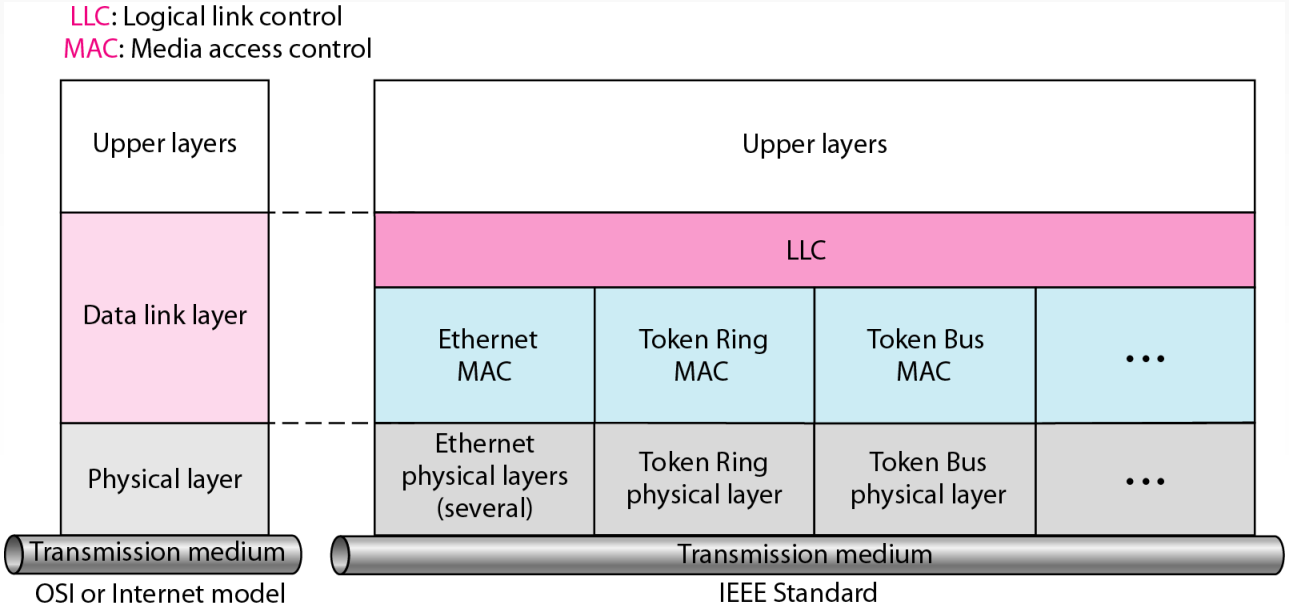
Wired LANs: *Ethernet*

- IEEE Standards
- Standard Ethernet
- Changes in the Standard
- Fast Ethernet
- Gigabit Ethernet

IEEE Standards

- 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.

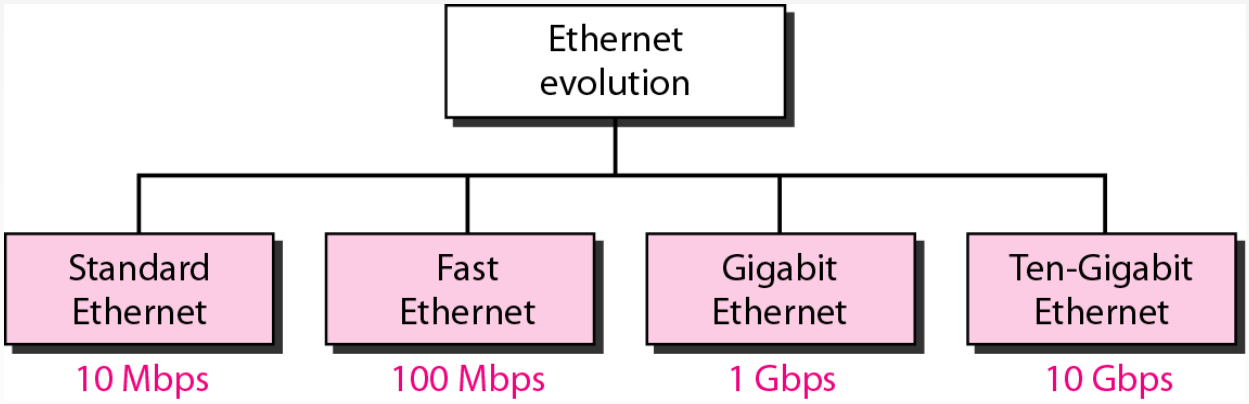


IEEE 802 Working Group

Active working groups	Inactive or disbanded working groups
802.1 Higher Layer LAN Protocols Working Group	802.2 Logical Link Control Working Group
802.3 Ethernet Working Group	802.4 Token Bus Working Group
802.11 Wireless LAN Working Group	802.5 Token Ring Working Group
802.15 Wireless Personal Area Network (WPAN) Working Group	802.7 Broadband Area Network Working Group
802.16 Broadband Wireless Access Working Group	802.8 Fiber Optic TAG
802.17 Resilient Packet Ring Working Group	802.9 Integrated Service LAN Working Group
802.18 Radio Regulatory TAG	802.10 Security Working Group
802.19 Coexistence TAG	802.12 Demand Priority Working Group
802.20 Mobile Broadband Wireless Access (MBWA) Working Group	802.14 Cable Modem Working Group
802.21 Media Independent Handoff Working Group	
802.22 Wireless Regional Area Networks	

