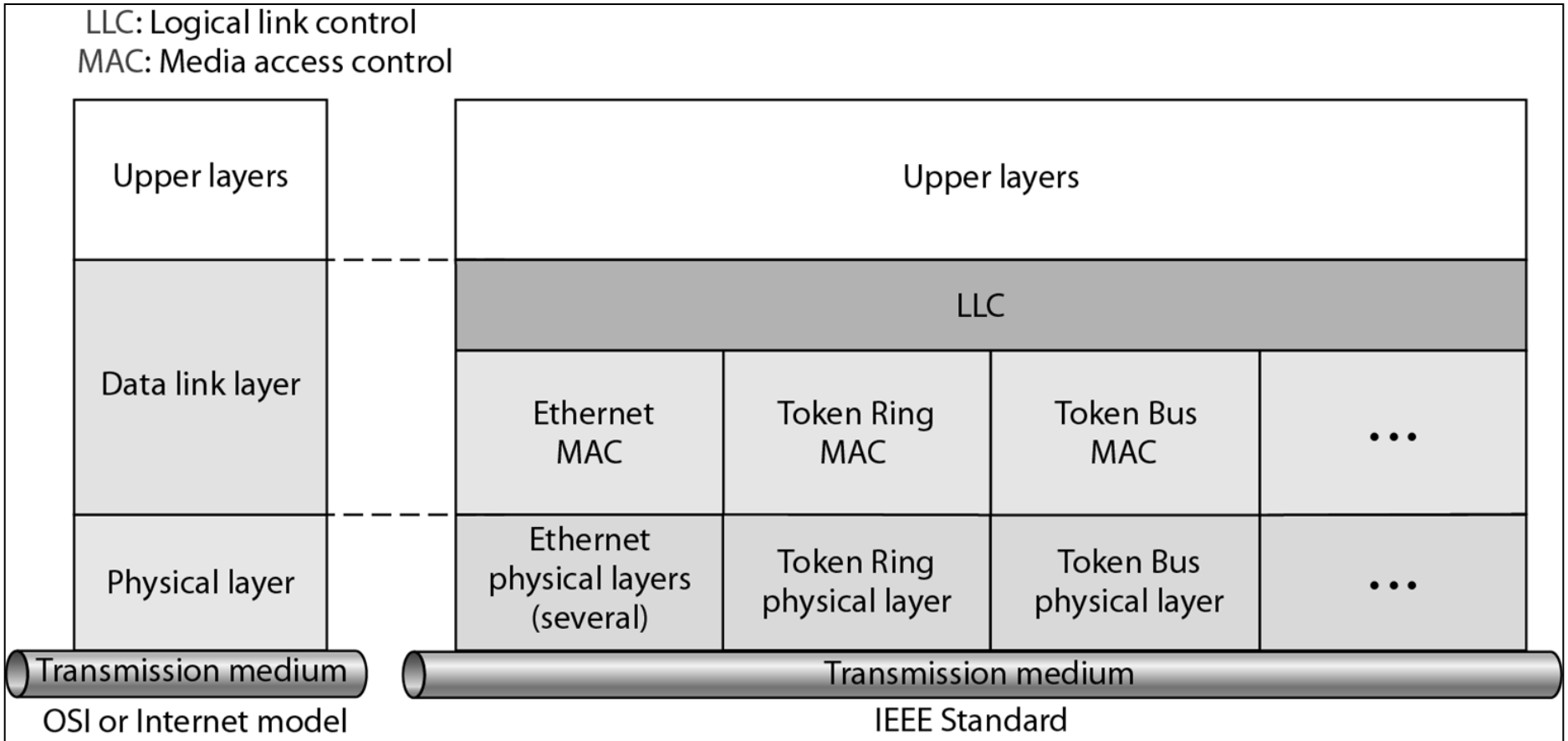
3. Ethernet

IEEE Standard

- IEEE started a project, called **Project 802** to set standard to enable intercommunication among equipment from variety of manufacturers.
- IEEE has subdivided the data link layer into two sublayers: Logical Link Control (LLC) and Media Access Control (MAC).
- IEEE has also created several physical layer standard for different LAN protocol.



IEEE Standard

- Data link layer include:
  - Two sublayers: LLC, MAC
  - Framing
  - Needs for LLC
- **LLC- Logical Link Control**
  - Data link control handles framing, flow control and error control.
  - In IEEE project 802, flow control, error control and part of the framing duties are collected into one sublayer called LLC.
  - **Framing is handle by both LLC and MAC.**

LLC provides one single data link control protocol for all IEEE LANs. MAC provides different protocols for different LANs.

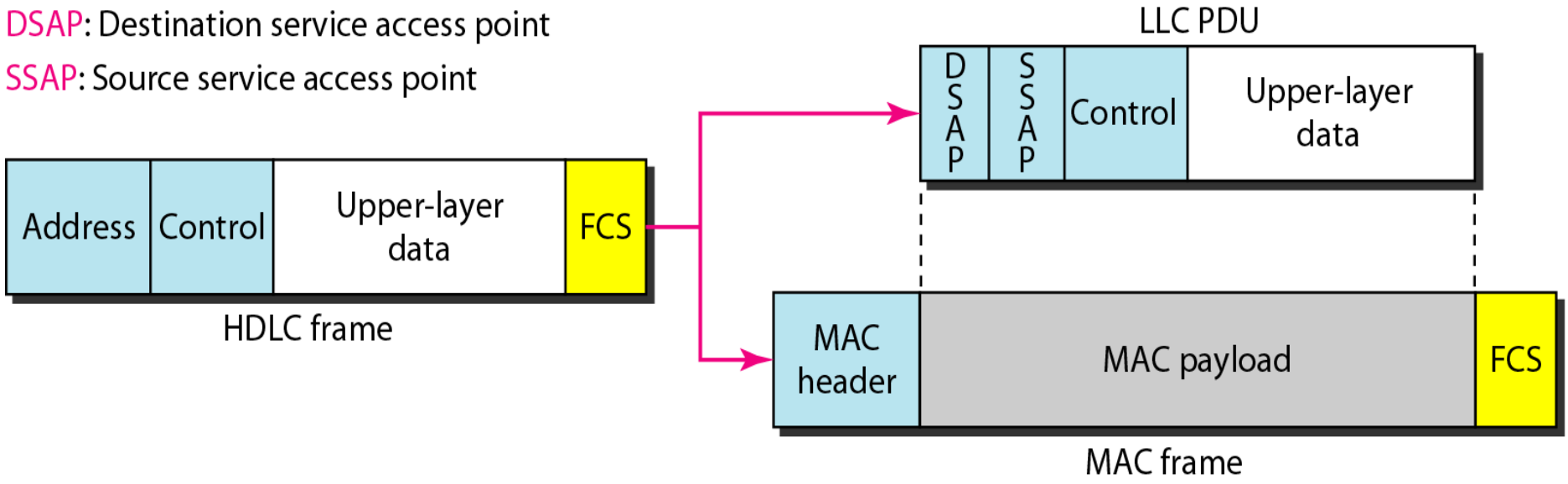
  - A single LLC protocol can provide interconnectivity between different LANs because it makes the MAC sublayer transparent..

