Chapter 10 Ethernet: 10 Mbps

Ethernet

- Ethernet is the most widely used LAN protocol.
- It was designed in 1973 by Xerox with a data rate of 10 Mbps and a bus topology.
- It has gone through a long evolution (see Chapter 11). Later a faster Ethernet was introduced with a data rate of 100 Mbps. Today Gigabits Ethernet (1000 Mbps) is also available.
- Although there are several implementation of Ethernet, we only discuss the common ones: **baseband** and **10 Mbps**.

Access Method: CSMA/CD

- The IEEE 802.3 standard (the Ethernet MAC layer protocol) defines 1-persistent CSMA/CD as the access method for first generation Ethernet as discussed in Chapter 8 (see Fig. 10-1).
- Notes to Fig. 10-1:
  - **k** is the backoff factor
  - **IFG (interframe gap)** is the time needed to send 96 bits, which is 9.6 μs for 10-Mbps
  - **backoff-time** = $r \times$ slot-time

    where r is an random integer, and $0 \le r \le 2^k - 1$

Figure 10-1

Procedure for Access Method in 10-Mbps Ethernet

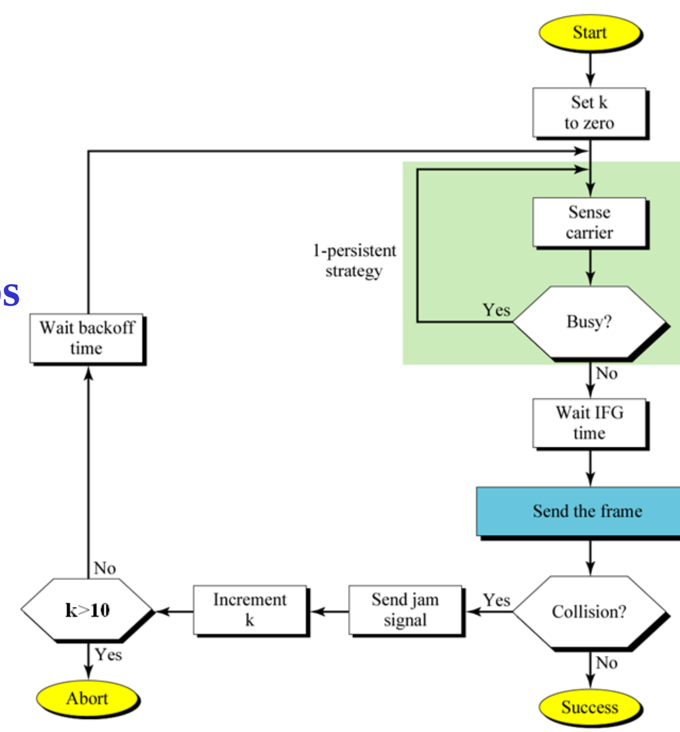


Table 10-1

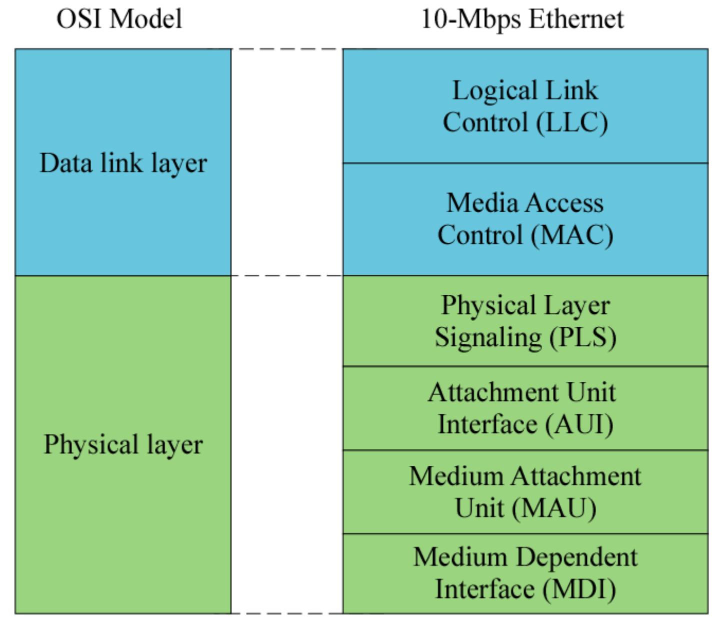
Example of Backoff Time

Suppose a station senses the channel and finds it idle. The station sends a frame, but detects a collision. It tries two more times, but detects a collision each time. Finally, it is successful on the fourth try. What is the backoff if the slot time is 512 bits (51.2 μs)?

