Overview

- Last Lecture
  - Flow control and error control
- This Lecture
  - Local area networking 1
  - Source: Sections 13
- Next Lecture
  - Local area networking 2
  - Source: Sections 17.1-17.2

Data Link Layer Standards

- Data link layer can be divided into 2 parts
  - Logical Link Control (LLC)
    - Frame formats, error control, flow control
  - Medium Access Control (MAC)
    - Access to medium, contention protocols
- IEEE 802.3, 802.4, and 802.5 are Medium Access Control (MAC) sub-layer protocols
- Note: octet (8 bits) is used instead of byte in standards to avoid confusion.

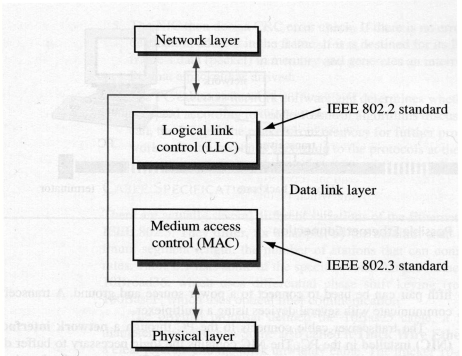


Figure 6.4 Data Link Layer Refinement

LAN Standards

- LAN standards for different topologies
  - IEEE Standard 802.3
    - Ethernet
    - Bus topology
  - IEEE Standard 802.5
    - Token Ring
    - Ring topology
  - IEEE Standard 802.4 (obsolete)
    - Token Bus
    - Bus topology

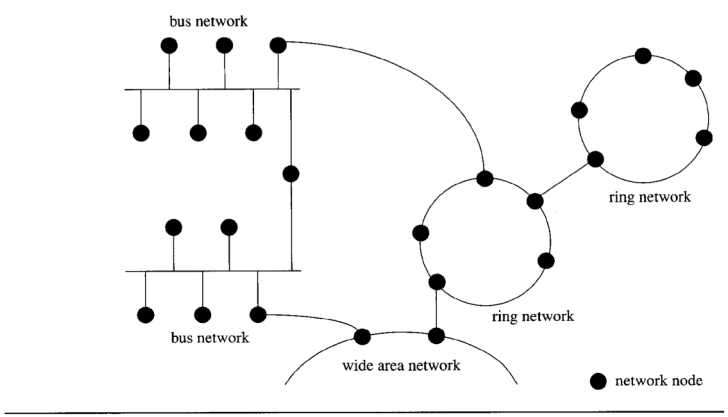
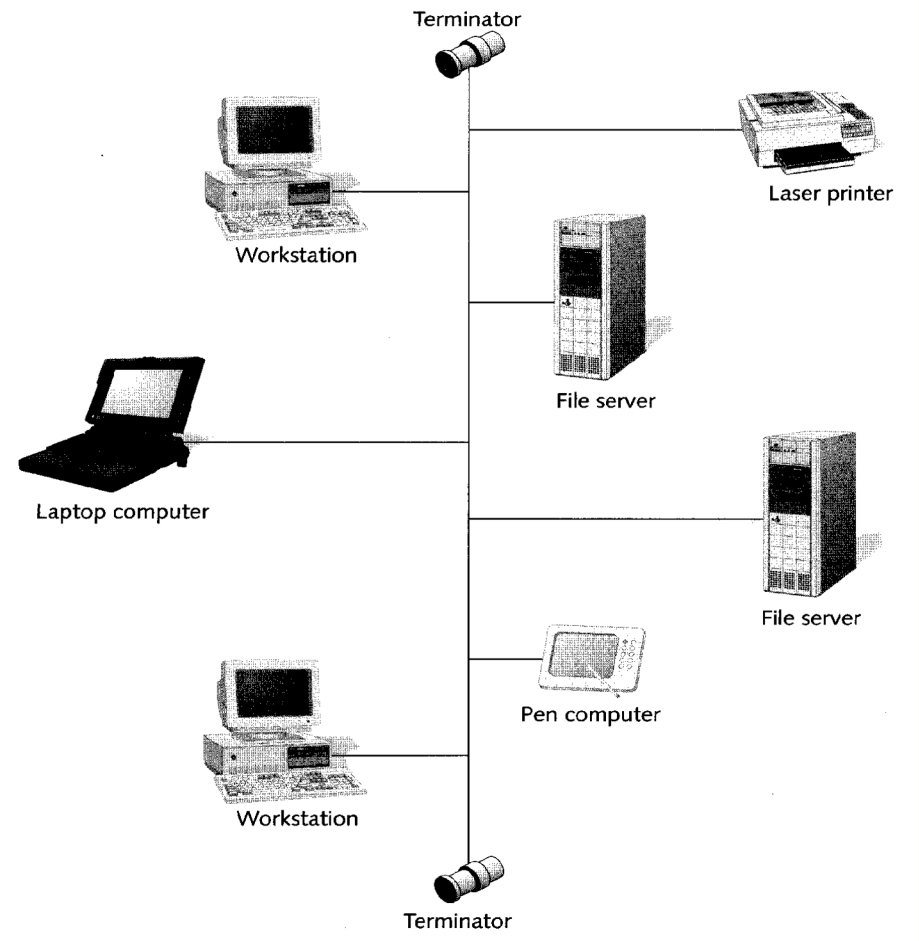