IEEE Standard

- Framing
  - LLC define PDU (Protocol Data Unit), somewhat similar to HDLC.
  - Header contain control field like HDLC, which is used for flow and error control.
  - The two header fields define the upper layer protocol at the source and destination that uses LLC. This fields are called **Destination Service Access Point (DSAP)** and **Source Service Access Point (SSAP)**.
  - A frame defined in HDLC is divide into PDU at the LLC sublayer and a frame at MAC sublayer.
  - HDLC (High Level Data Link Control)
  - FCS (Frame Check Sequence)

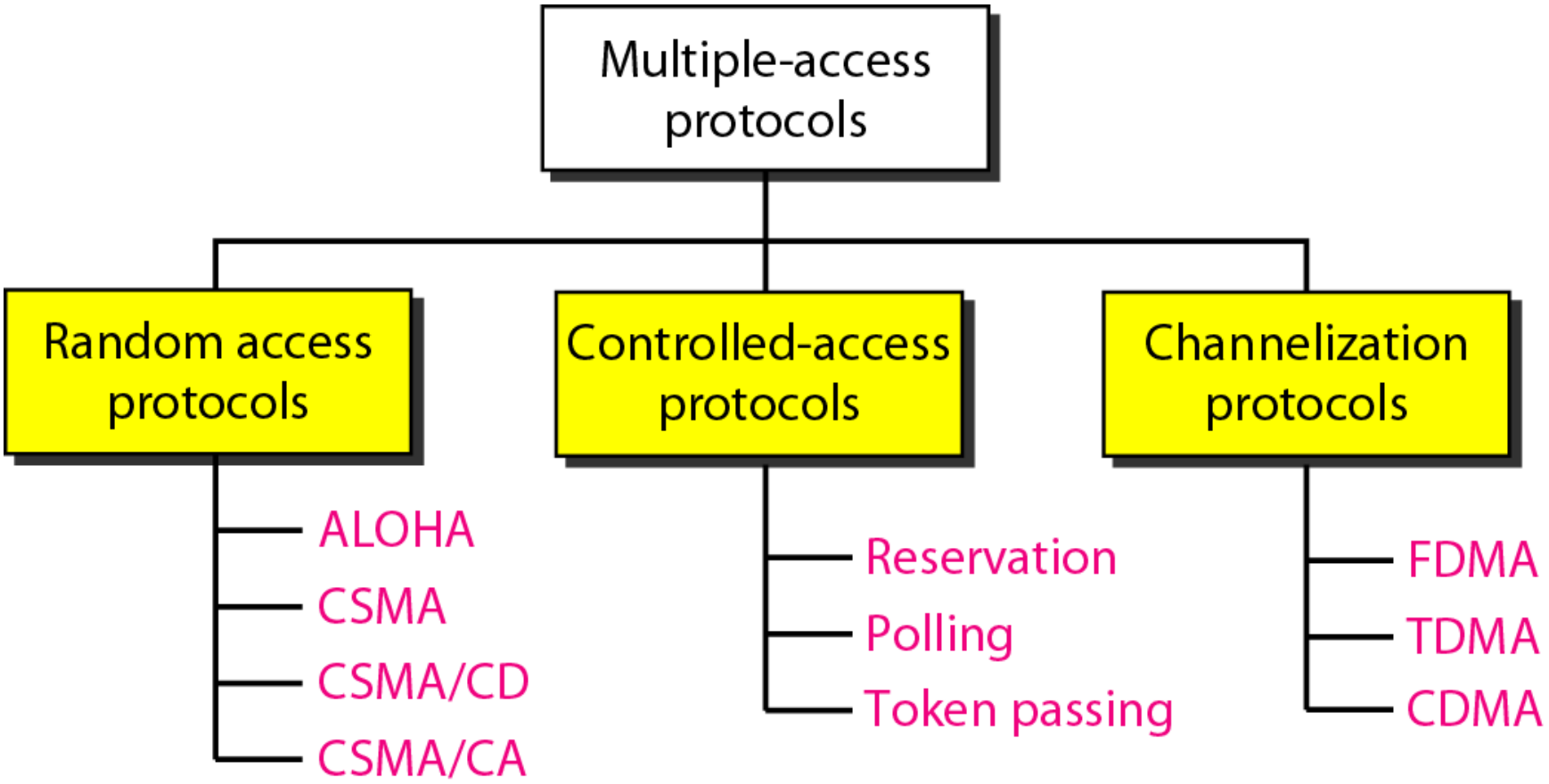
DSAP: Destination service access point

SSAP: Source service access point



IEEE Standard

- Need for LLC
  - The purpose of the LLC is to provide flow and error for the upper layer protocol.
  - Example: If a LAN or several LANs are used in isolated system.
    - LLC may be needed to provide flow and error control for the application layer protocols.

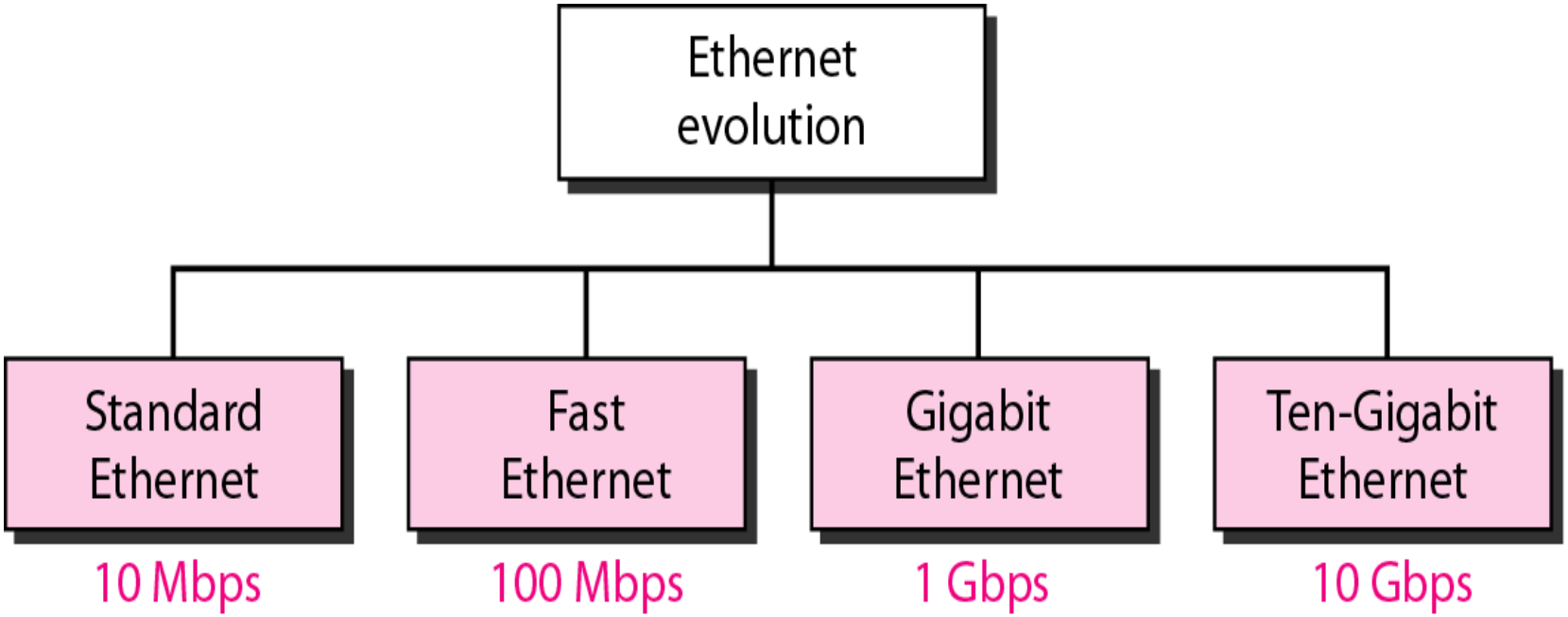


IEEE Standard

- Media Access Control
  - It defines the specific access method for each LAN.
  - Part of framing function is also handled by the MAC layer.
- Physical layer
  - It is dependent on the implementation and type of physical media used.
  - IEEE defines detailed specification for each LAN implementation.
- Summary
  - Ethernet is a most widely used local area network.
  - The data link layer of Ethernet consist of LLC sub layer and MAC sublayer.
  - MAC sublayer is responsible for the operation of CSMA/CD access method and framing.