Try	k	$2^k - 1$	r *(range)*	*Backoff time (μs)*
1	1	1	0 to 1	0 or 51.2
2	2	3	0 to 3	0, 51.2, 102.4, or 153.6
3	3	7	0 to 7	0, 51.2, 102.4, 153.6, 204.8, . . . , 358.4
4	N/A	N/A	N/A	N/A

Figure 10-2

Layers in 10-Mbps Ethernet

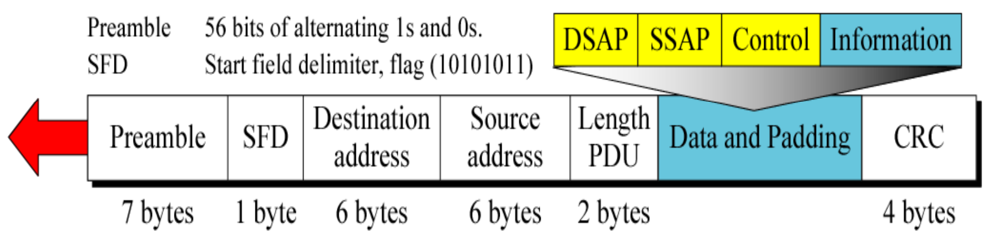


MAC Sublayer

- The MAC sublayer is responsible for the operation of the CSMA/CD access method.
- It also frames data received from the LLC layer and passes them to the PLS sublayer for encoding.
- IEEE 802.3 specifies one type of frame format containing seven fields: preamble, SFD, DA, SA, length/type of PDU, LLC data, and the CRC (see Fig. 10-3).

Figure 10-3

802.3 MAC Frame



802.3 MAC Frame

- **Preamble** – 7 bytes of alternating 0s and 1s that alert the receiver to the coming frame and enable it to synchronize its input timing. Preamble is added at the physical layer (not formally part of the frame).
- **Start frame delimiter (SFD)** – tells the stations that they have a last chance for synchronization (not formally part of the frame).
- **Destination address (DA)** – contains the physical address of the destination station(s) to receive the packet.

802.3 MAC Frame

- **Source address (SA)** – contains the physical address of the sender of the packet
- **Length/type** – if the value ≤ 1518, it defines the length of the whole MAC frame in bytes including all five fields; if the value ≥ 1536, it defines the type of the PDU packet encapsulated in the frame
- **Data** – carries the data encapsulated from the upper-layer protocols. 46 bytes ≤ data length ≤ 1500 bytes
- **CRC** – error detection code CRC-32

Addressing

- Each station on an Ethernet network has its own NIC, which provides the station with a 6-byte built-in physical address.
- The Ethernet address is normally written in hexadecimal notation using a hyphen to separate the bytes (see Fig. 10-4).
- The address 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 (see Fig. 10-5).

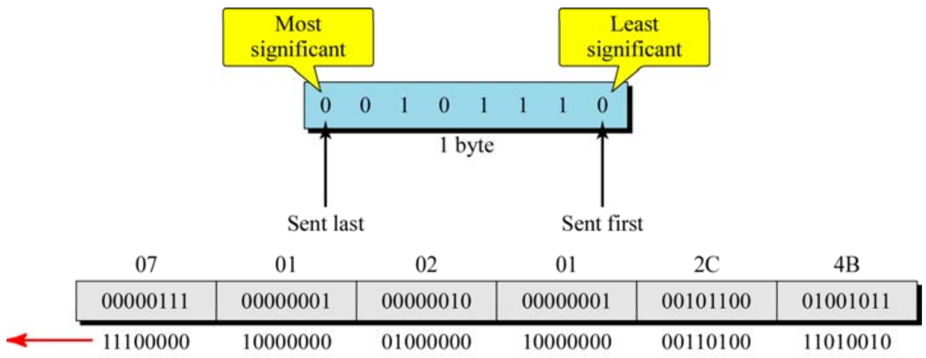
Figure 10-4

Ethernet Address in Hexadecimal Notation

07-01-02-01-2C-4B

Figure 10-5

Transmitting an Ethernet Address

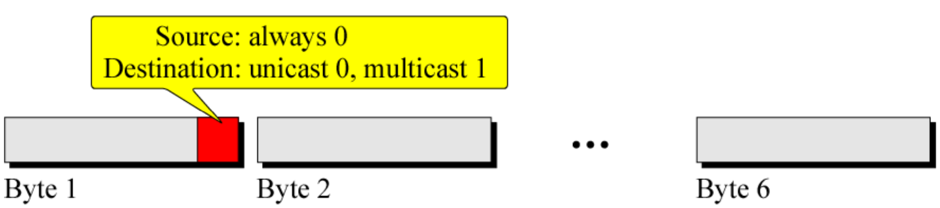


Unicast and Multicast Addresses

- A source address is always a **unicast** address. The destination address can be unicast or **multicast**.
- If the first bit transmitted is 0, the address is a unicast address, and defines only one recipient.
- If the first bit transmitted is 1, the address is a multicast address, and defines a group of recipients. The broadcast address contains all 1s (48 ones) and is a special case of multicast address.

Figure 10-6

Unicast and Multicast Address

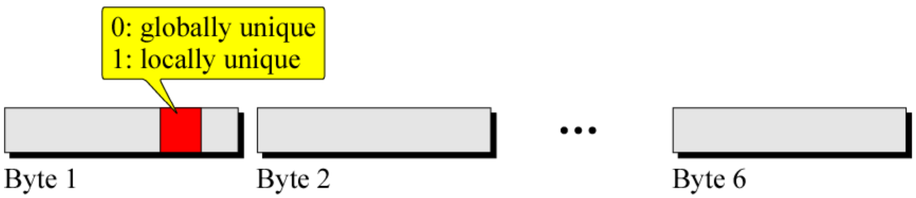


Globally and Locally Unique Addresses

- To be useful, an address should be unique, either globally or locally.
- If the address is globally unique, the 2nd bit transmitted is 0, the first 3 bytes are the vendor block code and the second 3 bytes are vendor specific identifier. The administrator does not need to worry about duplicate addresses in a LAN.
- If the 2nd bit transmitted is 1, the administrator of the LAN must ensure that the address is locally unique.

