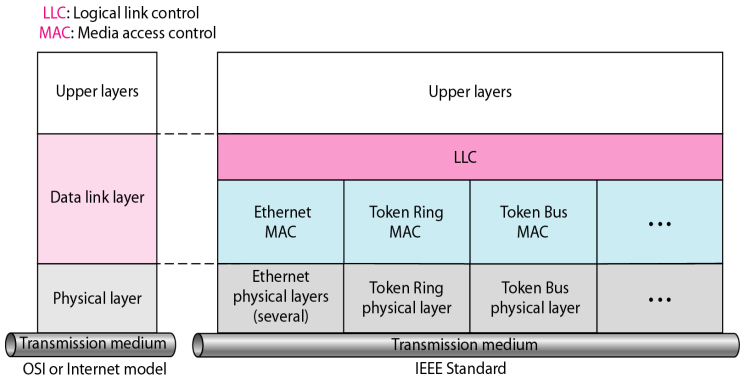
Computer Networks
#4 Local Area Networks
- Ethernet -

Universitas Komputer Indonesia

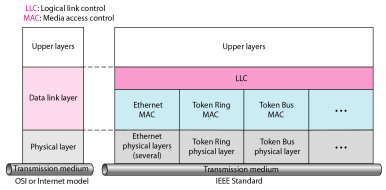
IEEE Standards

- Ethernet: It is a LAN protocol that is used in Bus and Star topologies and implements CSMA/CD as the medium access method
- 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.

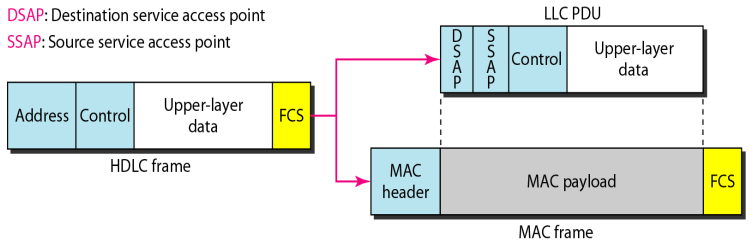
IEEE Standard for LAN



- In IEEE 802.3 Ethernet Data link layer is split into two sublayers:
  - **Bottom part: MAC**
    - The frame is called IEEE 802.3
    - Handles framing, MAC addressing, Medium Access control
    - Specific implementation for each LAN protocol
      - Defines CSMA/CD as the access method for Ethernet LANs and Token passing method for Token Ring.
    - Implemented in hardware
  - **Top part: LLC (Logical Link Control)**
    - The subframe is called IEEE 802.2
    - Provides error and flow control if needed
    - It makes the MAC sublayer transparent
      - Allows interconnectivity between different LANs data link layers
    - Used to multiplex multiple network layer protocols in the data link layer frame
    - Implemented in software



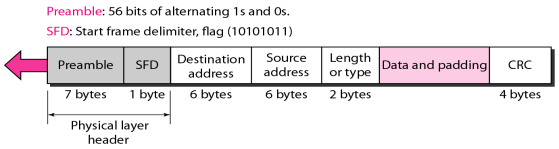
HDLC frame compared with LLC and MAC frames



Standard Ethernet

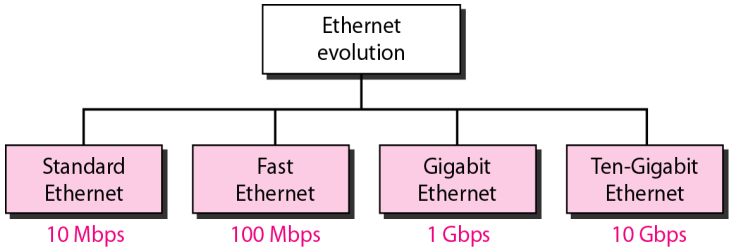
- The original Ethernet was created in 1976 at Xerox's Palo Alto Research Center (PARC). Since then, it has gone through four generations. We briefly discuss the Standard (or traditional) Ethernet in this section.
- Ethernet data link layer protocol provides **connectionless service** to the network layer
  - No handshaking between sending and receiving adapter.
- Ethernet protocol provides Unreliable service to the network layer :
  - Receiving adapter doesn't send ACK or NAK to sending adapter
  - This means stream of datagrams passed to network layer can have gaps (missing data)
    - Gaps will be filled if application is using reliable transport layer protocol
      - Otherwise, application will see the gaps