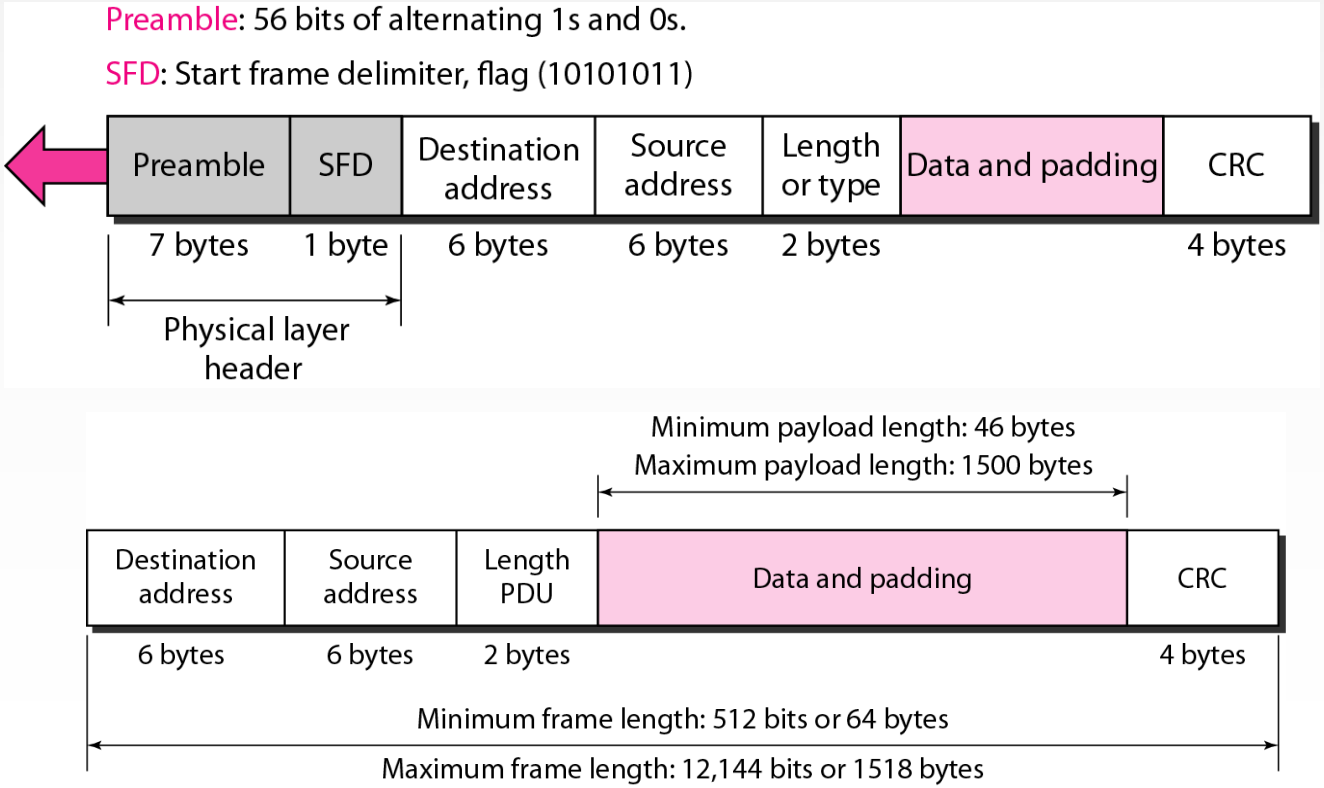
Standard Ethernet

- The original Ethernet was created in 1976 at Xerox's Palo Alto Research Center (PARC). Since then, it has gone through several generations



MAC Sublayer

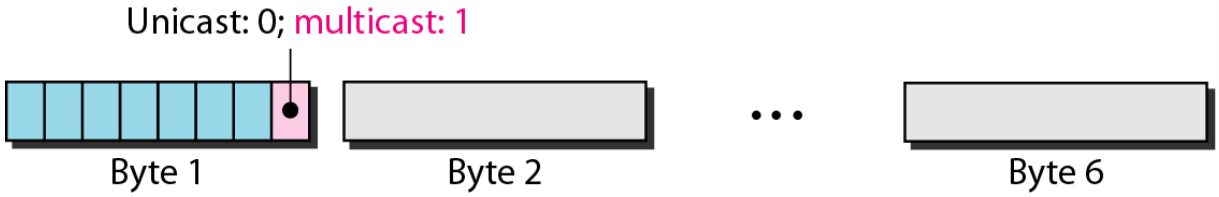
- Preamble: alerting the receiving system to the coming frame and enabling it to synchronize its input timing
- CRC: CRC-32