Figure 6.3 Interconnecting Networks

IEEE Standard 802.3

- The standard for Ethernet（video）
- Originated from ALOHA system
- Ethernet was developed originally by Xerox PARC
- Ethernet named after ether, which was thought to propagate radio.
- Bus topology
- Originally used coax
- Can be extended by repeaters
- CSMA/CD protocol

IEEE Standard 802.3 (cont.)



IEEE Standard 802.3 (cont.)

- Physical layer
  - Cabling - coax cable, twisted pair, or fibre optics
  - Uses Manchester digital encoding
  - Terminators: prevents reflection on coax
  - A coax cable is called one Ethernet segment or backbone.
  - Two or more segments can be connected by *repeaters*, a device that receives a signal, regenerates it, and transmits it.

Hardware Components

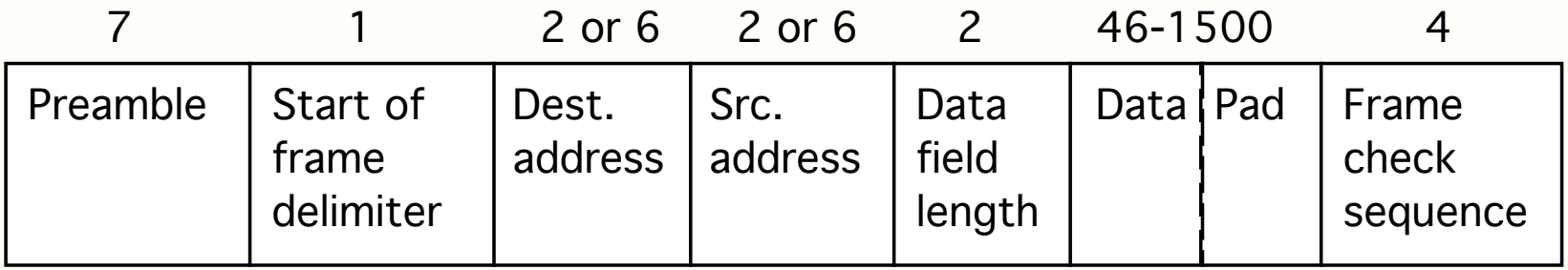
- Network Interface Card (NIC)
  - Receives packets from PC software
  - Formats frames
  - Executes binary exponential backoff algorithm if required
  - Detects incoming frames for itself
  - Performs CRC error checking
  - Has a hardware address

Hardware Components (cont.)

- Ethernet hardware address
  - Six octets: XX XX XX XX XX XX, where X is a hexadecimal number
  - Example: 00 05 02 74 8D 0D
  - Number of addresses = 281,474,976,710,656

This is more than 56,000 MAC addresses for each person on the planet!

Ethernet Frame Format



- Preamble
  - 7-octet pattern of alternating 0's and 1's
- Start of frame delimiter
  - 1010 1011 pattern indicating the start of a frame
- Destination address/Source address
- Data length field
  - Number of octets in the combined data and pad fields

Ethernet Frame Format (cont.)

- Data field - Maximum is 1500 octets
- Pad field: decided by the minimum size of a frame 512 bits or 64 octets
- Frame check sequence - 32-bit CRC

Advanced Ethernet techniques

- Fast Ethernet -- 100Mbps
  - Mainly differ at physical layer
- Gigabit Ethernet
  - Full-duplex mode without CSMA/CD
- 10 Gigabit Ethernet
  - For backbone network
  - Use the same MAC frames
  - No CSMA/CD

IEEE Standard 802.5

- A standard for Token Ring LAN
- Ring consists of point-to-point links
- Can be connected by twisted pair, coax, and fibre optics