Figure 10-7

Globally and Locally Unique Addresses

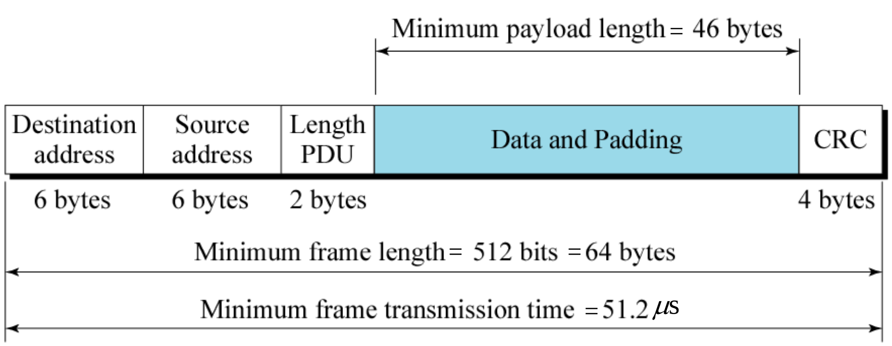


Minimum Frame Length

- The minimum length restriction is required for the correct operation of CSMA/CD.
- If there is a collision, the physical layer needs to detect it and send out a jam signal before the entire frame is sent out.
- The standard has defined the smallest frame length to be 51.2 μs or 512 bits for a data rate of 10 Mbps.
- Preamble and SFD fields are added by the physical layer, and are not included in the calculation of the length.

Figure 10-8

Minimum Length

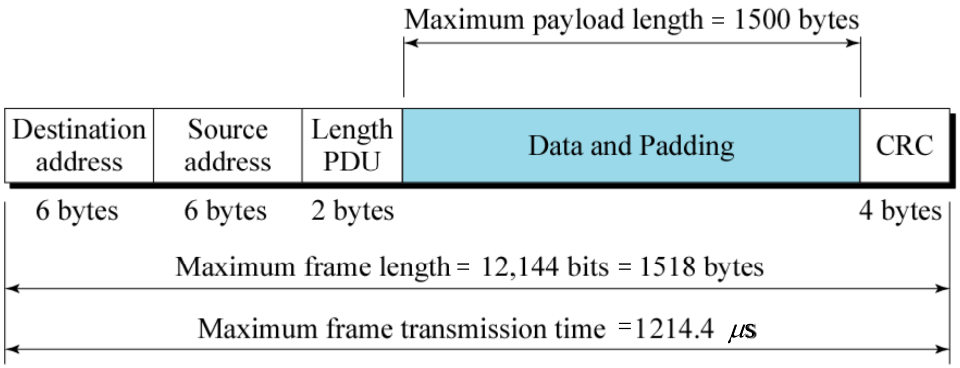


Maximum Frame Length

- The standard defines the maximum length of a frame to be 1214.4 μs or 12144 bits or 1518 bytes for a data rate of 10 Mbps.
- The restriction is due to
  i. The memory was very expensive when Ethernet was designed – the restriction helped to reduce the size of the buffer
  ii. The restriction prevents one station from monopolizing access to the shared medium

Figure 10-9

Maximum Length



Slot Time

- In an Ethernet, the round trip time 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**.
- The slot time should be shorter than the time needed for the sender to send the minimum frame, which is 512 bits.
- The slot time in Ethernet is defined to be the time to send 512 bits or 51.2 μs for a data rate of 10 Mbps.

Slot Time

- If a sender sends a minimum-size packet of 512 bits and senses a collision, the sender has enough time to abort the sending of the frame and send a jam sequence to inform other stations of the collision.
- If the sender sends a frame larger than the minimum size, and if the station has sent out 512 bits and has not heard a collision, it is guaranteed that collision will never occur during the transmission of the frame because all stations have already sensed the signal and refrained from sending.
- Collision can only occur during the first half of the slot time, and can be sensed during the slot time.

Slot Time

- There is a relationship between the slot time and the maximum length of the network. The propagation speed of the signal is also related to it.
- In most media, the signal propagates at 2×10^8 m/s.

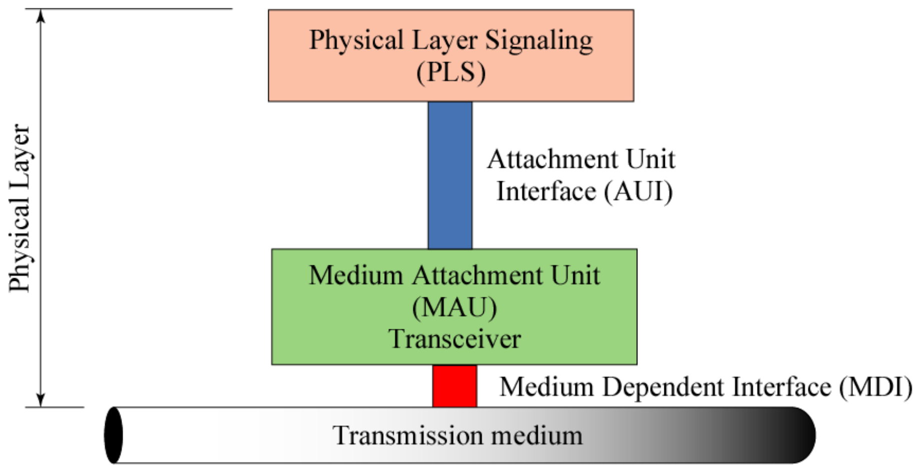
  MaxLength = PropagationSpeed × SlotTime/2