Addressing

- Ethernet address in hexadecimal notation

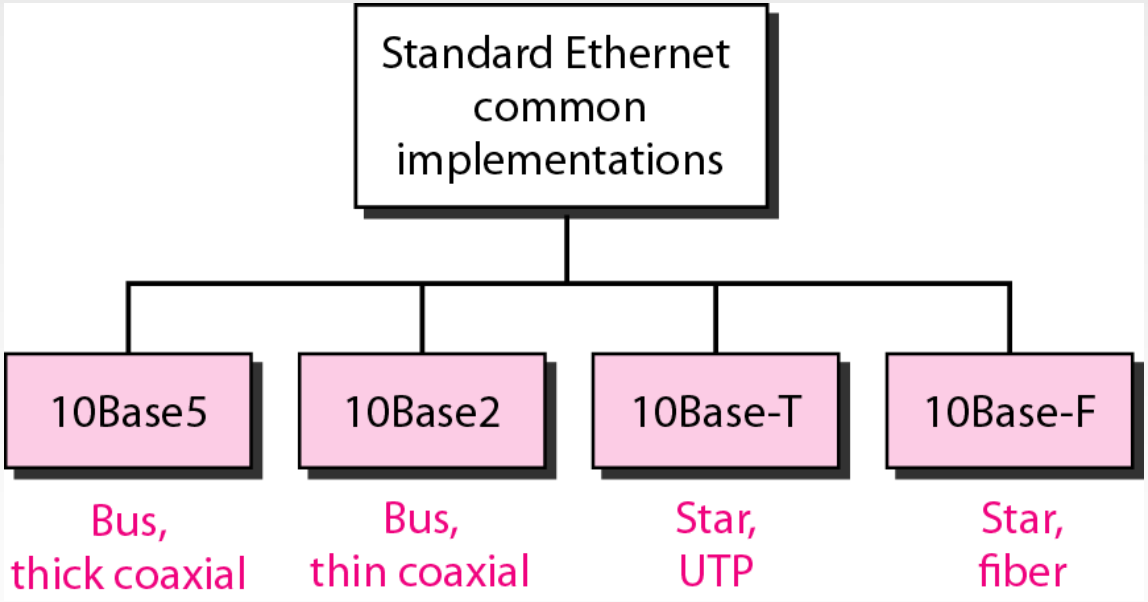
- The least significant bit of the first byte defines the type of address.
  If the bit is 0, the address is unicast; otherwise, it is multicast
- The broadcast destination address is a special case of the multicast address in which all bits are 1s

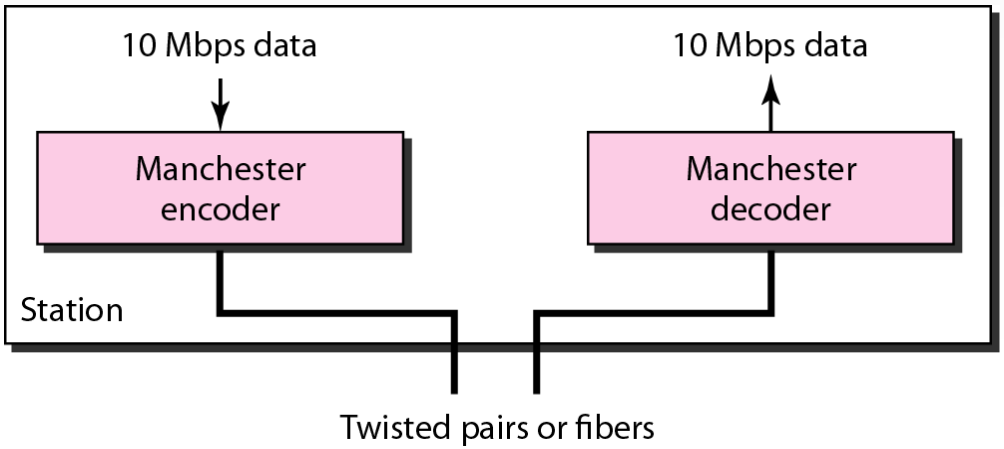


Ethernet

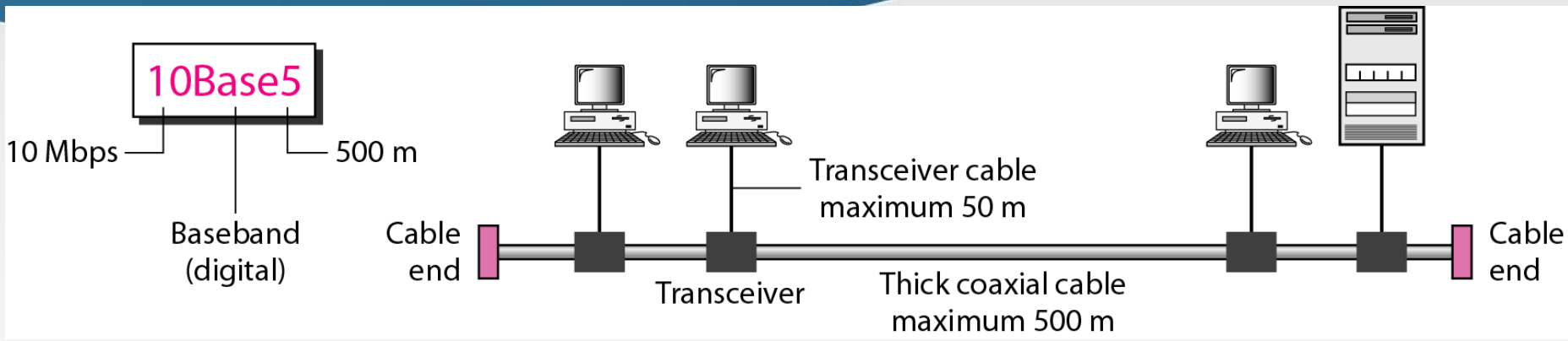
- Access method: 1- persistent CSMA/CD
- Slot time = rount-trip time + time required to send the jam sequence
  - 512 bits for Ethernet, 51.2 μs for 10 Mbps Ethernet