Standard Ethernet

- **Ethernet evolution through four generations**



- The original Ethernet was created in 1976 at Xerox's Palo Alto Research Center (PARC).
- From that time it has gone through four generation: Standard Ethernet (10Mbps), Fast Ethernet (100Mbps), Gigabit Ethernet (1Gbps) and Ten-Gigabit Ethernet (10Gbps).
- Topics discuss in this section are:
  - MAC sublayer
  - Physical Layer

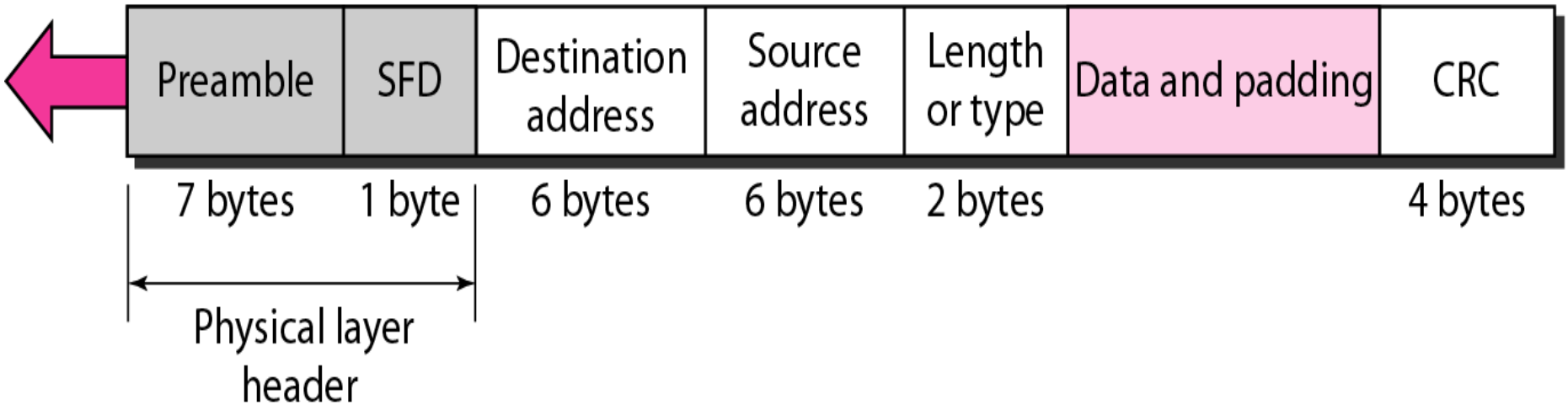
Standard Ethernet

MAC sub layer

- MAC sublayer governs the operation of the access method.
- It also frames data received from the upper layer and passes them to the physical layer.
- ***Frame Format***:
  - It contain 7 fields.
  - Ethernet does not provides any mechanism for acknowledging receiving frame so it is unreliable.
  - Acknowledgement must be implemented at the higher layers.

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

SFD: Start frame delimiter, flag (10101011)



Standard Ethernet

MAC Frame (802.3)

- Preamble: 56 bits of alternating 0s and 1s.
  - 56 bits alerts receiving system to the coming frame and enables it to synchronizing its input timing.
  - Pattern provides only an alert and a timing pulse.
  - Preamble is actually added at the physical layer and is not (formally) part of the frame.
- SFD (Start Frame Delimiter)
  - Signals beginning of the frame.
  - It warns station that this is last chance for synchronization.
  - Last bit is 11 and alerts the receiver that the next field is the destination address.
- DA (Destination Address)
  - 6 byte field and contains the physical address of the destination stations to receive the packet.
- SA (Source Address)
  - 6 byte field and contains the physical address of the sender of the packet.

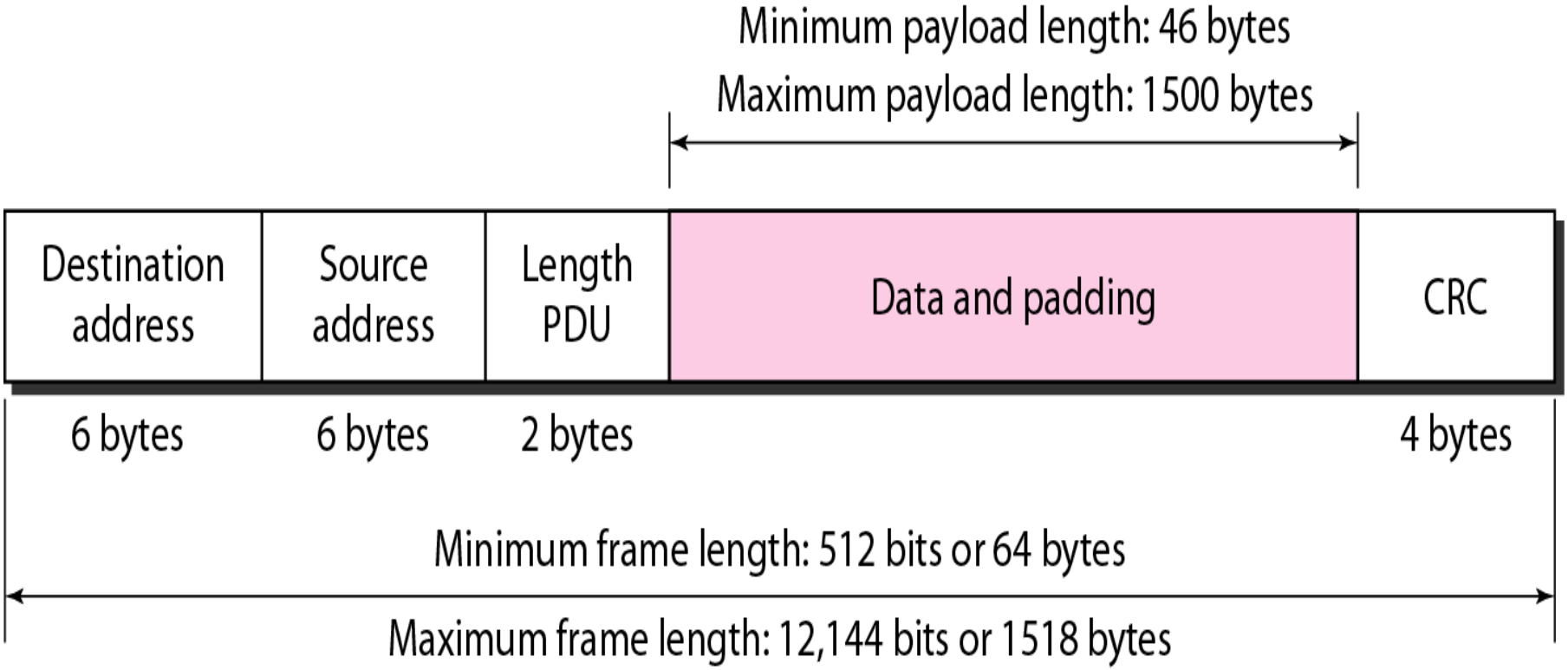
Standard Ethernet

MAC Frame (802.3) (Cont…)

- Length or type
  - The original Ethernet used this field as the type field that define the upper-layer protocol using the MAC frame.
  - IEEE standard used it as the length field to define the number of bytes in the data field.
- Data:
  - Data encapsulated from the upper-layer protocol.
  - Minimum 46 and maximum 1500 bytes.
- CRC:
  - Carries error detection information.