  = $(2\times10^8)\times(51.2\times10^{-6}/2)$ = 5120 m
- Consider delays in repeaters, interfaces and the time needed to send the jam sequence, practically

  MaxLength = 2500 m

Figure 10-10

Physical Layer

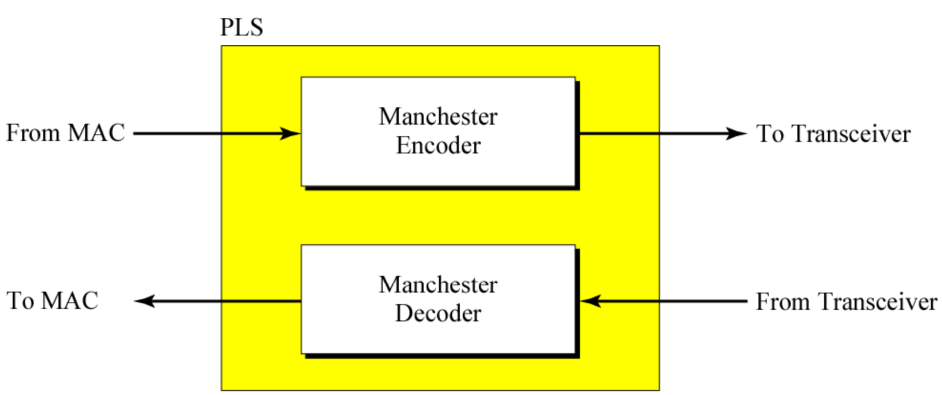


Physical Layer Signaling (PLS)

- The PLS sublayer is common for all 10-Mbps Ethernet implementation.
- The PLS sublayer is responsible for encoding and decoding the data.
- 10-Mbps Ethernet uses Manchester encoding.
- For a 10 Mbps data rate, Manchester encoding needs a bandwidth of 20 Mbauds, because two signal level transitions may be needed for each bit.

Figure 10-11

PLS

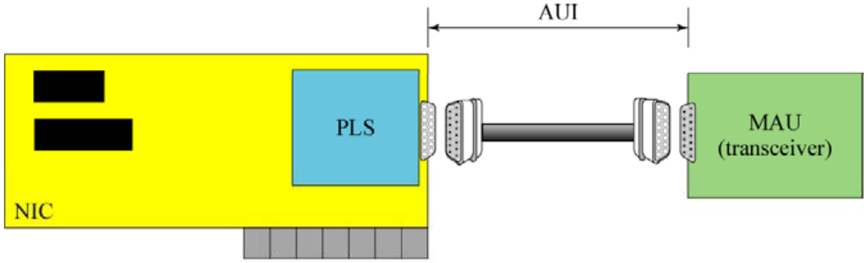


Attachment Unit Interface (AUI)

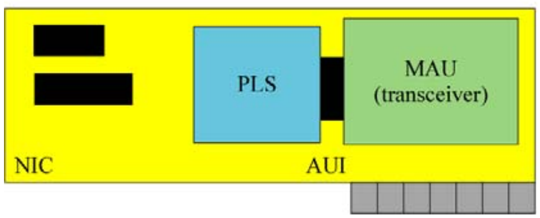
- The AUI sublayer may or may not be present in some implementation.
- The AUI defines the interface between the PLS and MAU.
- It was developed to create a medium independent interface between the PLS and MAU. If a new medium (hence a different MAU) is used later, there is no need to change the PLS.

Figure 10-12

AUI Interface



a. AUI cable is needed for external transceiver



b. AUI cable is not needed for internal transceiver

AUI

- The AUI defines four types of signals:
  1. Transmit data: Manchester encoding, +0.7 to –0.7 V
  2. Receive data: Manchester encoding, +0.7 to –0.7
  3. Collision presence: sent to NIC from the transceiver
  4. Power: power for transceiver from NIC (12V DC)
- The AUI connector is a 15-pin D-connector with four groups of pins.
- The AUI cable contains four twisted-pair cables to carry signals between the NIC and the transceiver.

