Local Area Network

References:
Chapters 15 and 16 Stallings
Chapters 14 and 16 Forouzan
Study Guide 8

Review of Lecture 7

- Question - What are the station types supported by HDLC? Describe each.

Review of Lecture 7

- Question - What are the station types supported by HDLC? Describe each.
- Answer - Primary station: Responsible for controlling the operation of the link. Frames issued by the primary are called commands. Secondary station: Operates under the control of the primary station. Frames issued by a secondary are call responses. The primary maintains a separate logical link with each secondary station on the line. Combined station: Combines the features of primary and secondary. A combined station may issue both commands and responses.

Review of Lecture 7

- Question - What are the transfer modes supported by HDLC? Describe each.

Review of Lecture 7

- Question - What are the transfer modes supported by HDLC? Describe each.
- Answer - Normal Response Mode (NRM): Used with an unbalanced configuration. The primary may initiate data transfer to a secondary, but a secondary may onlytransmit data in response to the command of the primary. Asynchronous Balanced Mode (ABM): Used with a balanced configuration. Either combined station may initiate transmission without receiving permission from the other combined station. Asynchronous Response Mode (ARM): Used with an unbalanced configuration. The secondary may initiate transmission without explicit permission of the primary. The primary still retains responsibility for the line, including initialisation, error recovery, and logical disconnection.

Review of Lecture 7

- What is the purpose of the flag field?

Review of Lecture 7

- What is the purpose of the flag field?
- Answer - The flag delimits the beginning and end of a frame.

Learning Objectives

- **Understand Local Area Network protocol concepts;**
- **Understand Media Access Control;**
- **describe the common LAN Topologies (Bus, Tree and Ring);**
- **describe ethernet;**
- **define Unshielded Twisted Pair Wiring; and**
- **define Carrier Sense Multiple Access with Collision detection CSMA/CD.**

Local Area Network

- A collection of computers and computing devices, generally located in a building, connected so information and communication between computers can occur
- Optimised for a limited distance
- The scope of LAN is small
- Owned, used and operated by a single organization
- Shared resources
  - Information – consistent, restricted, better control
  - Hardware – efficient, cost-effective use of expensive devices
  - Software – better installation, configuration, management
- May provide access to the organization's mainframe computer

Information Sharing

- Refers to having users who access the same data files, exchange information
- Types of information an enterprise might want to locate centrally and share or control access include
  - inventory
  - company letterhead and letter style
  - sales contact information
  - Company procedure manuals
  - Sensitive financial records
  - Employee record
  - Company memos
- Different level of access control can be defined

Hardware Resource Sharing

- Refers to many computers sharing the same hardware resources
- Hardware devices that networked computers can share
  - Printers
  - Plotters
  - Fax modems
  - Scanners
  - Hard disks
  - CD-ROMs
  - Tape backup units
  - Almost any devices that can be attached to a computer

Software Resource Sharing

- An alternative to purchasing a single copy of software for each user is to install the software on the network for all to use
- Central installation and configuration
  - Easy maintenance
- In most cases, not all users would need to access the software package simultaneously, allowing a reduced number of licenses to be purchased
  - Exact restrictions on network usage need to checked in software package documentation

Local Area Network

- Type of LAN is determined by:
  - Topology - how the stations are connected
  - Transmission medium - what type of medium is used
  - Medium Access Control - what rules/algorithms are used to control the shared medium

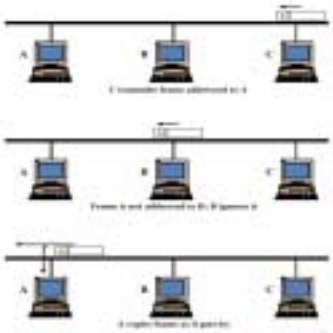
LAN Topology

- Topology defines how nodes/stations are connected and refers to the physical layout of the network
- Typical topology:
  - Bus: all nodes connect to a common medium
  - Star: all nodes are joined to a central node
  - Ring: nodes form a ring by point-to-point link to adjacent neighbours

BUS/Tree Topology

- All stations attach directly to a linear transmission media (***bus***) through hardware interface (***tap***)
- Transmission from any station propagates along the bus, can be received by all stations
  - Need to identify target station
    - each station has unique address
    - destination address is included in frame header
- ***Terminators*** *are* attached at both ends of the bus to stop signal from ringing (echoing back and forth along the bus)

Frame Transmission on BUS



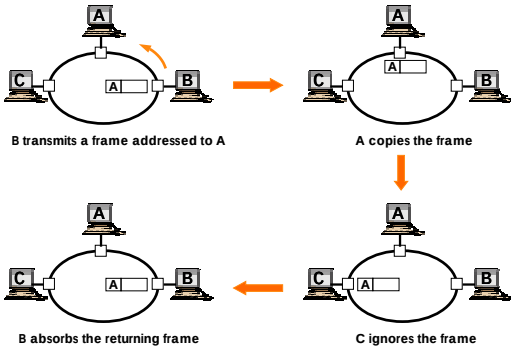
BUS/Tree Topology

- **Example:** Ethernet 10base2
- **Advantages**
  - simple, reliable in very small network, easy to use
  - less expensive - requires the least amount of cable
  - easy to extend
    - joining two cables with a BNC barrel connector
    - by using repeater
- **Disadvantages**
  - heavy traffic can slow a bus considerably
  - difficult to troubleshoot
    - cable break or loose connection can cause reflection and bring down the whole network
  - each barrel connector weakens the signal