Standard Ethernet

Frame Length



Frame Length

Minimum: 64 bytes (512 bits)

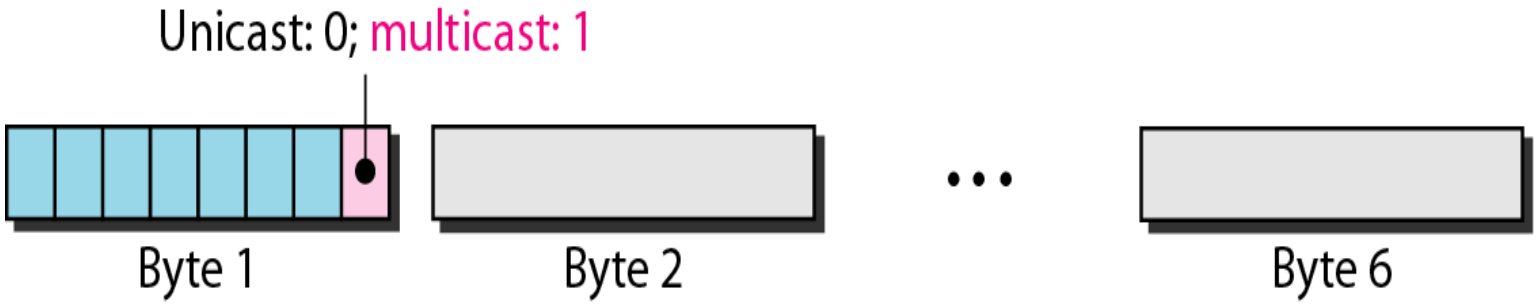
Maximum: 1518 bytes (12, 144 bits)

Standard Ethernet

Addressing

- Each station on an Ethernet network has its own Network Interface Card (NIC).
- NIC fits inside the station and provides the station with a 6-byte physical address which is normally written in hexadecimal notation with colon between bytes.

Unicast and Multicast addresses



Standard Ethernet

Addressing (Cont…)

- A source address is always a unicast address because frame comes only from one station.
- The destination address can be unicast, multicast or broadcast.
- **If least significant bit of the first byte in destination address is 0 then it is unicast otherwise multicast.**
- **The broadcast address is a special case of the multicast address, the recipients are all the station on the LAN. A broadcast destination address is forty-eight 1s.**
- unicast :– one – to one
- Broadcast :- one – to many

Standard Ethernet

Que : 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.

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 F's.

Standard Ethernet

- *Show how the address 47:20:1B:2E:08:EE is sent out on line.*

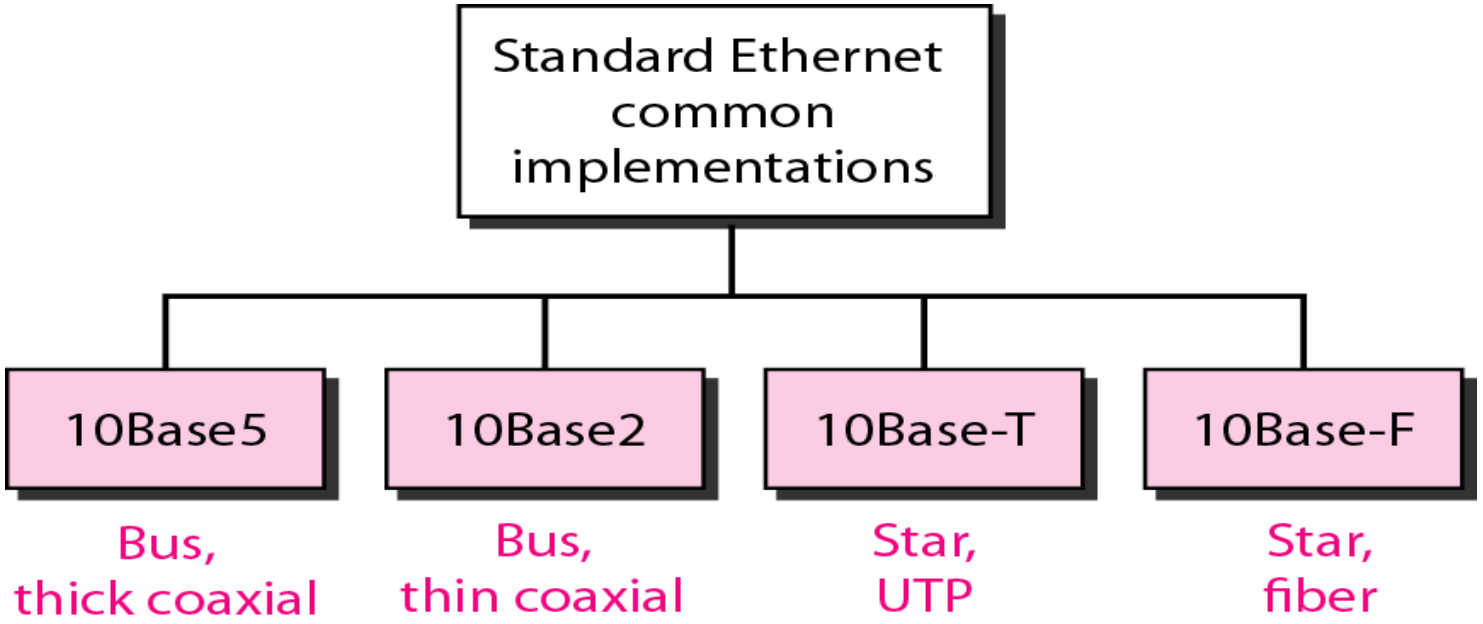
Solution

- ***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:***

Standard Ethernet

Physical layer:

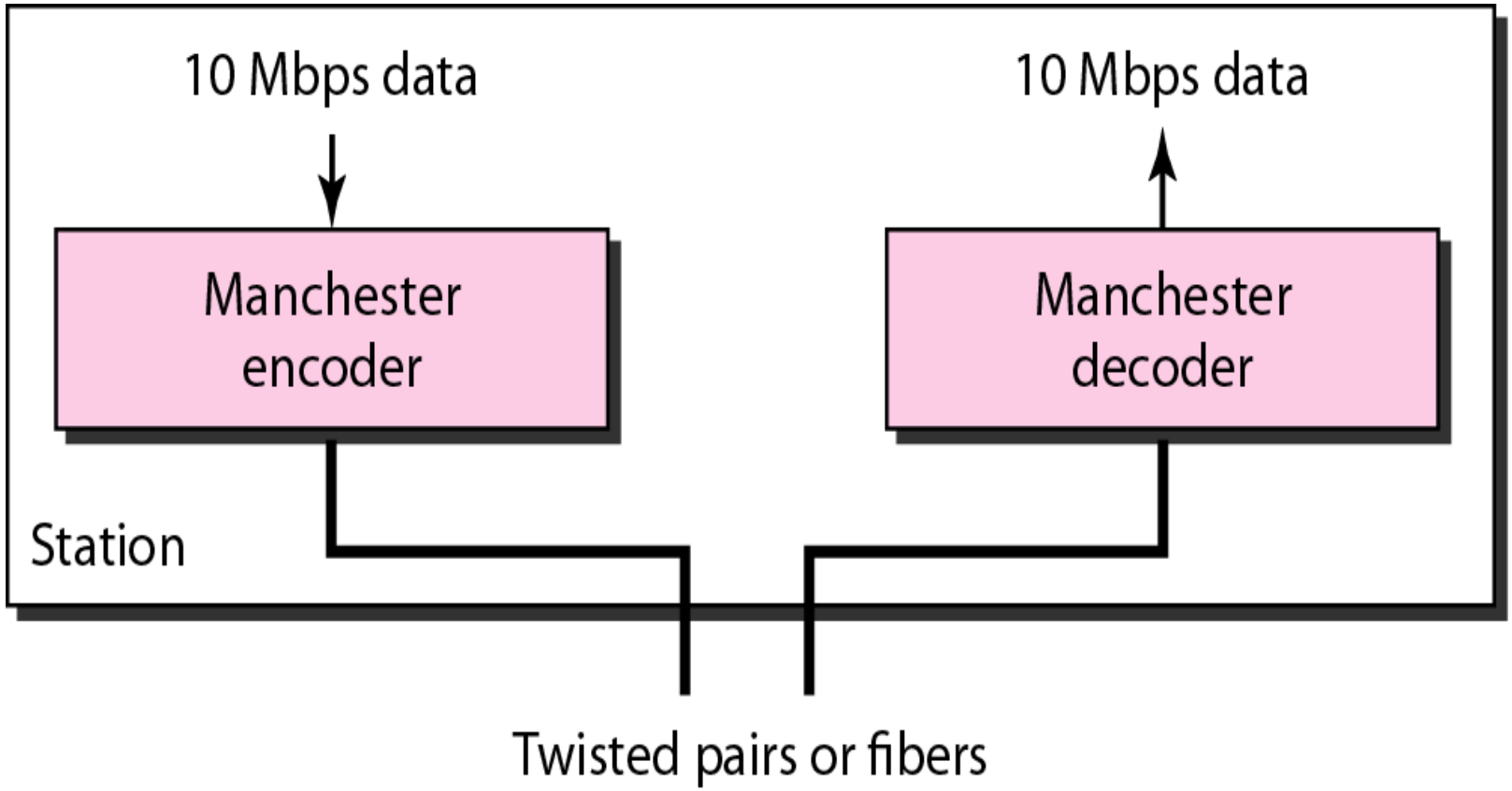
- It defines several physical layer implementation.