Figure 10-13

Signals in AUI

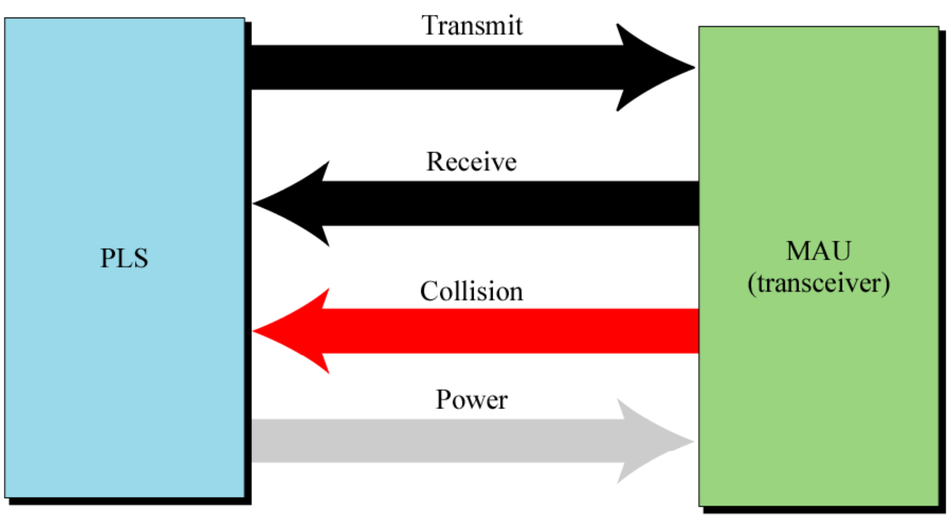


Figure 10-14

AUI Connector

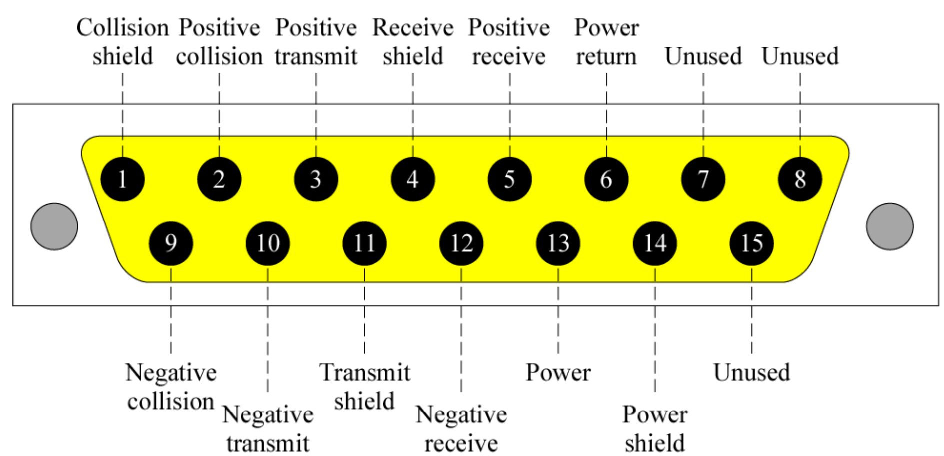
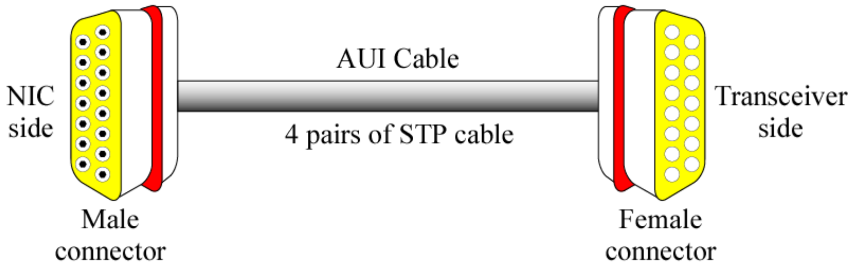


Figure 10-15

AUI Cable

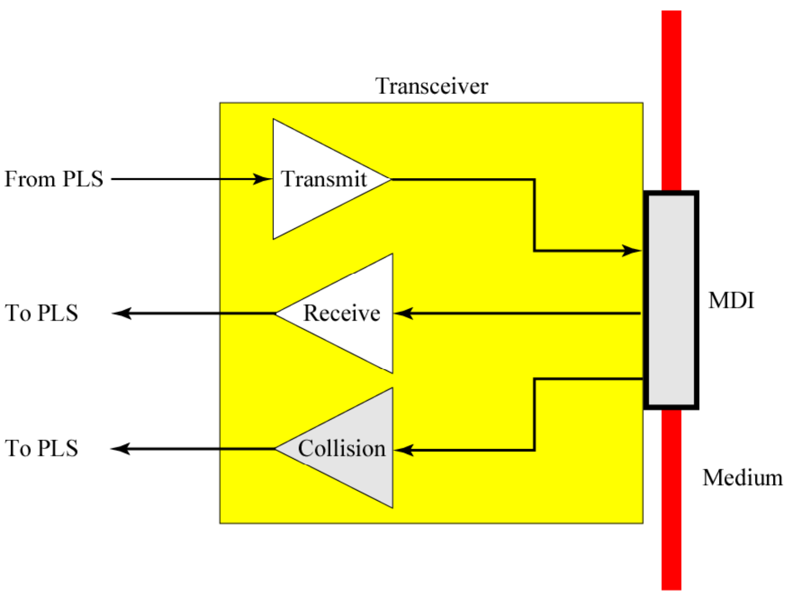


Medium Attachment Unit (MAU)

- The MAU or **transceiver** is medium dependent. There is a MAU for each type of medium used in 10-Mbps Ethernet.
- It transmits signals over the medium; it receives signals over the medium – both a transmitter and a receiver.
- It also detects signal collisions.
- It can be external (used with an AUI cable) or internal (installed inside the NIC).

