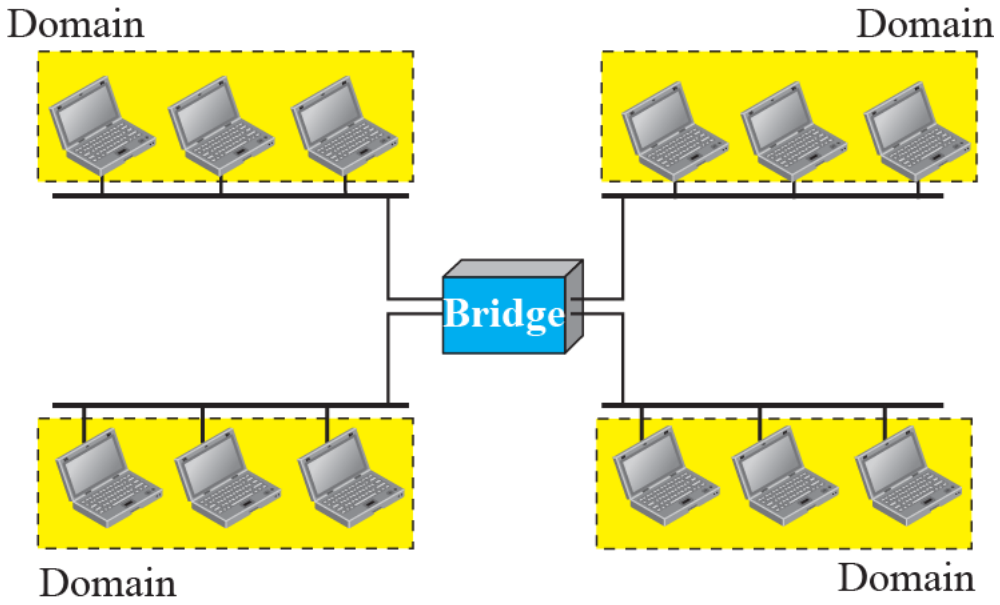
a. Without bridging



b. With bridging

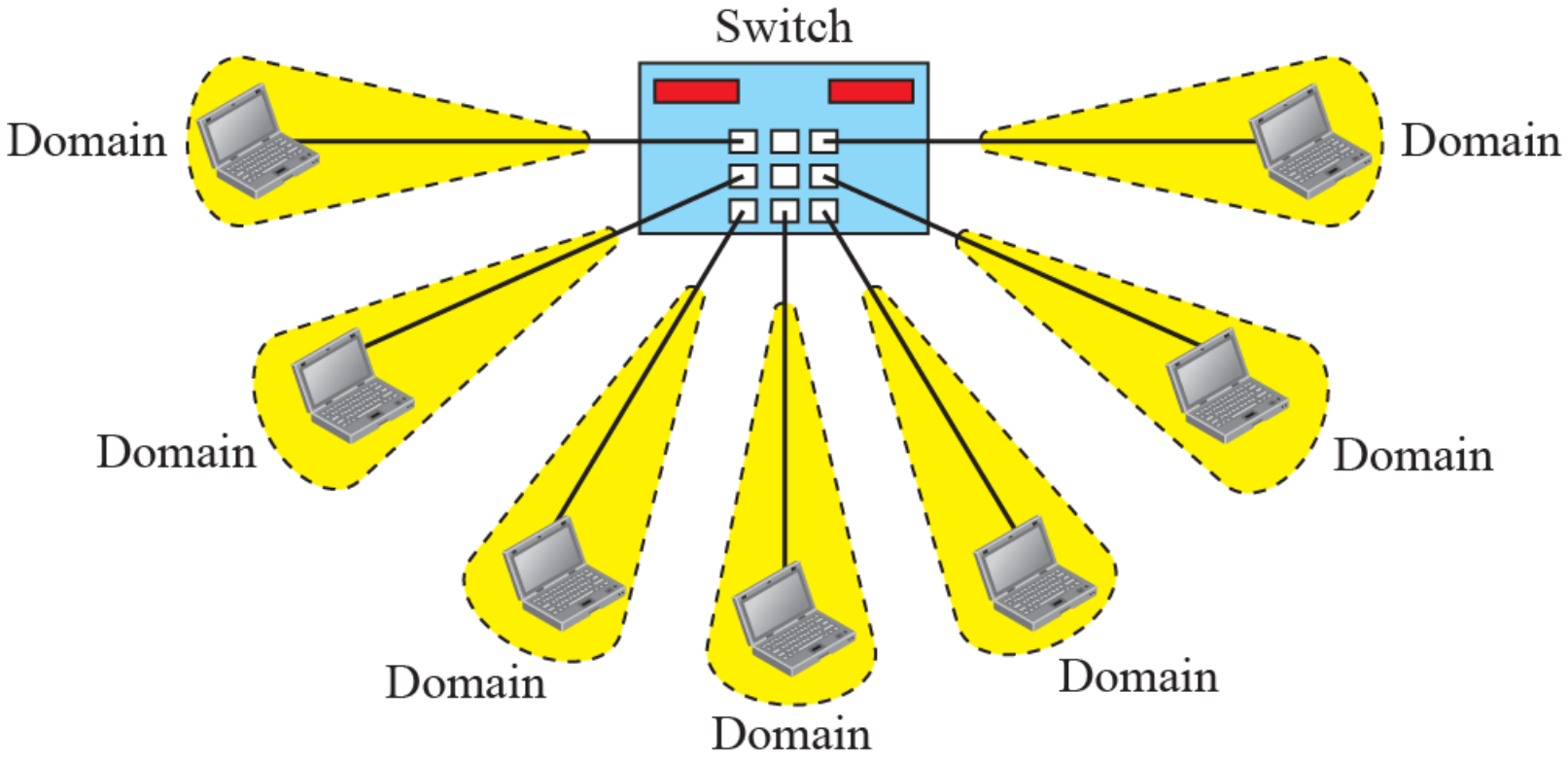
Collision domains

a. Without bridging

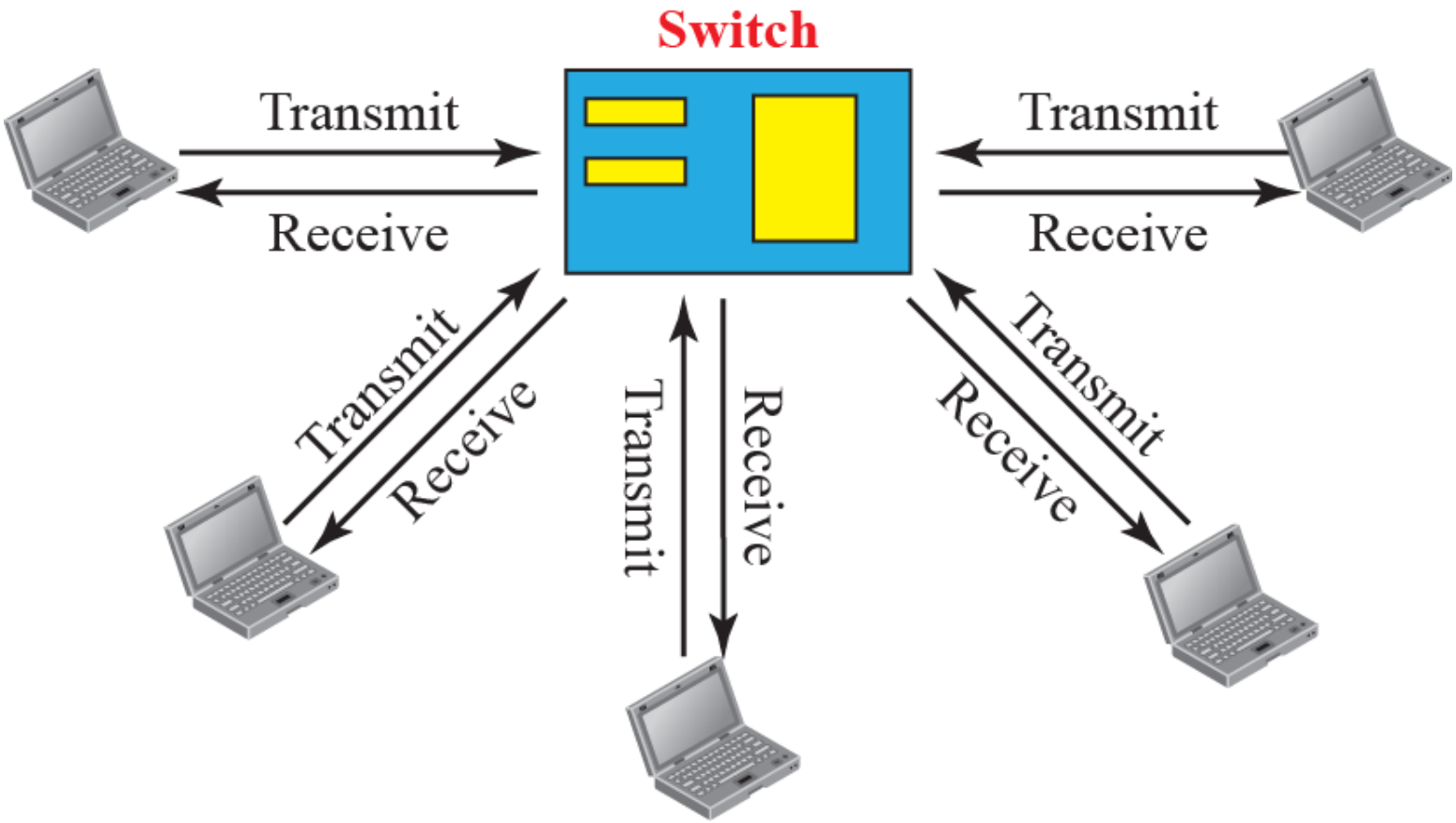


b. With bridging

Switched Ethernet



Full – duplex switched Ethernet



FAST ETHERNET

- **In the 1990s, Ethernet made a big jump by increasing the transmission rate to 100 Mbps, and the new generation was called the Fast Ethernet.**

- **The designers of the Fast Ethernet needed to make it compatible with the Standard Ethernet.**

- **The MAC sublayer was left unchanged. But the features of the Standard Ethernet that depend on the transmission rate, had to be changed.**