802.3 MAC Frame

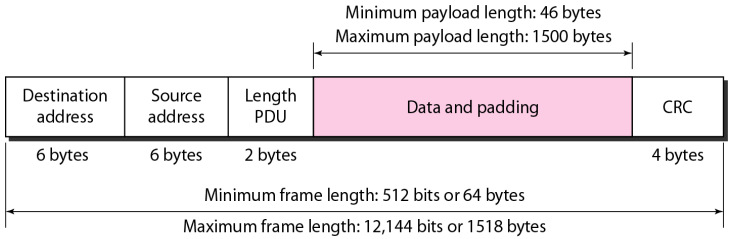


Preamble:
8 bytes with pattern 10101010 used to synchronize receiver, sender clock rates.
In IEEE 802.3, eighth byte is start of frame (10101011)
Addresses: 6 bytes (explained latter)
Type (DIX)
Indicates the type of the **Network layer protocol** being carried in the **payload (data)** field, **mostly IP** but others may be supported such as IP (**0800**), Novell IPX (**8137**) and AppleTalk (**809B**), ARP (**0806**))
Allow **multiple network layer** protocols to be supported on a single machine (multiplexing)
Its value starts at **0600h (=1536 in decimal)**
Length (IEEE 802.3): number of bytes in the **data field**.
Maximum 1500 bytes **(= 05DCh)**
CRC: checked at receiver, if error is detected, the frame is **discarded**
CRC-32
Data: carries data encapsulated from the upper-layer protocols
Pad: Zeros are added to the data field to make the **minimum data length = 46 bytes**

Ethernet evolution through four generations



Maximum and Minimum Lengths



Frame length:
Minimum: 64 bytes (512 bits)
Maximum: 1518 bytes (12,144 bits)

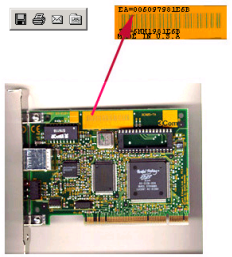
Example of an Ethernet address in hexadecimal notation

06 : 01 : 02 : 01 : 2C : 4B

6 bytes = 12 hex digits = 48 bits

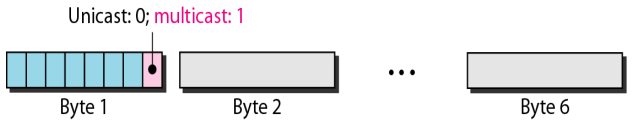
Ethernet Address for Desktop PC ethernet card

For the 3Com 3C905-TX PCI PnP network card



The ethernet address for the above network card is : 006097981E6B

Unicast and Multicast Address



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.

Example

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. Therefore, we have the following:

a. This is a unicast address because A in binary is 1010.

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

c. This is a broadcast address because all digits are F's.

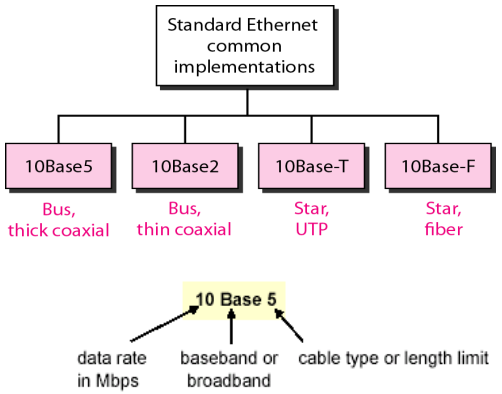
Example

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

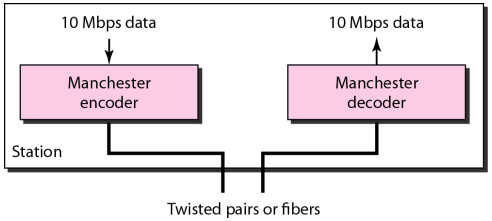
Solution

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:

