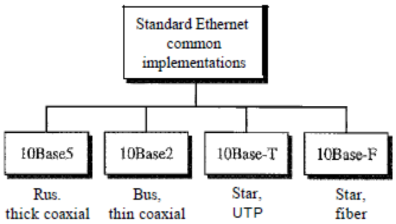
Physical Layer Implantation

The Standard Ethernet defines several physical layer implementations; four of the most common, are shown in Figure 13.8.

Encoding and Decoding

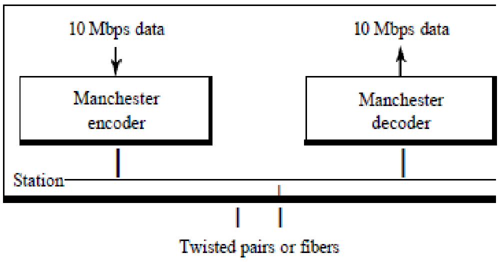
All standard implementations use digital signaling (base band) at 10 Mbps. At the sender, data are converted to a digital signal using the Manchester scheme; at the receiver

Figure 13.8 *Categories ofStandard Ethernet*



The received signal is interpreted as Manchester and decoded into data. Manchester encoding is self-synchronous, providing a transition at each bit interval. Figure 13.9 shows the encoding scheme for Standard Ethernet.

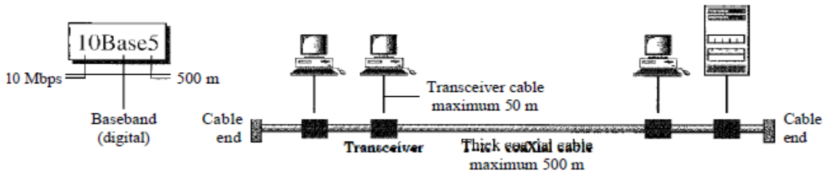
Figure 13.9 *Encoding in a Standard Ethernet implementation*



<u>10Base5: Thick Ethernet</u>

The first implementation is called 10Base5, thick Ethernet, or Thick net. The nickname derives from the size of the cable, which is roughly the size of a garden hose and too stiff to bend with your hands. 10BaseS was the first Ethernet specification to use a bus topology with an external transceiver (transmitter/receiver) connected via a tap to a thick coaxial cable. Figure 13.10 shows a schematic diagram of a l0Base5 implementation.

Figure 13.10 *IOBase5 implementation*



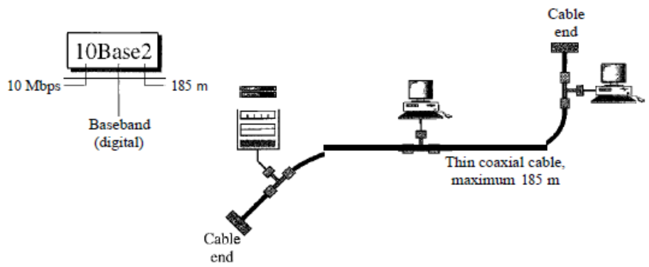
The transceiver is responsible for transmitting, receiving, and detecting collisions. The transceiver is connected to the station via a transceiver cable that provides separate paths for sending and receiving. This means that collision can only happen in the coaxial cable.

The maximum length of the coaxial cable must not exceed 500 m, otherwise, there is excessive degradation of the signal. If a length of more than 500 m is needed, up to five segments, each a maximum of Some-meter, can be connected using repeaters.

<u>10Base2: Thin Ethernet</u>

The second implementation is called l0Base2, thin Ethernet, or Cheaper net. I0Base2 also uses a bus topology, but the cable is much thinner and more flexible. The cable can be bent to pass very close to the stations. In this case, the transceiver is normally part of the network interface card (NIC), which is installed inside the station. Figure 13.11 shows the schematic diagram of a IOBase2 implementation.

Figure 13.11 *lOBase2 implementation*



Note that the collision here occurs in the thin coaxial cable. This implementation is more cost effective than 10BaseS because thin coaxial cable is less expensive than thick coaxial and the tee connections are much cheaper than taps. Installation is simpler because the thin coaxial cable is very flexible. However, the length of each segment cannot exceed 185 m (close to 200 m) due to the high level of attenuation in thin coaxial cable.

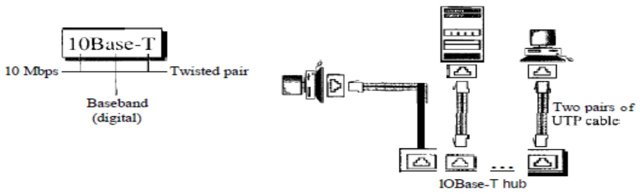
<u>10Base-T: Twisted-Pair Ethernet</u>

The third implementation is called 10Base-T or twisted-pair Ethernet. 10Base-T uses a physical star topology. The stations are connected to a hub via two pairs of twisted cable, as shown in Figure 13.12.