Physical Layer: Ethernet

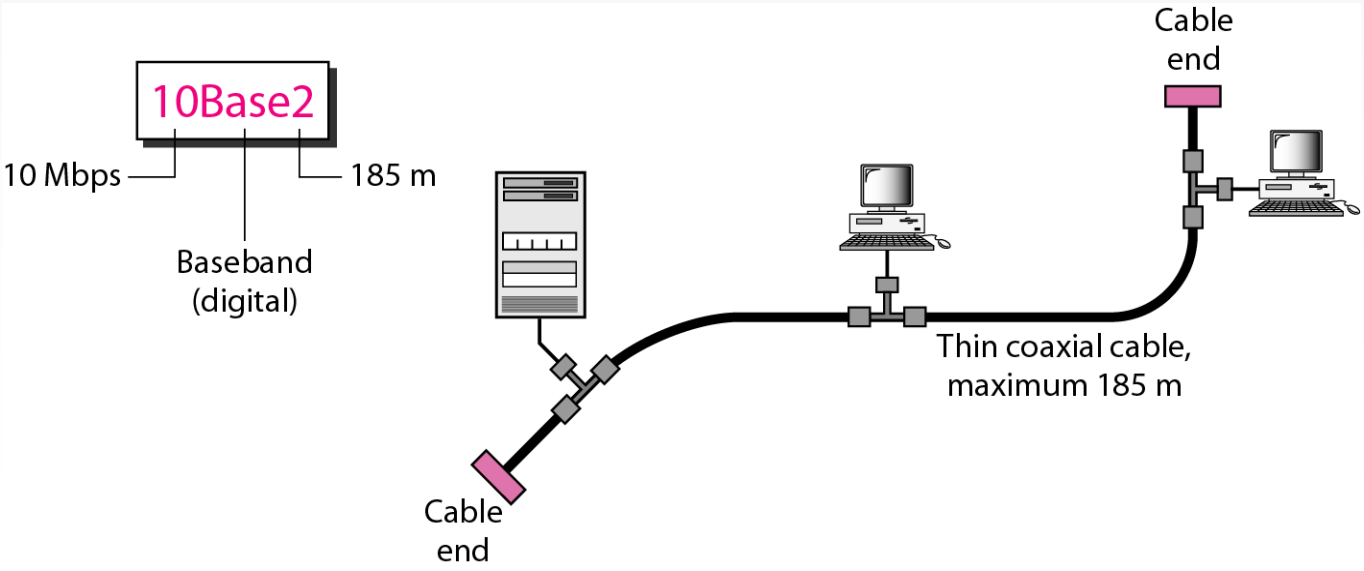




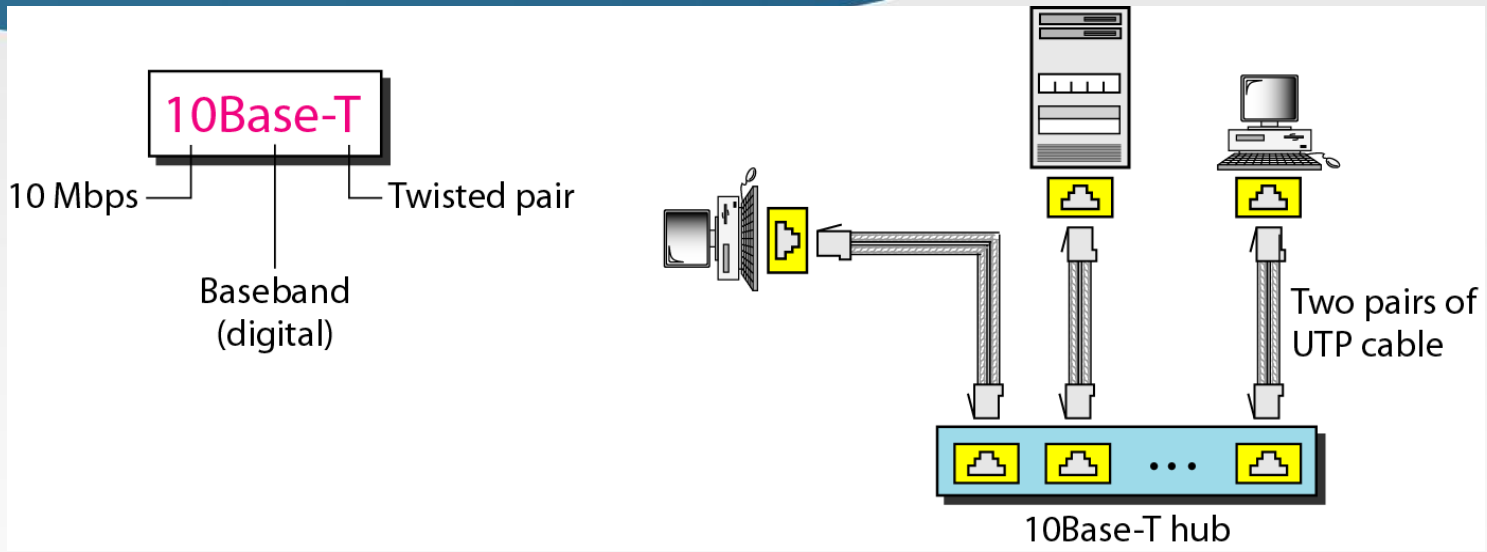
10Base5: Thick Ethernet



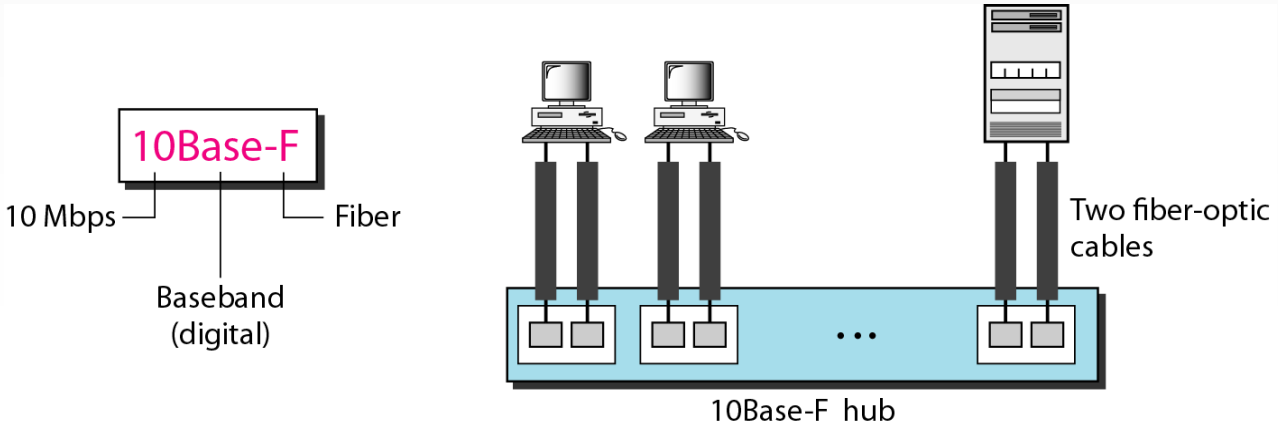
10Base2: Thin Ethernet



10BaseT: Twisted-Pair Ethernet



10Base-F: Fiber Ethernet

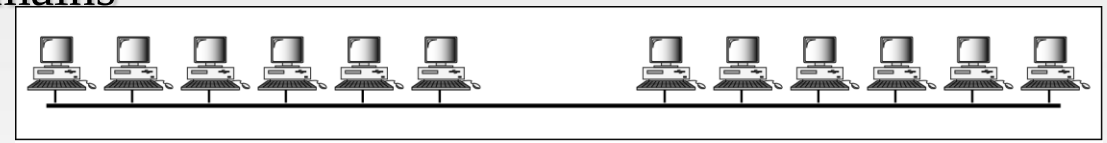


Summary of Standard Ethernet

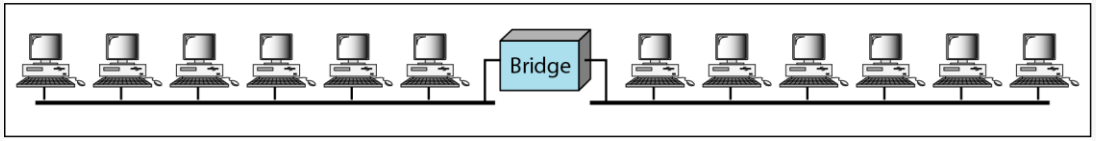
Characteristics	*10Base5*	*10Base2*	*10Base-T*	*10Base-F*
Media	Thick coaxial cable	Thin coaxial cable	2 UTP	2 Fiber
Maximum length	500 m	185 m	100 m	2000 m
Line encoding	Manchester	Manchester	Manchester	Manchester

Changes in the Standard

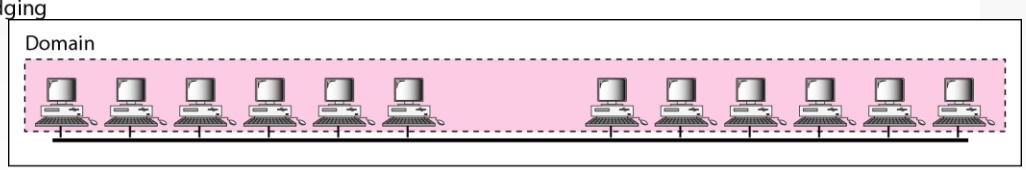
- Bridged Ethernet: Raising bandwidth and separating collision domains