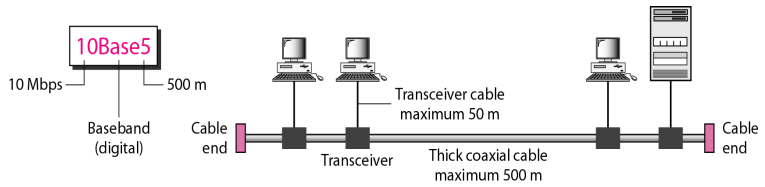
Categories of Standard Ethernet



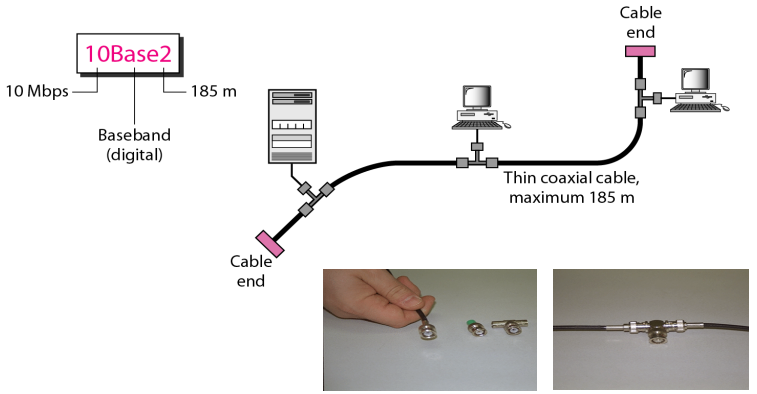
Encoding in a Standard Ethernet implementation