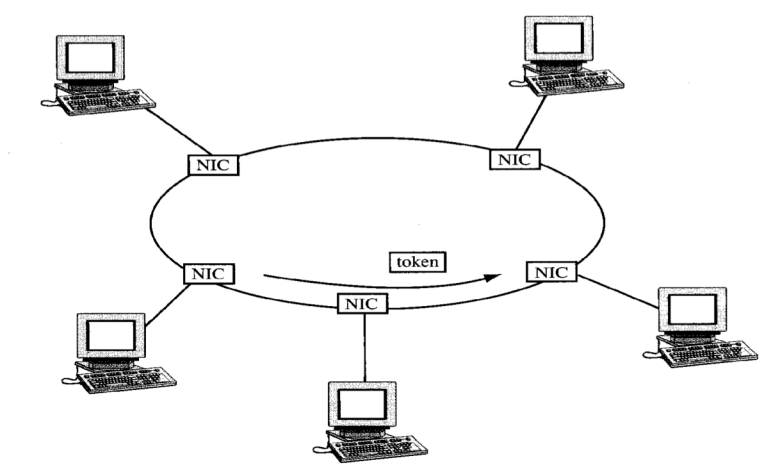


Figure 6.10 Token Ring Network and Circulating Token

Token Ring

- Advantages
  - No collisions because of the use of a token
- Physical layer
  - Uses Differential Manchester encoding
- Problem
  - One failed or improperly operating host can bring down the network

Token Ring (cont.)

- Most 802.5 LANs use wire centres to improve reliability
  - All Frames are through the wire center
  - Logically it works as a ring
  - Wire centre can bypass a failed host
- Physical topology vs. logical topology

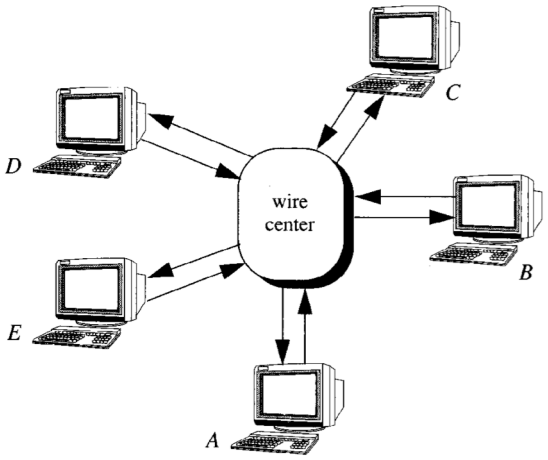


Figure 6.11 Token Ring Network Using Wire Center

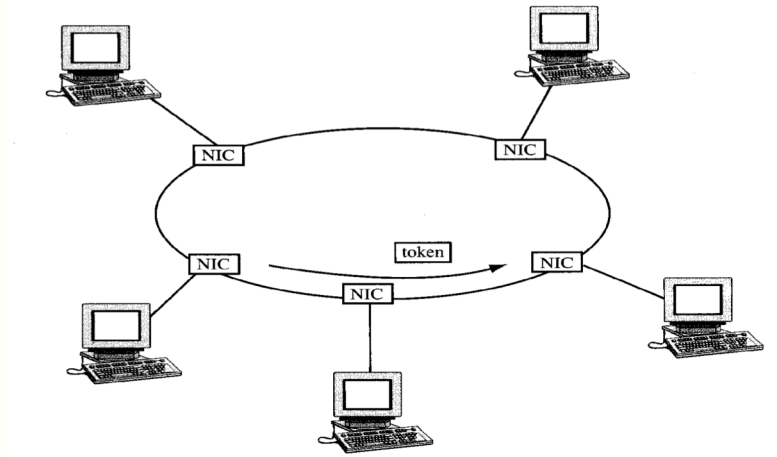


Figure 6.10 Token Ring Network and Circulating Token

Token Frame

- Starting delimiter (SD) - JK0JK000
  - J and K are special signals.
- Ending delimiter (ED) - JK1JK1IE
  - I, intermediate frame bit; E, error bit

SD	AC	FC	DA	SA	DATA	FCS	ED	FS

Token Frame (cont.)

- Access control (AC) - pppt mrrr
  - t, token bit - determine the frame type; 0, token frame; 1, data frame
  - ppp, priority bits - token's priority
    - Each host is assigned a priority. If a host's priority is smaller than the priority of the token, it can not claim the token, but it can reserve the token by setting the reservation bits
  - rrr, reservation bits - priority of the host who makes a reservation
  - m, monitor bit - for removing orphan frames

Data Frame

- DA - destination address
- SA - source address
- FCS - frame check sequence (CRC)
- Frame control (FC) - ffzzzzzz
  - f - frame type bits
  - z - control bits
  - Distinguish data frames from various possible control frames

Data Frame (cont.)