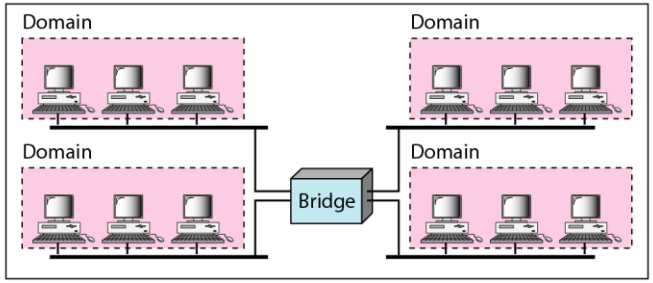
a. Without bridging



b. With bridging



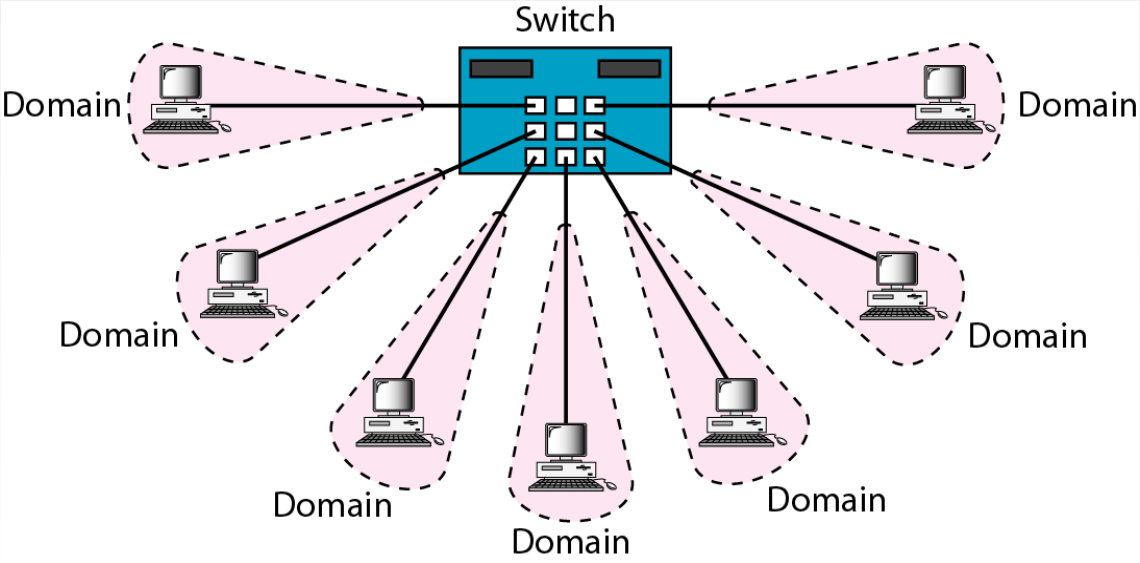
a. Without bridging



b. With bridging

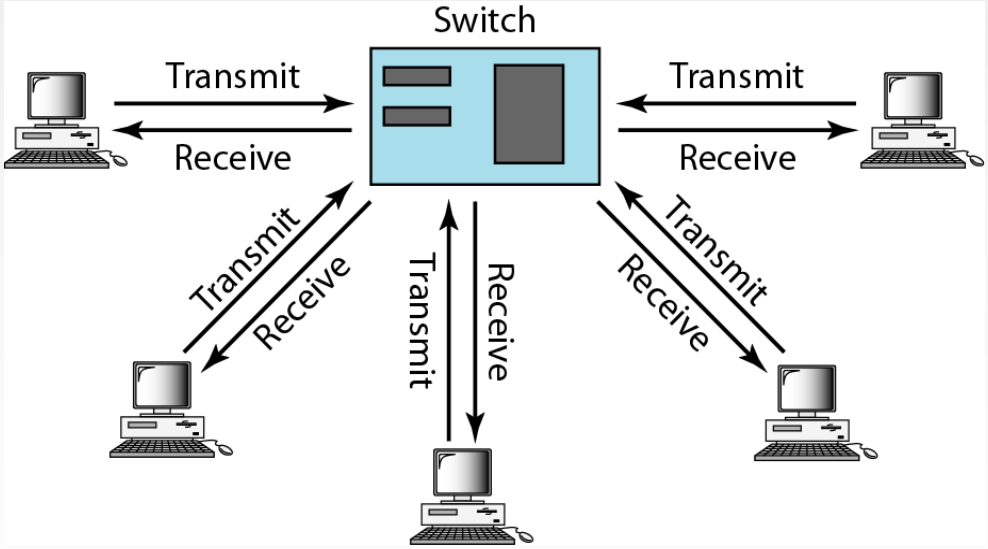
Changes in the Standard

- Switched Ethernet: N-port bridge



Changes in the Standard

- Full-duplex (switched) Ethernet: no need for CSMA/CD



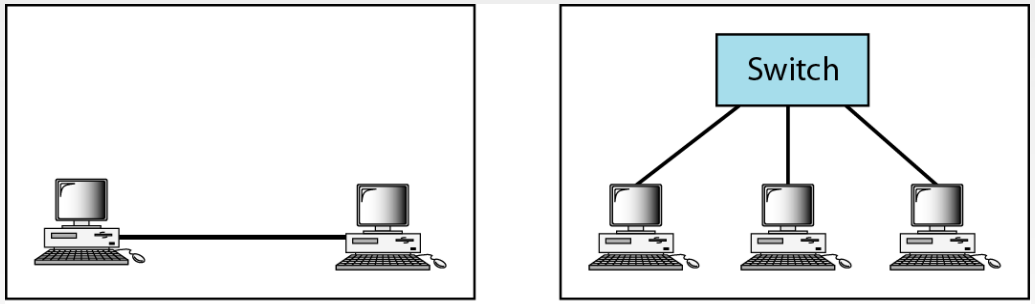
Fast Ethernet

- Under the name of IEEE 802.3u
  - Upgrade the data rate to 100 Mbps
  - Make it compatible with Standard Ethernet
  - Keep the same 48-bit address and the same frame format
  - Keep the same min. and max. frame length
- MAC Sublayer
  - CSMA/CD for the half-duplex approach
  - No need for CSMA/CD for full-duplex Fast Ethernet

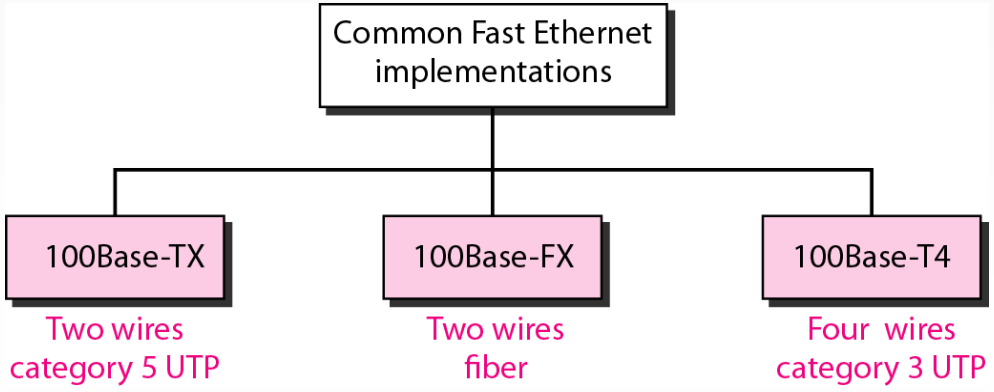
- Auto-negotiation: allow two devices to negotiate the mode or data rate of operation