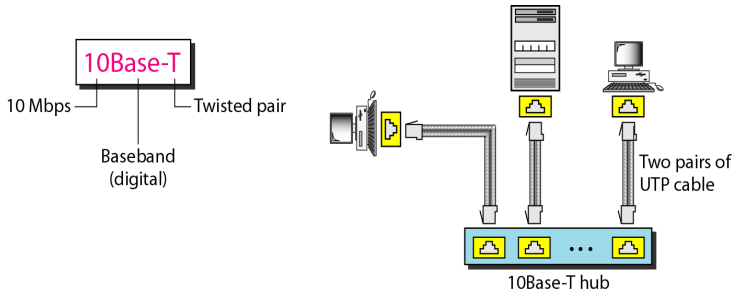
10Base5 implementation



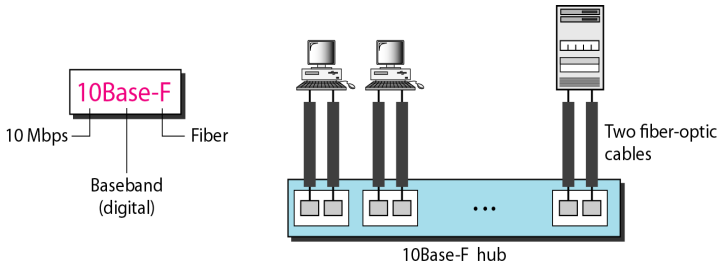
10Base2 implementation



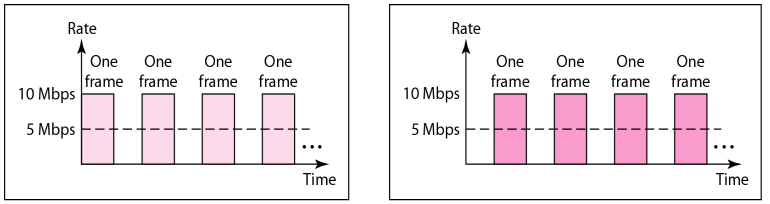
10Base-T implementation



10Base-F implementation



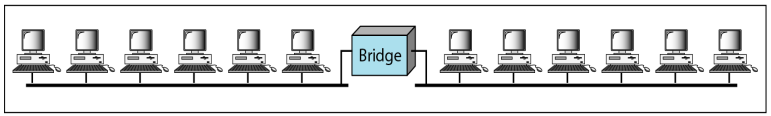
- The 10-Mbps Standard Ethernet has gone through several changes before moving to the higher data rates. These changes actually opened the road to the evolution of the Ethernet to become compatible with other high-data-rate LANs.



a. First station

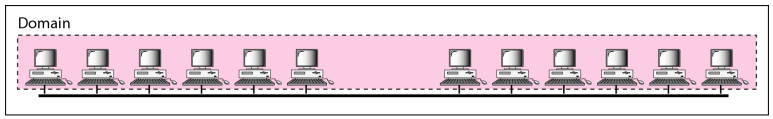
b. Second station

a. Without bridging

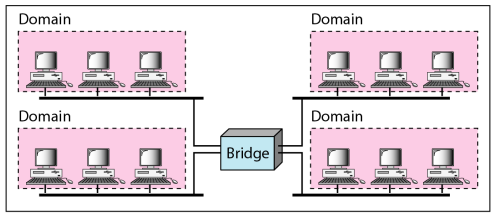


b. With bridging

Collision domains in an unbridged network and a bridged network

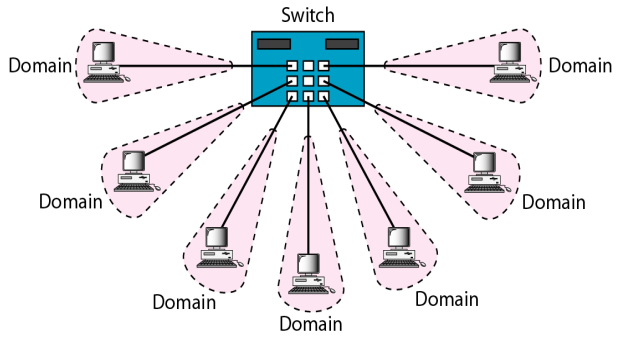


a. Without bridging

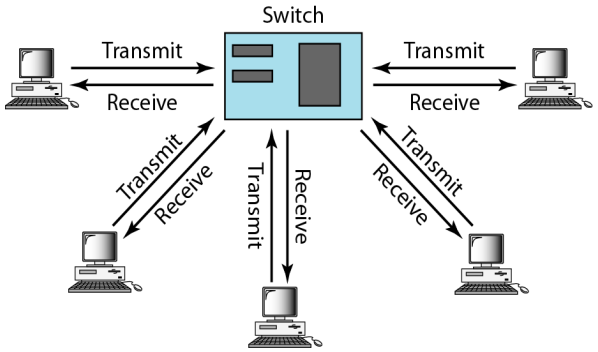


b. With bridging

Switched Ethernet



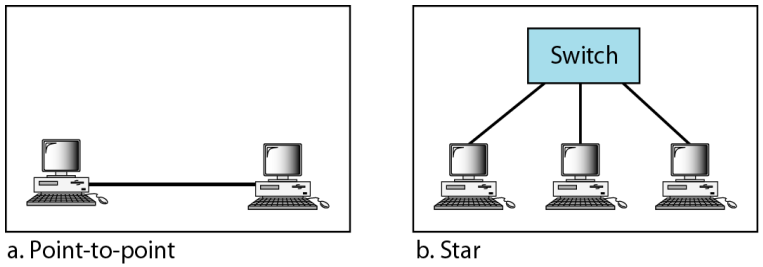
Full-duplex switched Ethernet



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.