- Frame status (FS) - acxxacxx
  - Has two copies of its bits in case of error.
  - a - address recognized bit. If the destination host is on the ring, the bit is set by the host when the data frame gets through.
  - c - frame copied bit. After the destination host has copied the frame, it sets the bit.
  - x - undefined bit

Ring Maintenance

- Designate a monitor host to oversee the ring.
- Orphan frames
  - An orphan frame is a data frame that cannot be drained because the sender is no longer available.
  - How to remove orphan frames?
    - When a frame is created, the monitor bit in the AC (Access Control) octet is set to 0. The monitor host sets it to 1. If the monitor host sees it again, the frame is drained.

Ring Maintenance (cont.)

- No token circulating
  - A host receives a frame or token and fails before sending it on.
  - How to fix the problem?
    - The monitor host sets a timer whenever it sends a frame or token. If the timer expires before a frame or token is received by the monitor, a new token is sent.
- Monitor host cannot solve all problems.
- How about if the monitor host fails?
- Hosts can bid to become the monitor. The one with the highest address wins.

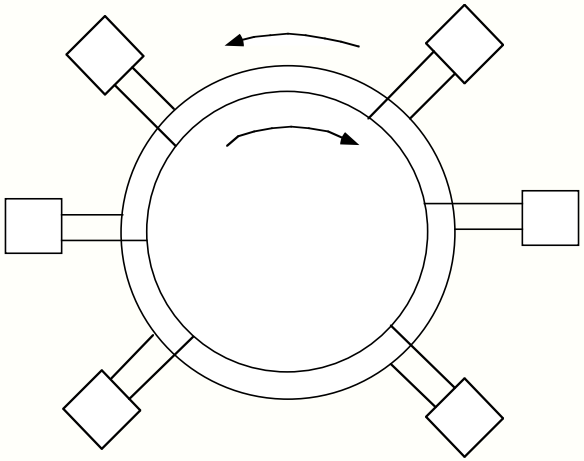
Another Ring Standard

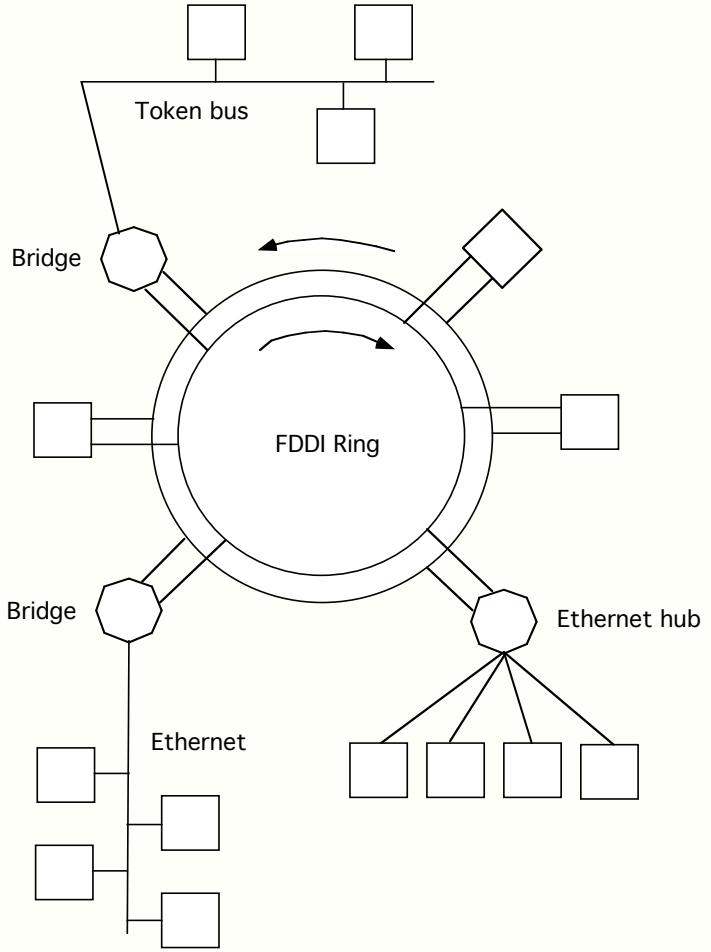
- FDDI: Fiber Distributed Data Interface
- Developed by ANSI in 1980s
- Modelled on token ring
- Mainly used for large span distance up to 200 km or for very high data rates
- Can connect up to 1000 hosts

FDDI

- Two counter-rotating fibre rings

(Dual Ring Topology: demo)





Summary

- Concepts
  - IEEE802.3 (Ethernet)
  - IEEE802.5 (Token ring)
  - Network Interface Card (NIC)
- Ethernet
- Token ring
- FDDI