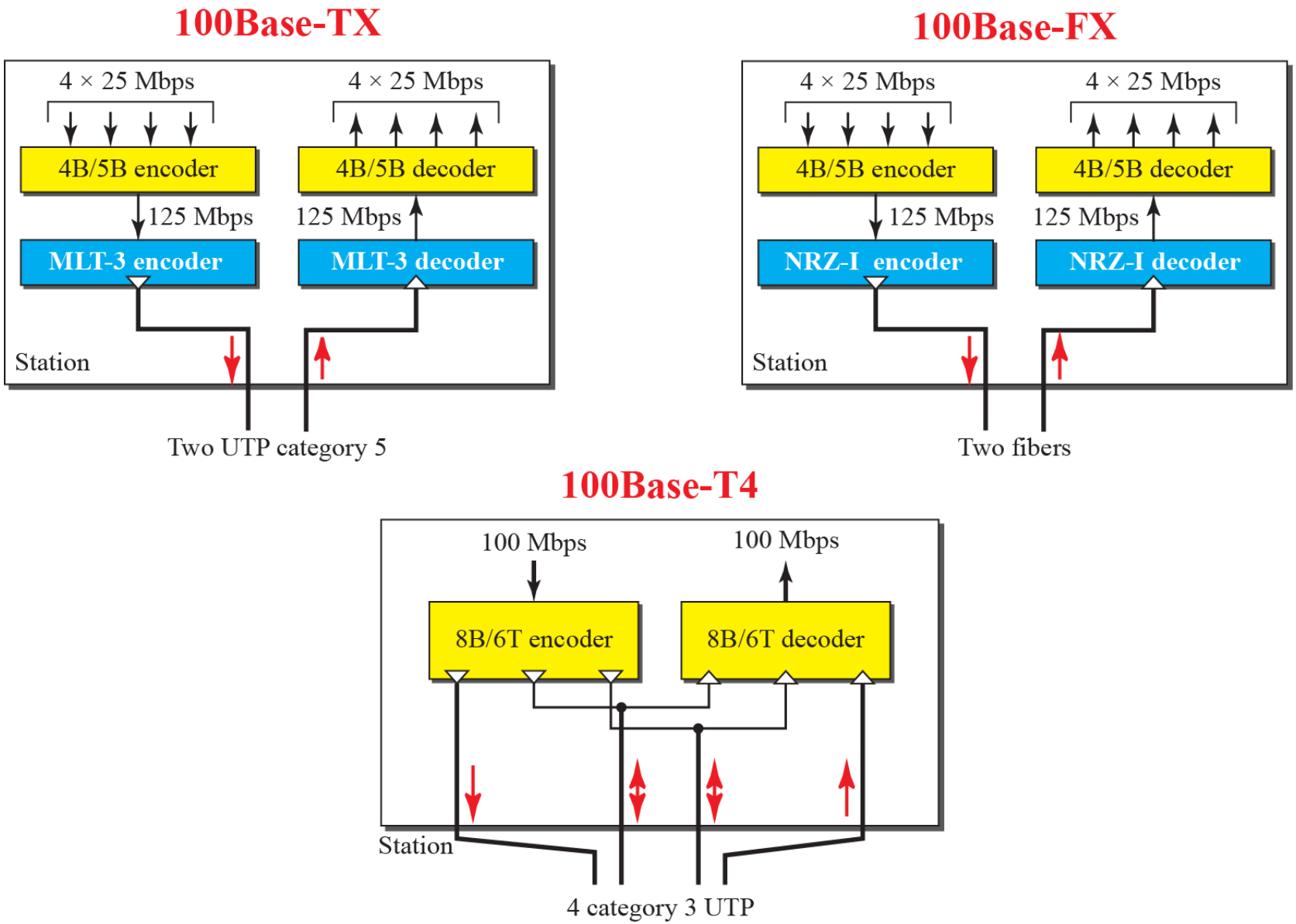
Access Method

- The proper operation of the CSMA/CD depends on the transmission rate, the minimum size of the frame, and the maximum network length.
- If we want to keep the minimum size of the frame, the maximum length of the network should be changed.
- In other words, if the minimum frame size is still 512 bits, and it is transmitted 10 times faster, the collision needs to be detected 10 times sooner, which means the maximum length of the network should be 10 times shorter (the propagation speed does not change).

Physical Layer

To be able to handle a 100 Mbps data rate, several changes need to be made at the physical layer.

Encoding for fast Ethernet



Summary of Fast Ethernet implementations

Implementation	*Medium*	*Medium Length*	*Wires*	*Encoding*