- **Encoding and Decoding:**
  - All implementations use digital signaling at 10 Mbps.
  - At the sender, data are converted to a digital signal using Manchester Scheme.
  - At the receiver, the received signal is interpreted as Manchester and decoded onto data.

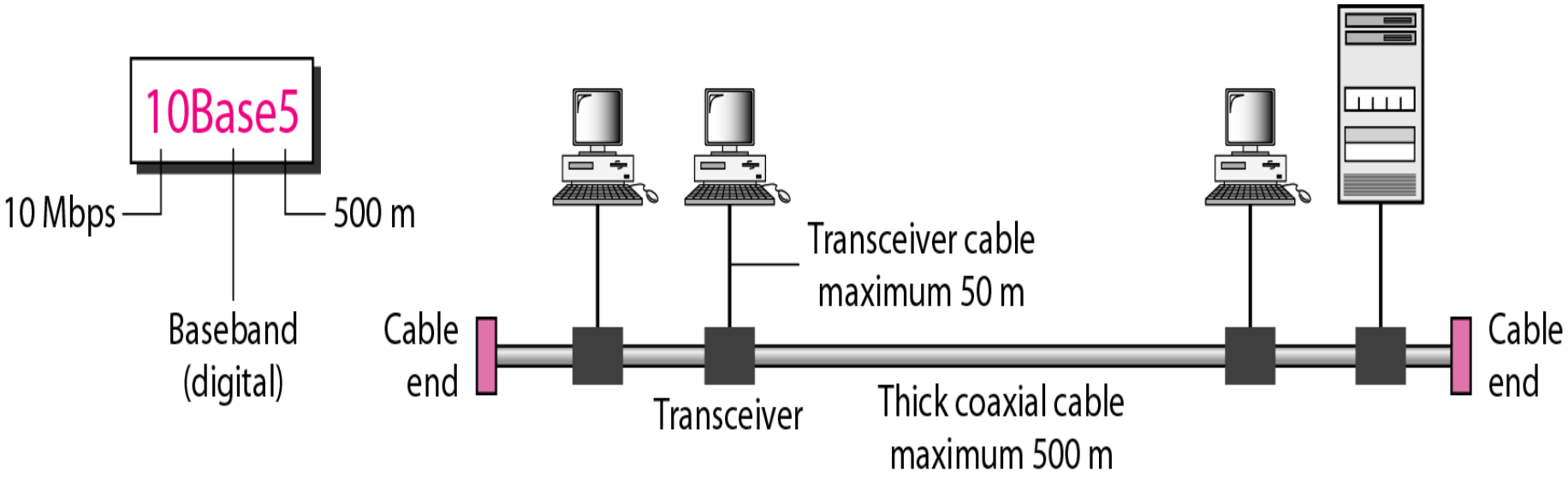
  (Manchester encoding is self-synchronous, providing a transition at each bit interval.)

Standard Ethernet



- **10Base5: Thick Ethernet**
  - 1st implementation is called **10Base5 Thick Ethernet** or **Thicknet**.
  - The name derives from size of the cable.
  - It is to hard to band with your hand.

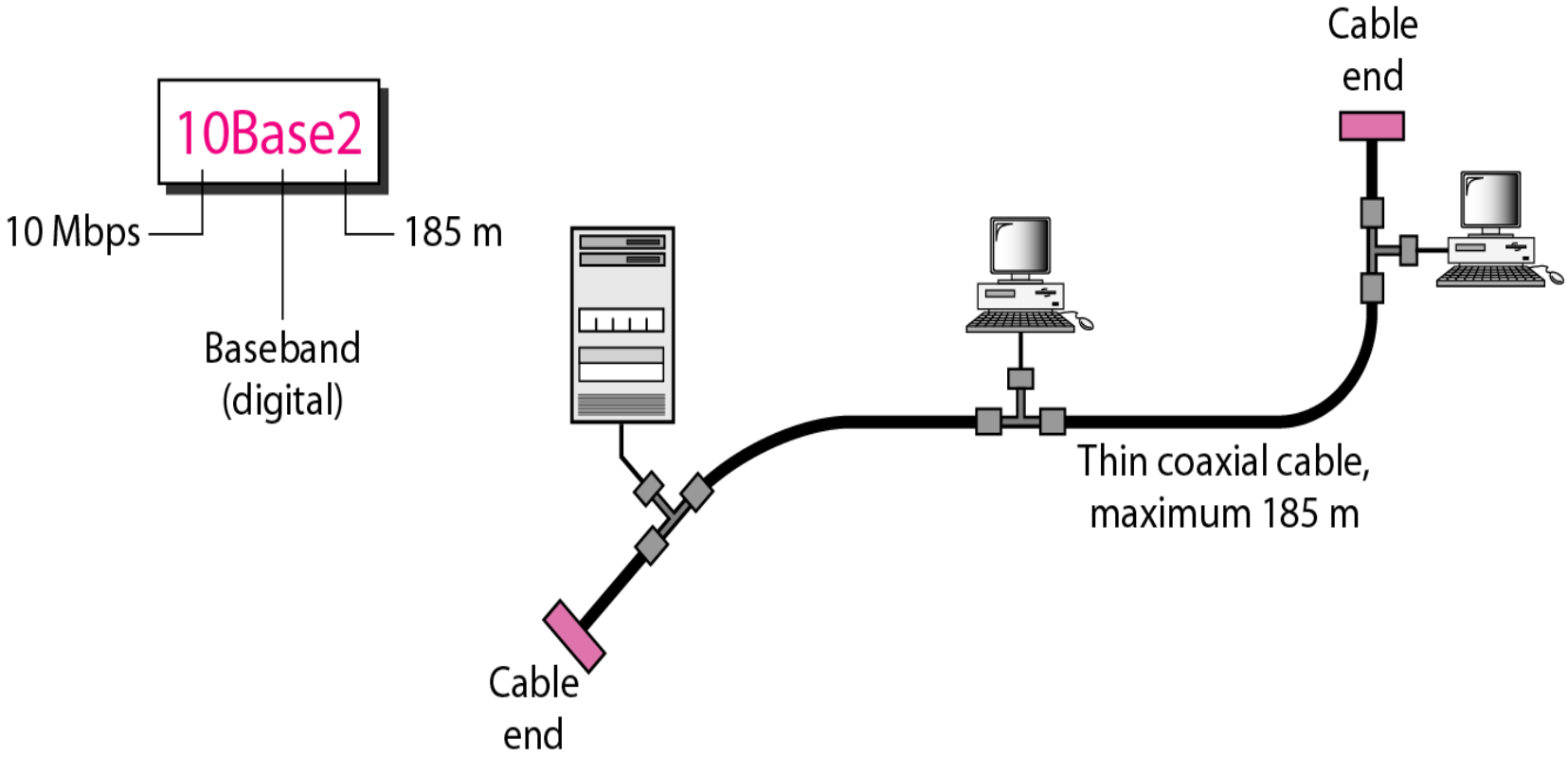
Standard Ethernet



- Characteristics:
  - It use bus topology with external transceiver connected via a tap to a thick coaxial cable.
- **The transceiver is responsible for transmitting, receiving, and detecting collision**.
- Connected to a station via transceiver cable that provide separate path for sending and receiving.
- This means collision can only occur in coaxial cable