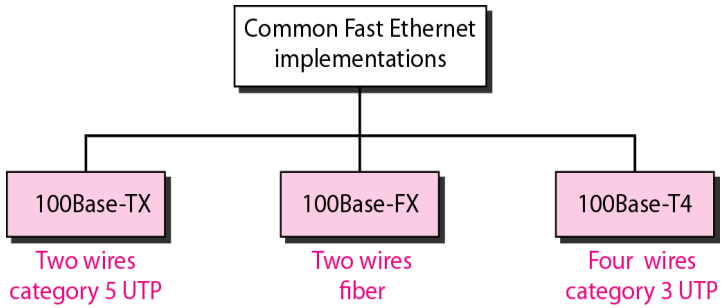
Fast Ethernet topology



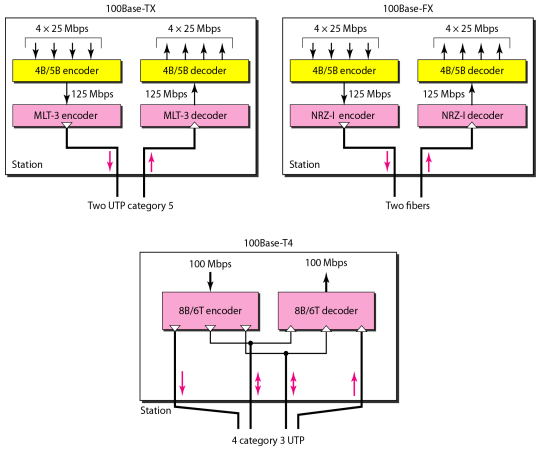
a. Point-to-point

b. Star

Fast Ethernet implementations



Encoding for Fast Ethernet implementation



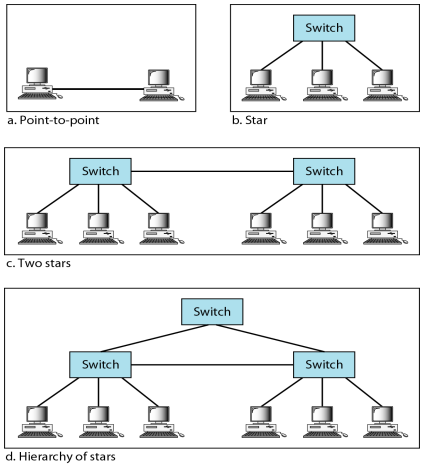
Summary of Fast Ethernet implementations

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

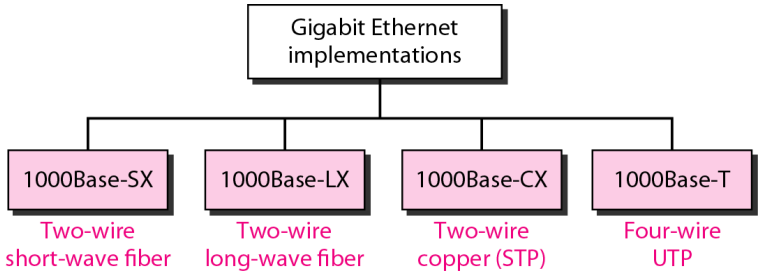
Gigabit Ethernet

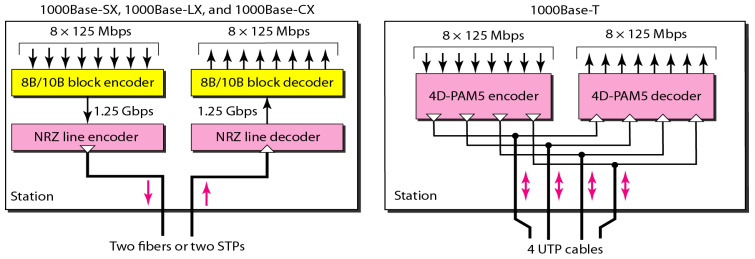
- The need for an even higher data rate resulted in the design of the Gigabit Ethernet protocol (1000 Mbps). The IEEE committee calls the standard 802.3z.

- 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.



Gigabit Ethernet implementations





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

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