100Base-TX	STP	100 m	2	4B5B + MLT-3
100Base-FX	Fiber	185 m	2	4B5B + NRZ-I
100Base-T4	UTP	100 m	4	Two 8B/6T

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 it the Standard 802.3z.
- The goals of the Gigabit Ethernet were to upgrade the data rate to 1 Gbps, but keep the address length, the frame format, and the maximum and minimum frame length the same.

MAC Sublayer

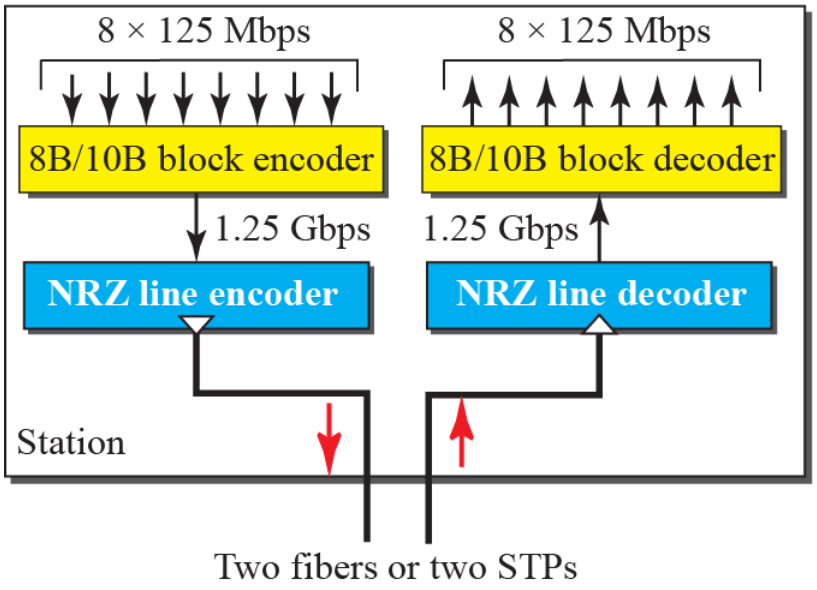
- A main consideration in the evolution of Ethernet was to keep the MAC sublayer untouched.
- However, to achieve a data rate of 1 Gbps, this was no longer possible.
- Gigabit Ethernet has two distinctive approaches for medium access: **half-duplex** and **full-duplex**. Almost all implementations of Gigabit Ethernet follow the full-duplex approach, so we mostly ignore the half-duplex mode.