Note that two pairs of twisted cable create two paths (one for sending and one for receiving) between the station and the hub. Any collision here happens in the hub.

Compared to10Base5 or lOBase2, we can see that the hub actually replaces the coaxial

Figure 13.12 *IOBase-T implementation*

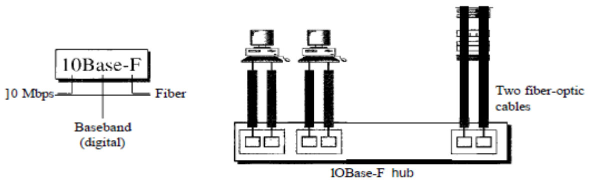


Cable as far as a collision is concerned. The maximum length of the twisted cable here is defined as 100 m, to minimize the effect of attenuation in the twisted cable.

<u>10Base-F: Fiber Ethernet</u>

Although there are several types of optical fiber l0-Mbps Ethernet, the most common is called 10Base-F. 10Base-F uses a star topology to connect stations to a hub. The stations are connected to the hub using two fiber-optic cables, as shown in Figure 13.13.

Figure 13.13 *IOBase-F implementation*



Summary

Table 13.1 shows a summary of Standard Ethernet implementations.

Table 13.1 *Summary ofStandard Ethernet implementations*

Characteristics	*lOBase5*	*lOBase2*	*lOBase-T*	*IOBase-F*
Media	Thick coaxial cable	Thin coaxial cable	2UTP	2 Fiber
Maximum length	500m	185 m	100m	2000m
Line encoding	Manchester	Manchester	Manchester	Manchester

13.3 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. We discuss some of these changes in this section.

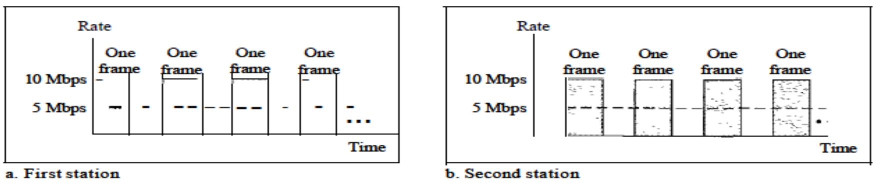
Bridged Ethernet

The first step in the Ethernet evolution was the division of a LAN by bridges. Bridges have two effects on an Ethernet LAN: They raise the bandwidth and they separate collision domains.

Raising the Bandwidth

In an unabridged Ethernet network, the total capacity (10 Mbps) is shared among all stations with a frame to send; the stations share the bandwidth of the network. If only one station has frames to send, it benefits from the total capacity (10 Mbps). But if more than one station needs to use the network, the capacity is shared. For example, if two stations have a lot of frames to send, they probably alternate in usage. When one station is sending, the other one refrains from sending. We can say that, in this case, each station on average sends at a rate of 5 Mbps. Figure 13.14 shows the situation.

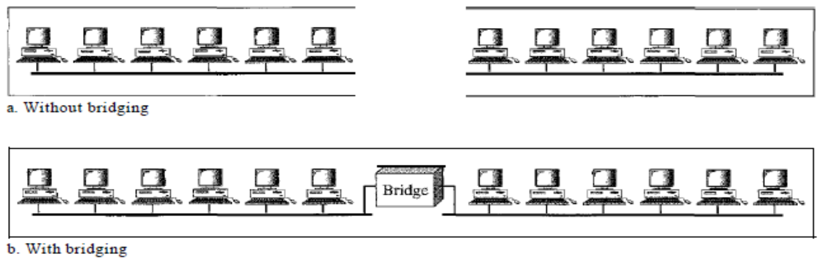
Figure 13.14 *Sharing bandwidth*



The bridge, as we will learn in Chapter 15, can help here. A bridge divides the network into two or more networks. Bandwidth-wise, each network is independent. For example, in Figure 13.15, a network with 12 stations is divided into two networks, each with 6 stations. Now each network has a capacity of 10 Mbps. The l0-Mbps capacity in each segment is now shared between 6 stations (actually 7 because the bridge acts as a station in each segment), not 12 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.

It is obvious that if we further divide the network, we can gain more bandwidth for each segment. For example, if we use a four-port bridge, each station is now offered 10/3 Mbps, which is 4 times more than an unabridged network.