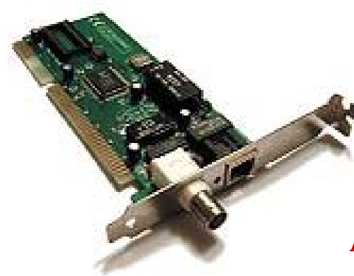
Figure 10-16

MAU (transceiver)



Medium Dependent Interface (MDI)

- The MDI is just a piece of hardware for connecting the transceiver to the medium.
- For an external transceiver, it can be a tap or a tee connector.
- For an internal transceiver, it can be a jack.

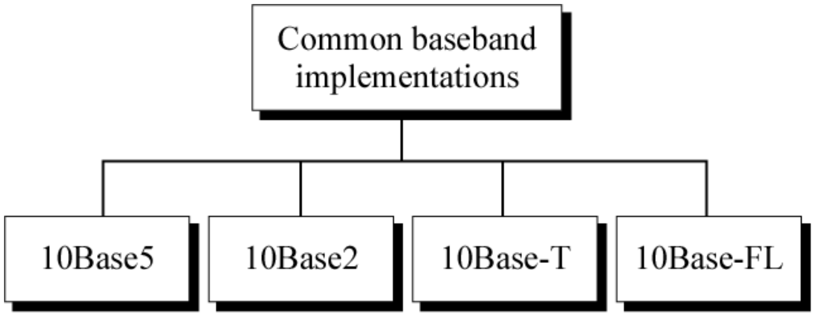


A BNC Tee Connector

An Ethernet Jack

Figure 10-17

Categories of 10-Mbps, Baseband Ethernet



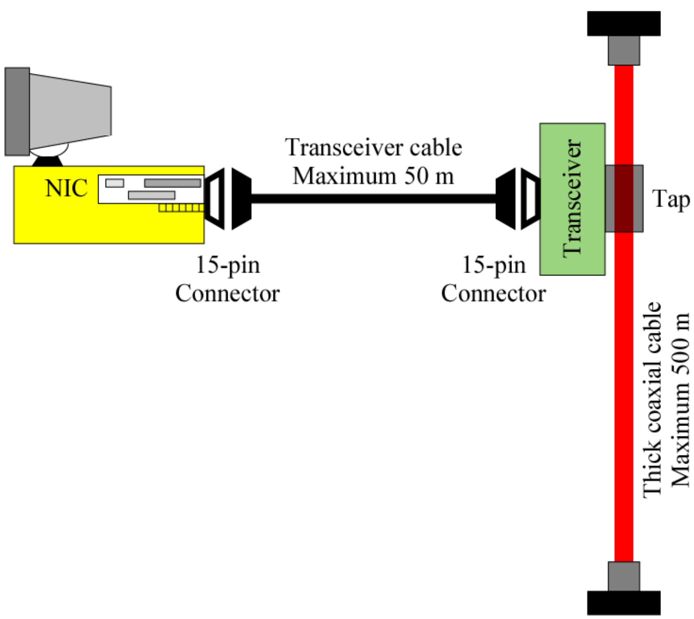
The IEEE standard defines four different implementations for baseband (digital), 10-Mbps Ethernet.

10Base5: Thick Ethernet

- 10Base5 was the first Ethernet specification.
- It is called thick Ethernet, or Thicknet, because of the size of the cable which is roughly the size of a garden hose.
- It uses a bus topology with an external transceiver connected via a tap to a think coaxial cable.
- It can have a maximum of five segments, with each segment a maximum of 500 m. But only three segments can be used to connect stations; the other two can only be used to connect remote repeaters.

Figure 10-18

Connection of a Station to the Medium Using 10Base5



10BASE5 Transceiver and Tap

Figure 10-19

Segments in 10Base5

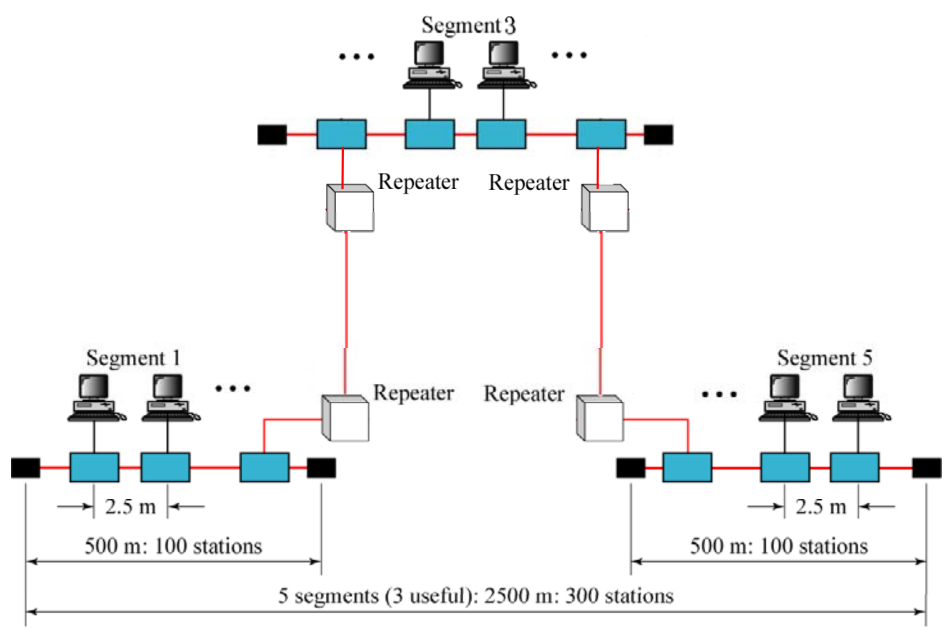


Table 10-2

Specifications for Thick Coaxial Cable

Specification	*Value*
Characteristic impedance	50 ohm
Diameter	1 cm (2/5 in)
Bending radius	240 mm (10 in)
Segment length	500 m (1640 ft)
Minimum spacing between transceiver taps	2.5 m (8.2 ft)
Maximum number of transceiver taps per segment	100
Maximum number of segments	5
Maximum number of repeaters	4
Maximum number of useful segments	3
Maximum length of a network	2500 m (8200 ft)
Maximum number of stations	300