Physical Layer

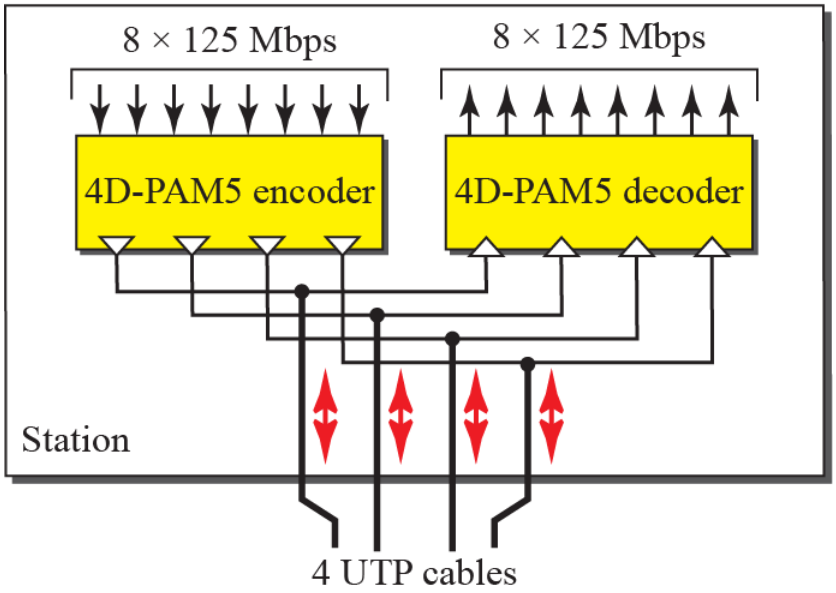
The physical layer in Gigabit Ethernet is more complicated than that in Standard or Fast Ethernet.

Encoding in Gigabit Ethernet

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



1000Base-T



Summary of Gigabit Ethernet implementations

Implementation	*Medium*	*Medium Length*	*Wires*	*Encoding*
1000Base-SX	Fiber S-W	550 m	2	8B/10B + NRZ
1000Base-LX	Fiber L-W	5000 m	2	8B/10B + NRZ
1000Base-CX	STP	25 m	2	8B/10B + NRZ
1000Base-T4	UTP	100 m	4	4D-PAM5

10-GIGABIT EHTERNET

- The Ethernet for use in metropolitan areas.
- The idea is to extend the technology, the data rate, and the coverage distance so that the Ethernet can be used as LAN and MAN (metropolitan area network).
- The IEEE committee created 10 Gigabit Ethernet and called it Standard 802.3ae.

Implementation

- **10 Gigabit Ethernet operates only in full-duplex mode, which means there is no need for contention;**

- **CSMA/CD is not used in 10 Gigabit Ethernet.**

- **Four implementations are the most common: 10GBase-SR, 10GBase-LR, 10GBase-EW, and 10GBase-X4.**

Summary of 10-Gigabit Ethernet implementations

Implementation	*Medium*	*Medium Length*	*Number of wires*	*Encoding*
10GBase-SR	Fiber 850 nm	300 m	2	64B66B
10GBase-LR	Fiber 1310 nm	10 Km	2	64B66B
10GBase-EW	Fiber 1350 nm	40 Km	2	SONET
10GBase-X4	Fiber 1310 nm	300 m to 10 Km	2	8B10B