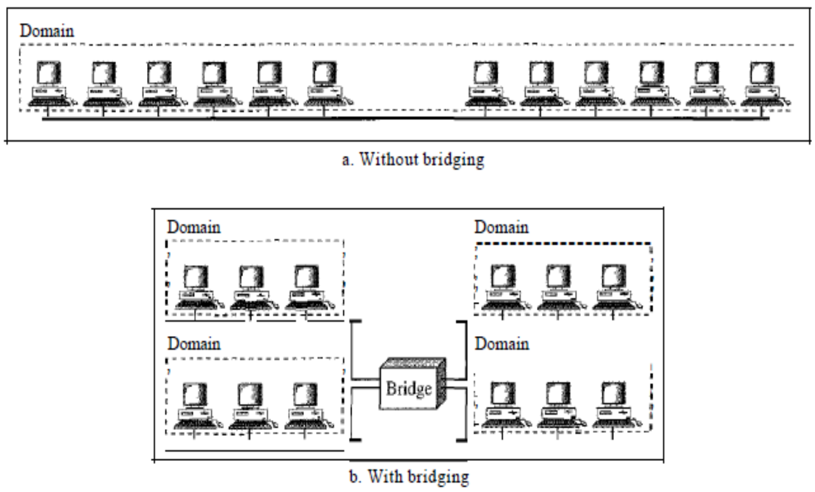
Figure 13.15 *A network with and without a bridge*



Separating Collision Domains

Another advantage of a bridge is the separation of the collision domain. Figure 13.16shows the collision domains for an unabridged and a bridged network. You can see that the collision domain becomes much smaller and the probability of collision is reduced tremendously. Without bridging, 12 stations contend for access to the medium; with bridging only 3 stations contend for access to the medium.

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

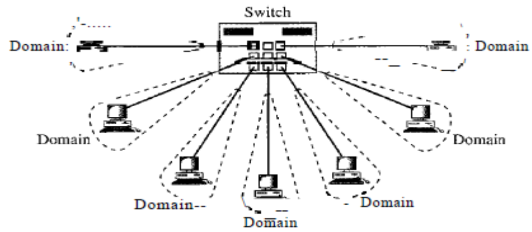


Switched Ethernet

The idea of a bridged LAN can be extended to a switched LAN. Instead of having two to four networks, why not have N networks, where N is the number of stations on the LAN? In other words, if we can have a multiple-port bridge, why not have an N-port switch? In this way, the bandwidth is shared only between the station and the switch (5 Mbps each). In addition, the collision domain is divided into N domains. A layer 2 switch is an N-port bridge with additional

sophistication that allows faster handling of the packets. Evolution from a bridged Ethernet to a switched Ethernet was a big step that opened the way to an even faster Ethernet, as we will see. Figure 13.17 shows a switched LAN.

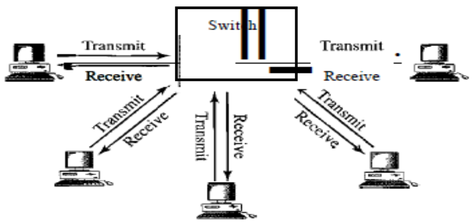
Figure 13.17 *Switched Ethernet*



Full-Duplex Ethernet

One of the limitations of 10Base5 and l0Base2 is that communication is half-duplex (l0Base-T is always full-duplex); a station can either send or receive, but may not do both at the same time. The next step in the evolution was to move from switched Ethernet to full-duplex switched Ethernet. The full-duplex mode increases the capacity of each domain from 10 to 20 Mbps. Figure 13.18 shows a switched Ethernet in full-duplex mode. Note that instead of using one link between the station and the switch, the configuration uses two links: one to transmit and one to receive.

Figure 13.18 *Full-duplex switched Ethernet*



No Need for CSMA/CD

In full-duplex switched Ethernet, there is no need for the CSMA/CD method. In a full duplex switched Ethernet, each station is connected to the switch via two separate links.

Each station or switch can send and receive independently without worrying about collision. Each link is a point-to-point dedicated path between the station and the switch. There is no longer a need for carrier sensing; there is no longer a need for collision detection. The job of the MAC layer becomes much easier. The carrier sensing and collision detection functionalities of the MAC sub layer can be turned off.

MAC Control Layer

Standard Ethernet was designed as a connectionless protocol at the MAC sub layer. There is no explicit flow control or error control to inform the sender that the frame has arrived at the destination without error. When the receiver receives the frame, it does not send any positive or negative acknowledgment. To provide for flow and error control in full-duplex switched Ethernet, a new sub layer, called the MAC control, is added between the LLC sub layer and the MAC sub layer.