Fast Ethernet: Physical Layer

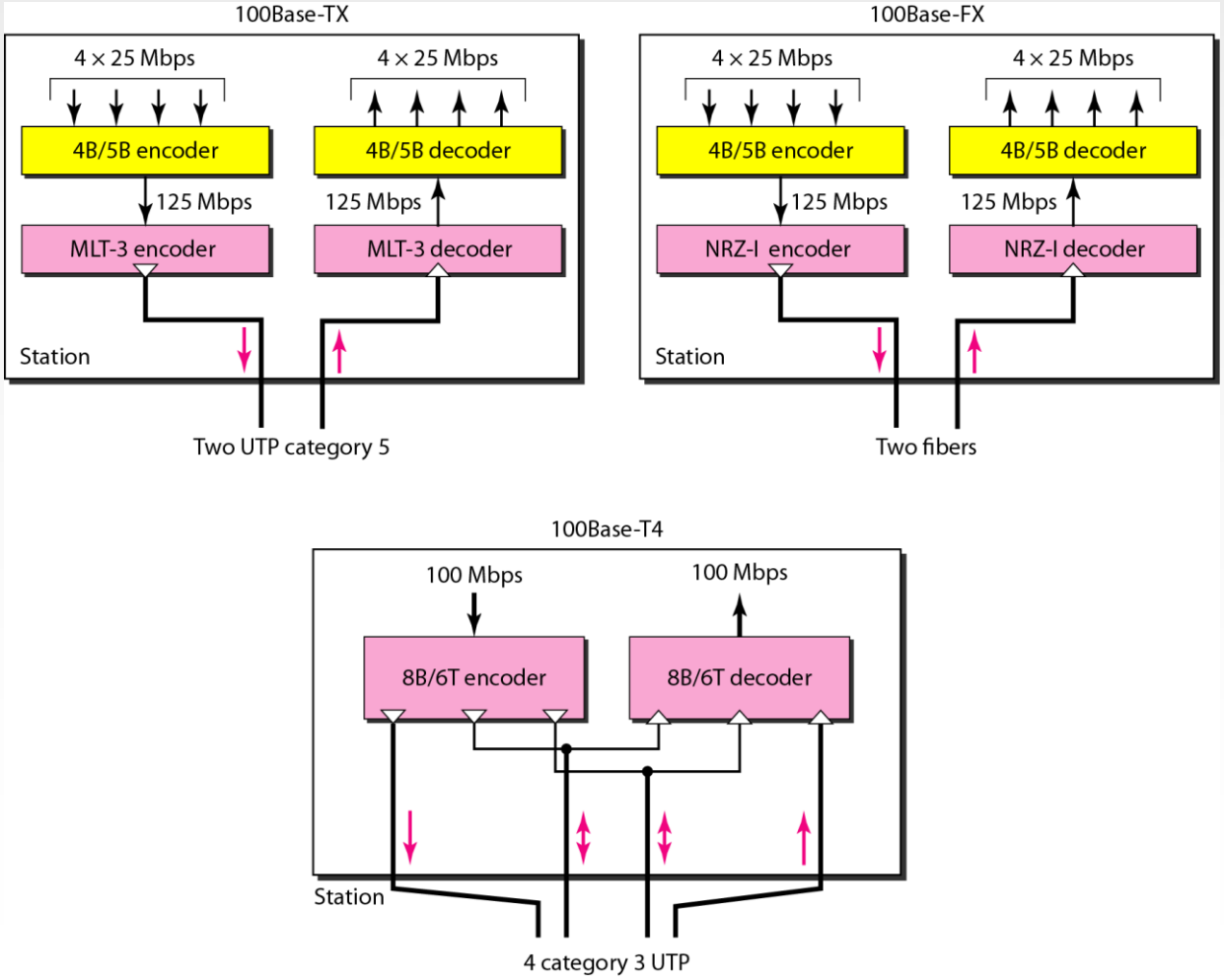
- Topology



- Implementation



Fast Ethernet: Encoding



Summary of Fast Ethernet

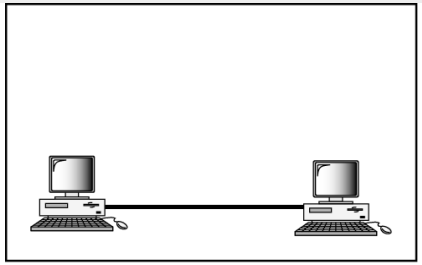
Characteristics	*100Base-TX*	*100Base-FX*	*100Base-T4*
Media	Cat 5 UTP or STP	Fiber	Cat 4 UTP
Number of wires	2	2	4
Maximum length	100 m	100 m	100 m
Block encoding	4B/5B	4B/5B	
Line encoding	MLT-3	NRZ-I	8B/6T

Gigabit Ethernet

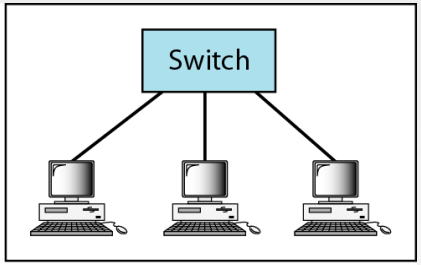
- Under the name of IEEE 802.3z
  - Upgrade the data rate to 1 Gbps
  - Make it compatible with Standard or Fast Ethernet
  - Keep the same 48-bit address and the same frame format
  - Keep the same min. and max. frame length
  - Support autonegotiation as defined in Fast Ethernet
- MAC Sublayer
  - Most of implementations follows full-duplex approach
  - 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.
- Half-duplex mode (very rare)
  - Traditional: 0.512 μs (25m)
  - Carrier Extension: 512 bytes (4096 bits) min. length
  - Frame bursting to improve the inefficiency of carrier extension