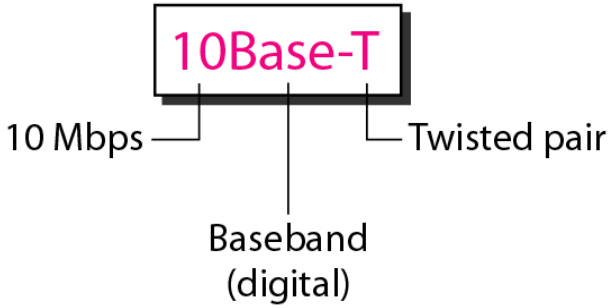
Standard Ethernet

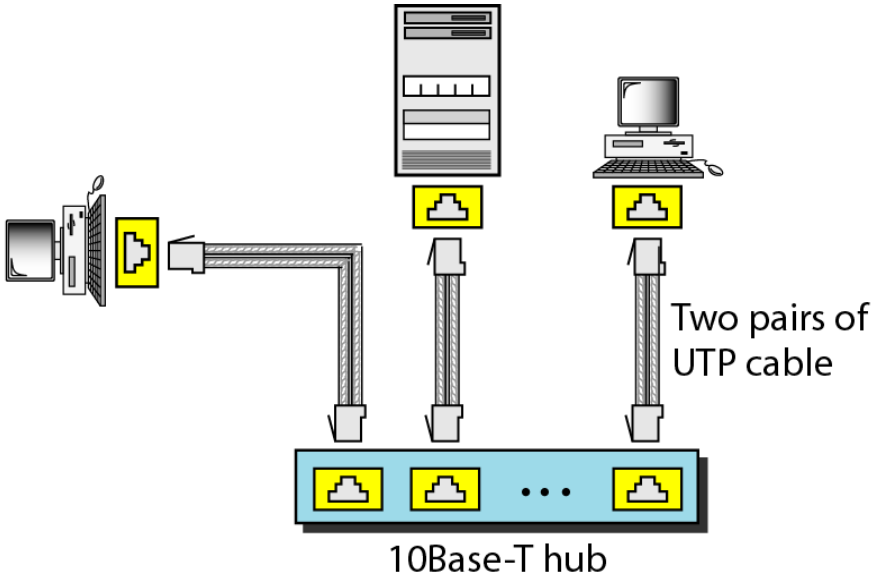
- **10Base2: Thin Ethernet**
  - 2nd implementation is called 10Base2, Thin Ethernet or Chepernet.
  - It also uses bus topology, but cable is much thinner and more flexible.



Standard Ethernet

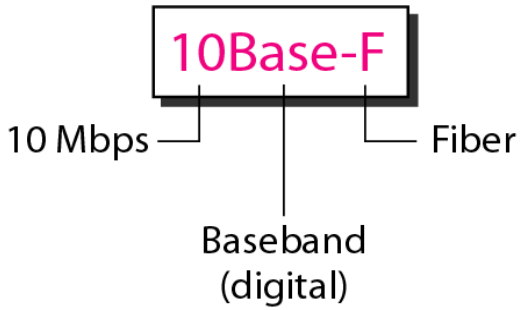
- Characteristics:
  - The cable can bent to pass very close to the station.
  - In this case transceiver is normally part of NIC, which is installed inside the station.
  - The collision is occur in thin Ethernet.
  - Its implementation is more cost effective than 10Base5.
  - Installation is simpler because the thin coaxial cable is very flexible.
- 10BaseT: Twisted Pair Ethernet
  - 3rd implementation is called 10BaseT or twisted-pair Ethernet.

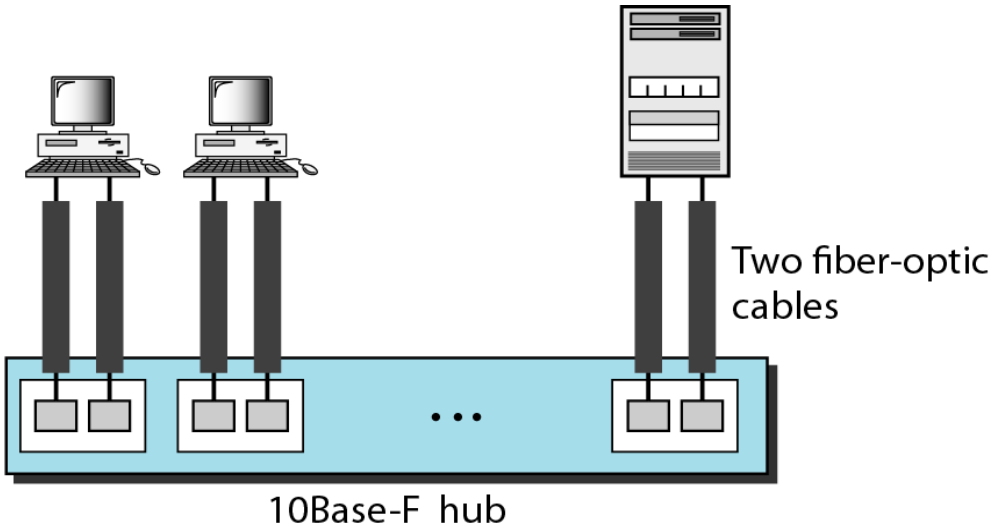




Standard Ethernet

- Characteristics:
  - It uses physical star topology, station are connected with hub via 2 pair of twisted cable.
  - Two pairs of twisted pair cable creates two path (one for sending and one for receiving) between the station and the hub.
  - Collision is happen in HUB.
  - Compared to 10Base5 and 10Base2, hub actually replaces the coaxial cable as far as collision concern.
  - Maximum length of the twisted cable is 100m.
- 10BaseF: Fiber Ethernet
  - 4th implementation is called **10BaseF or Fiber Ethernet.**





Standard Ethernet

- Characteristics:
  - It is a types of optical fiber 10-Mbps Ethernet.
  - It uses star topology to connect station to hub.
  - Station are connected to hub using 2 fiber-optic cables.
  - Maximum length of the Fiber cable is 2000m.

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

Fast Ethernet

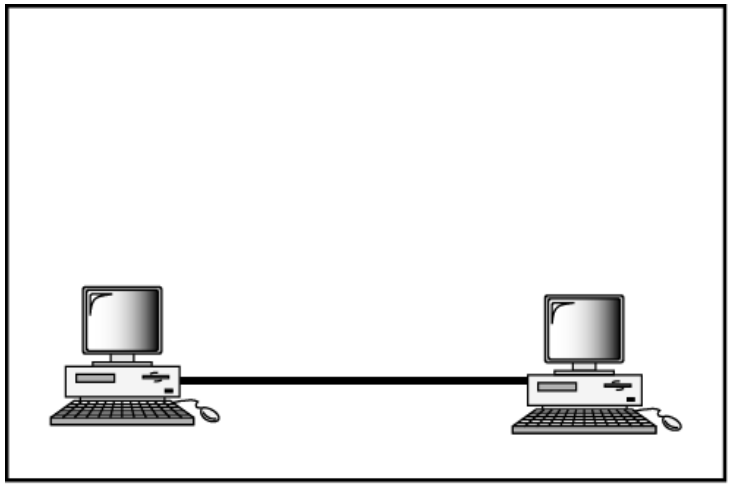
- Fast Ethernet was designed to compete with LAN protocols.
- It is also known as 802.3u.
- It can transmit data 10 times faster at rate of 100Mbps.
- Goals of Fast Ethernet
  - Upgrade the data rate to 100 Mbps.
  - Make it compatible with standard Ethernet.
  - Keep the same 48-bit address.
  - Keep the same frame format.
  - Keep the same minimum and maximum lengths.
- ***MAC sub layer***
  - It use star topology.
  - For star topology there are 2 choices: Half-Duplex and Full-Duplex.