10Base2: Thin Ethernet

- It was the second of the physical standard defined, also called Cheapernet
- It uses a bus topology with either an internal transceiver or an external transceiver.
- It can have a maximum of five segments, with each segment a maximum of 185 m. But only three segments can be used to connect stations; the other two can only be used to connect remote repeaters.
- The maximum number of stations is 96, three useful segments with 32 stations per segment.

Figure 10-20

Connection of Stations to the Medium Using 10Base2

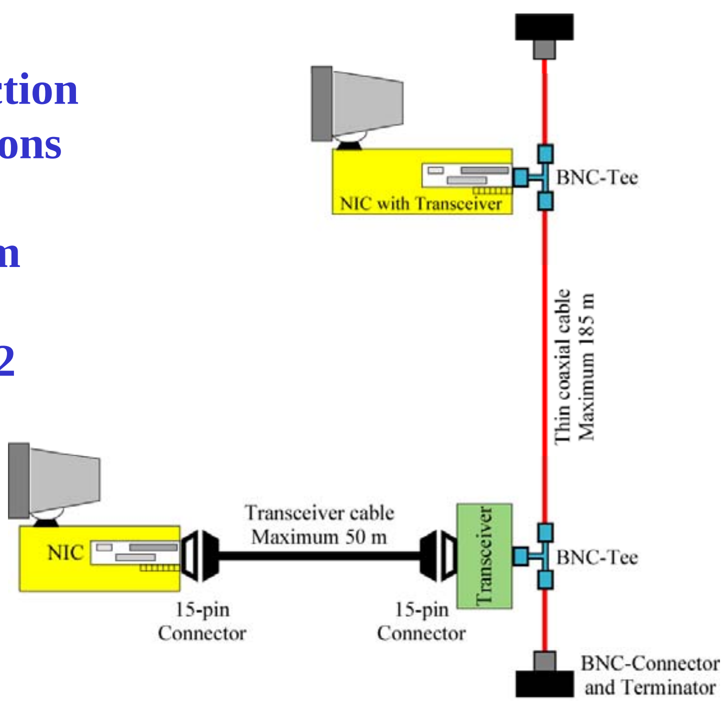


Figure 10-21

Segments in 10Base2

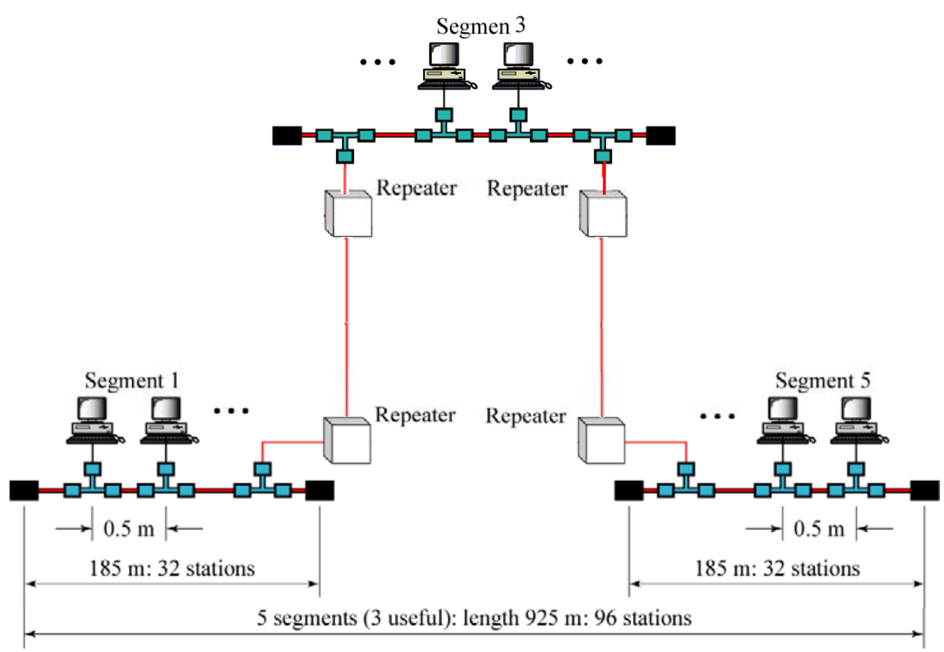


Table 10-3

Specifications for Thin Coaxial Cable

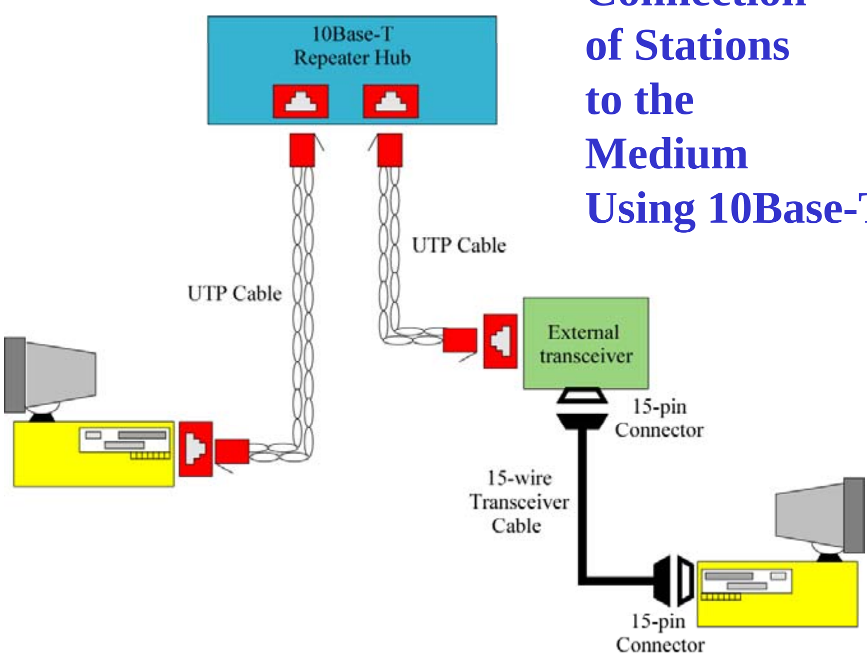
Specification	*Value*
Characteristic impedance	50 ohm
Diameter	0.50 cm (3/16 in)
Bending radius	5 cm (2 in)
Segment length	185 m (607 ft)
Minimum spacing between transceiver taps	0.5 m (1.64 ft)
Maximum number of stations in a segment	32
Maximum number of segments	5
Maximum number of repeaters	4
Maximum number of useful segments	3
Maximum length of a network	925 m (3024 ft)
Maximum number of stations	96

10Base-T: Twisted-Pair Ethernet

- 10Base-T uses a physical star topology (the logical topology is still a bus).
- The stations are connected to a hub with either an internal transceiver or external transceiver.
- Each segment has a maximum of 100 m (328 ft), with maximum of two stations per segment.

Figure 10-22

Connection of Stations to the Medium Using 10Base-T