Gigabit Ethernet: Physical Layer

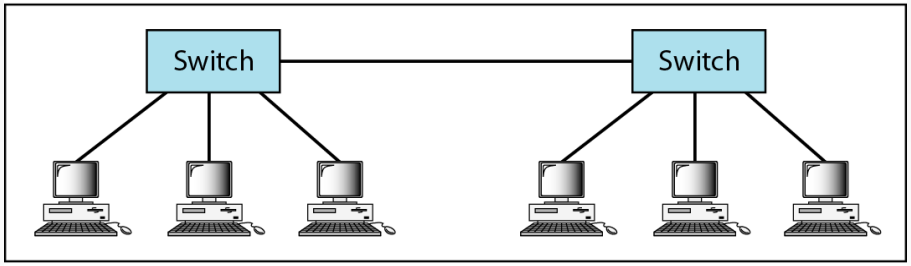
- Topology



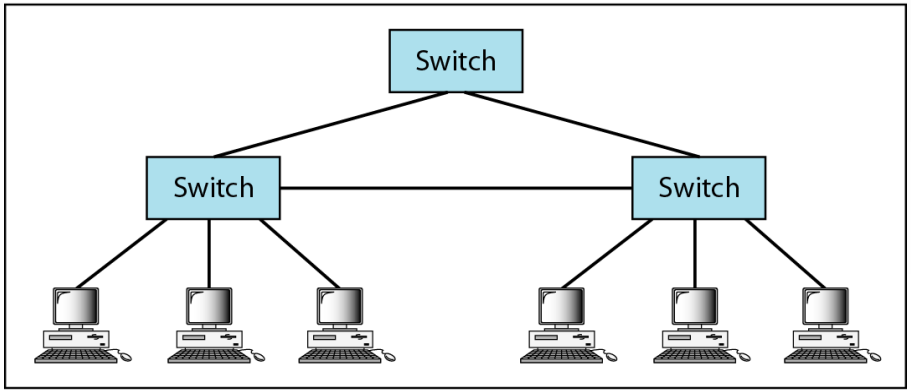
a. Point-to-point



b. Star



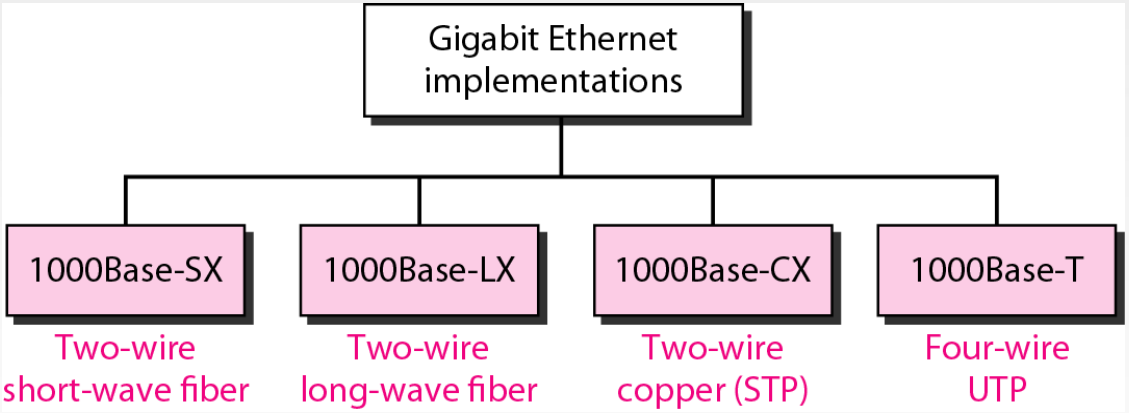
c. Two stars



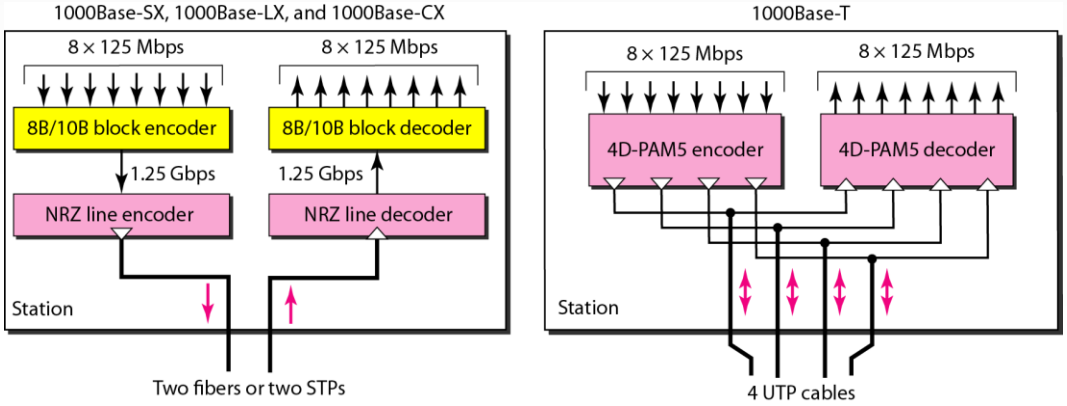
d. Hierarchy of stars

Gigabit Ethernet: Physical Layer

- Implementation



- Encoding



Gigabit Ethernet: Summary

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

Ten-Gigabit Ethernet

- Under the name of IEEE 802.3ae
  - Upgrade the data rate to 10 Gbps
  - Make it compatible with Standard, Fast, and Giga Ethernet
  - Keep the same 48-bit address and the same frame format
  - Keep the same min. and max. frame length
  - Allow the interconnection of existing LANs into a MAN or WAN
  - Make Ethernet compatible with Frame Relay and ATM

- MAC Sublayer: Only in full-duplex mode → no CSMA/CD

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