Fast Ethernet

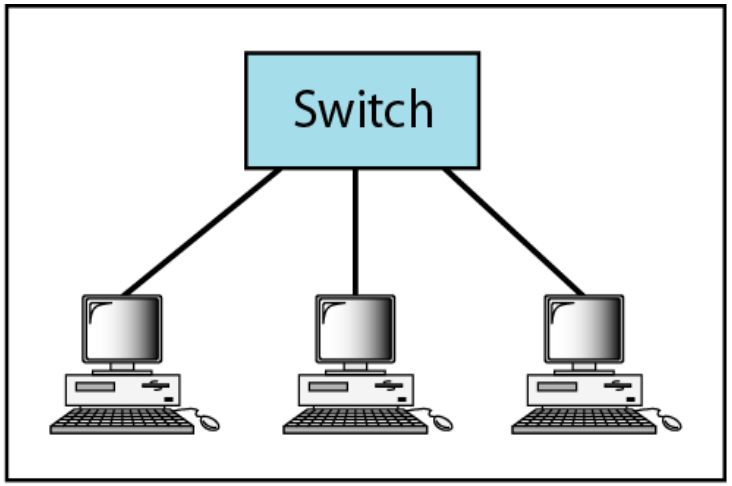
Half Duplex	Full Duplex
Stations are connected via hub.	The connection is made via switch with buffers at each port.
The access method is same (CSMA/CD) for half duplex approach.	For full duplex fast Ethernet, there is no need for CSMA/Cd.

- **Autonegotiation**
  - It allows two devices to negotiate the mode or data rate of operation. It was designed particularly for the following purposes:
    - To allow incompatible devices to connect one another.
    - To allow one device to have multiple capabilities.
    - To allow a station to check a hub's capabilities.
- ***Physical Layer***
  - Physical layer in Fast Ethernet is more compatible than standard Ethernet.
  - **Fast Ethernet Topology**
    - Fast Ethernet is designed to connect two or more station together.
    - If there are only two station, they can be connected by point – to – point network.
    - Three or more stations need to be connected in a star topology with hub or a switch at the center.

Fast Ethernet



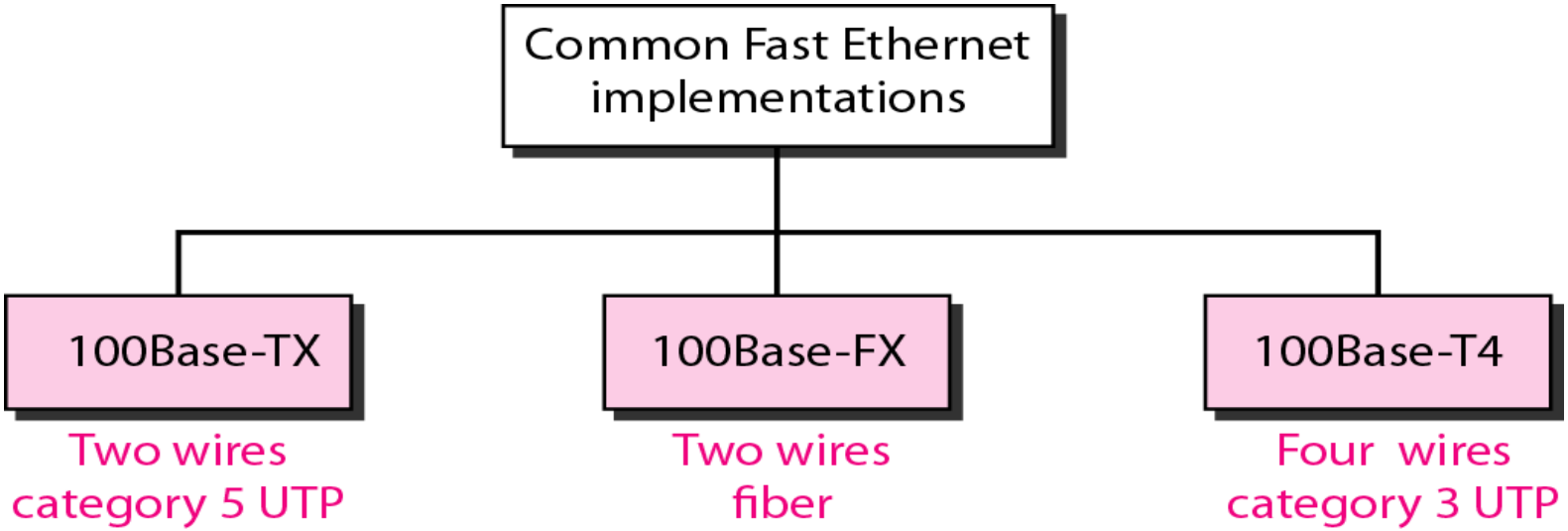
a. Point-to-point



b. Star

- ***Implementation***
  - It implementation at physical layer can be categorized as either two-wire or four-wire.
  - 2 wire implementation can be
    - Category-5 UTP (100Base – TX)
    - Fiber – optic cable (100Base – FX)
  - 4 wire implementation is designed for
    - Category-3 UTP (100Base – T4)

Fast Ethernet



- 100Base – TX
  - It uses 2 twisted pair cable (Either category 5 UTP or STP).
- 100Base – FX
  - It uses two pair of fiber optic cable.
  - Optical fiber can easily high bandwidth requirement by using simple encoding scheme.
- 100Base – T4
  - 100Base – T4 uses category-3 or higher UTP.
  - It uses 4 cables of UTP for transmitting 100Mbps.

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.**
- Goal :
  - Upgrade data rate to 1 Gbps.
  - Make it compatible with standard or Fast Ethernet.
  - Use same 48 bit address.
  - Use same frame format.
  - Keep same maximum and minimum frame length.
  - To support Autonegotiation as defined in Fast Ethernet.
- ***MAC Sublayer***
- Gigabit Ethernet has 2 distinctive approach for medium access:
  - Half duplex
  - Full duplex.
- Almost all implementation of gigabit follows full duplex mode.
- Half duplex approach to show that gigabit Ethernet can be compatible with the previous generation

Gigabit Ethernet

- **Full Duplex**
  - In this, central switch connected to all computer or other switch.
  - In this mode, each switch has buffers for each input port in which data are stored until they are transmitted.
  - So there is no collision, it means that there is no CSMA/CD is used.

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

- **Half Duplex**
  - In this mode switch can be replace by hub, which is act as the common cable in which collision might occur.
  - It used CSMA/CD protocol.
  - Maximum length of network is dependent on the minimum frame size.
  - Three methods:
    - Traditional
    - Carrier Extension
    - Frame Bursting

Gigabit Ethernet

- Traditional
  - We keep the minimum length of the frame as in traditional Ethernet (512 bits).
  - Maximum length of the network is 25m.
  - It is suitable if all stations are in one room.
  - It may not even long enough to connect the computer in one office.
- Carrier Extension
  - To allow long network, we increase minimum frame length.

The carrier Extension approach defines the minimum length of a frame as 512 bytes. This means that the minimum length is 8 times longer.

  - This method forces a station to adding extension bit to any frame, that is less than 4096 bits.
  - This allows a length of 100m from the hub to the station.