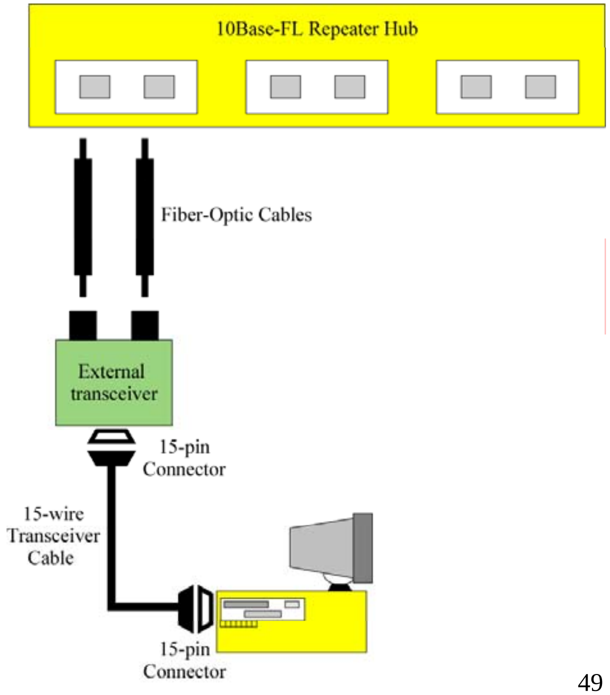


10Base-FL: Fiber Link Ethernet

- 10Base-FL uses a physical star topology to connect stations to the hub. The logical topology is still a bus.
- The standard is normally implemented using an external transceiver called fiber-optic MAU.
- The maximum length of the fiber-optic cable is 2000 m (6561 ft).
- The fiber-optic cable defined for 10Base-FL is graded-index multimode fiber with a 62.5 μm core and 125 μm of cladding.

Figure 10-23

Connection of Stations to the Medium Using 10Base-FL



Summary

- Ethernet is the most widely used LAN protocol.
- The IEEE 802.3 standard defines 1-persistent CSMA/CD as the access method for first-generation 10-Mbps Ethernet.
- The data link layer of Ethernet consists of the LLC sub-layer and the MAC sub-layer.
- The MAC sublayer is responsible for the operation of the CSMA/CD access method.

Summary

- Each station on an Ethernet network has a unique 48-bit (6-byte) address imprinted on its NIC.
- The minimum frame length for 10-Mbps Ethernet is 64 bytes; the maximum is 1518 bytes.
- The slot time for 10-Mbps Ethernet is 51.2 μs. The maximum length network is 2500 m.

Summary

- The physical layer of 10-Mbps Ethernet consists of four sublayers: the PLS sublayer, the AUI sub-layer, the MAU sublayer, and the MDI sublayer.
- The common baseband implementations of 10-Mbps Ethernet are 10Base5 (thick Ethernet), 10Base2 (thin Ethernet), 10Base-T (twisted-pair Ethernet), and 10Base-FL (fiber-link Ethernet).