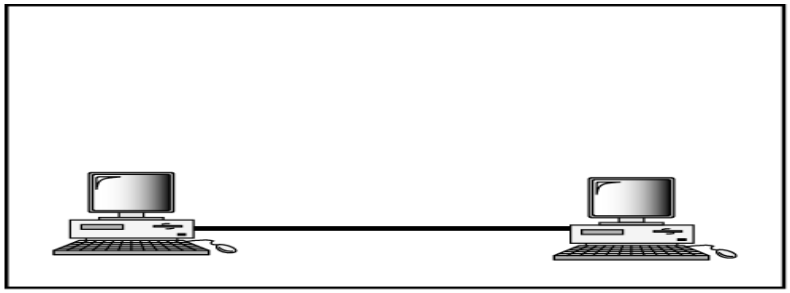
Gigabit Ethernet

- Frame Bursting
  - Carrier extension is very inefficient if we have a series of short frame to send, each frame carries redundant bit.

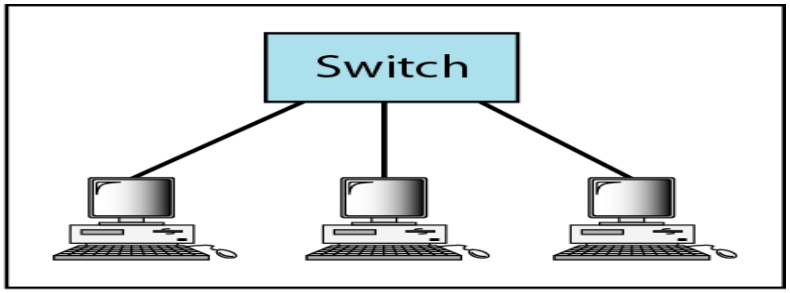
Instead of adding an extension to each frame, multiple frames are sent.

  - To make these multiple frames look like one frame, extra bit is added between the frames so that channel is not idle.
  - In other word method deceives other station onto thinking that a very large frame has been transmitted.
- Physical layer topology
  - 2 Stations
    - Point to point
  - 3 or more:
    - Star topology with hub or switch
  - 2 or more star topology

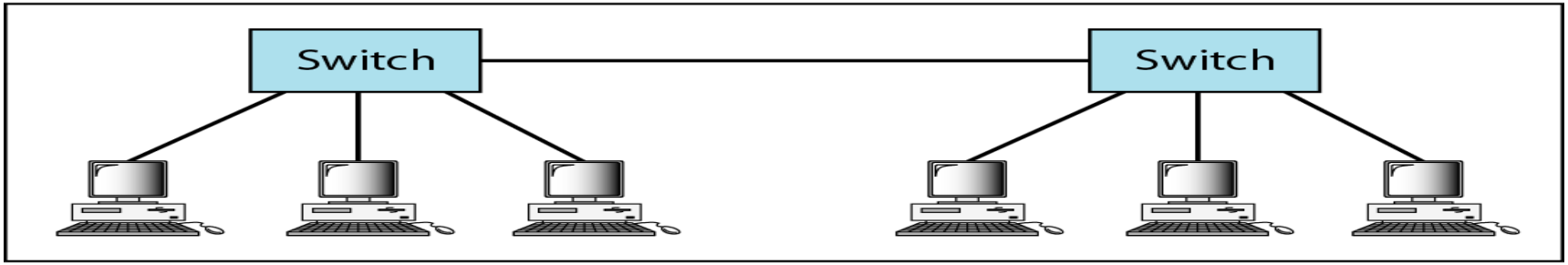
Gigabit Ethernet



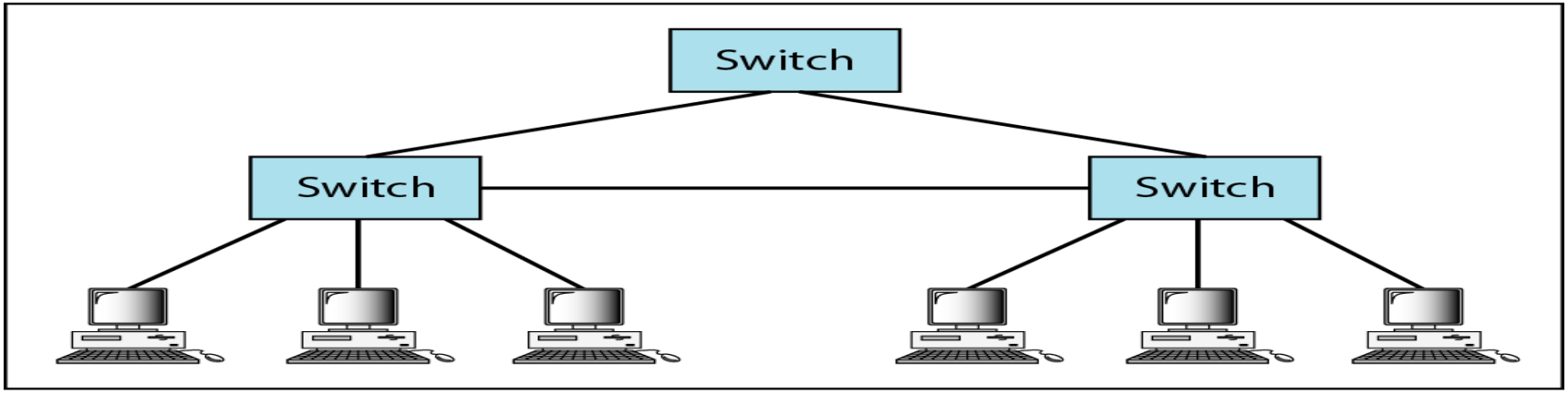
a. Point-to-point



b. Star



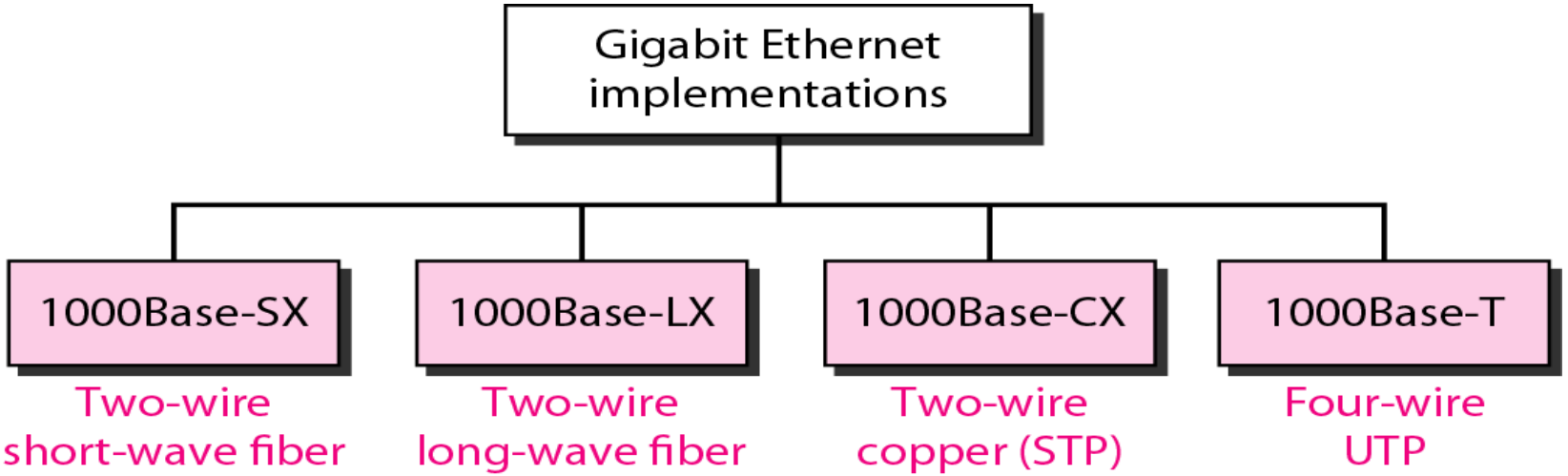
c. Two stars



d. Hierarchy of stars

Gigabit Ethernet

- Implementation



- It does can not use Manchester encoding scheme because it involves a very high bandwidth

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