Ring Topology

- Each station is attached to a repeater
- Repeaters are connected by point-to-point connection in a closed loop
- Each repeater regenerates and retransmits what it receives
- Only destination copies the frame to it, all others ignore it. The frame continues to circle until returns to source station
- Unidirectional links
- Used in high-performance networks
  - high bandwidth for video/audio
  - large number of client access
- Example: **FDDI** is a fast fiber-optic network based on ring topology

Ring Topology



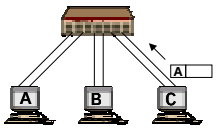
Ring Topology

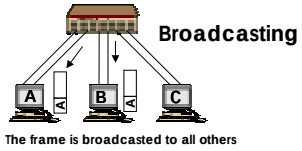
- Advantages:
  - Every station gets equal access to the medium, no station can monopolize the network
  - Fair sharing allows the network to degrade gracefully as more users are added
- Disadvantages:
  - Failure of one station on the ring can affect the whole network
  - Difficult to troubleshoot
  - Adding or removing station disrupts the network

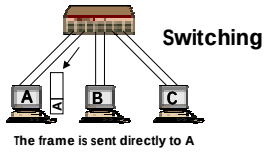
Star Topology

- Each station is directly connected to one central node
- Two alternative operation
  - Broadcasting – uses a shared hub, transmission is broadcasted to every station but only the destination station copies it
  - Switching – uses a switching device, transmission is sent directly to the destination station
- Example: **Ethernet 10baseT**

Star Topology







Star Topology

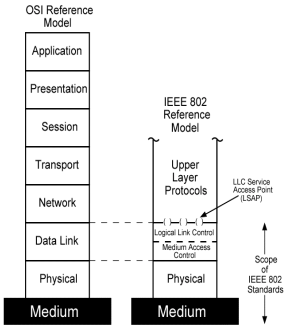
- **Advantage:**
  - easy to modify and add new stations
  - single station failure does not bring down the whole network
  - hub can detect network fault and isolate that station or cable. Star is the most flexible and easiest to diagnose network fault
  - intelligent hub provides centralized monitoring and management
  - can support several cable types
- **Disadvantages:**
  - if central hub fails, whole network fails to operate
  - costs more to cable a star network

Data Link Control in LAN

- Consists of two sublayers:
  - Logical Link Layer(LLC)
    - responsible for:
      - **flow and error control**
      - interface to higher layer
    - similar to a traditional data link protocol, like HDLC
  - Medium Access Control
    - responsible for controlling and coordinating access to the shared medium so that the medium is used efficiently.

Data Link Control in LAN

IEEE 802 v OSI



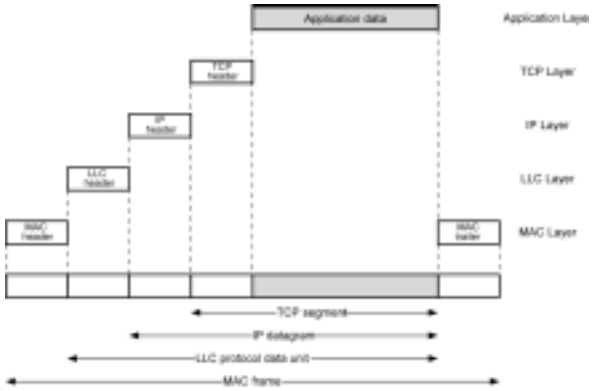
Logical Link Layer (LLC)

- Transmission of link level PDUs between two stations
- Must support multiaccess, shared medium
- Relieved of some link access details by MAC layer
- Addressing involves specifying source and destination LLC users
  - Referred to as service access points (SAP)
  - Typically higher level protocol
- LLC protocol is modeled after HDLC

Media Access Control

- Assembly of data into frame with address and error detection fields
- Disassembly of frame
  - Address recognition
  - Error detection
- Govern access to transmission medium
  - Not found in traditional layer 2 data link control
- For the same LLC, several MAC options may be available

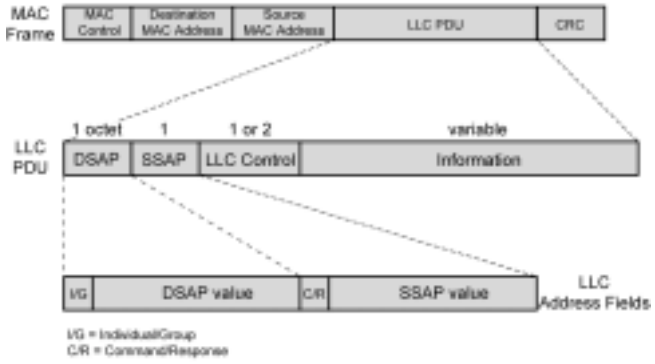
LAN Protocols in Context



MAC Frame Format

- MAC layer receives data from LLC layer
- MAC control
- Destination MAC address
- Source MAC address
- LLC PDU
- CRC
- MAC layer detects errors and discards frames
- LLC optionally retransmits unsuccessful frames

Generic MAC Frame Format



Generation of LANs

- First generation:
  - provides terminal-to-host connectivity and client/server architectures at moderate data rate
  - Ethernet (CSMA/CD) and token ring LANs
- Second generation:
  - provides support for backbone LAN and high performance workstations
  - FDDI
- Third generation:
  - provides the aggregate throughput and real time transport guarantees that are needed for multimedia application

LAN Standard

- IEEE 802.3 CSMA/CD (Ethernet)
- IEEE 802.3 Token Bus
- IEEE 802.5 Token Ring
- FDDI Fiber Distributed Data Interface

CSCA/CD

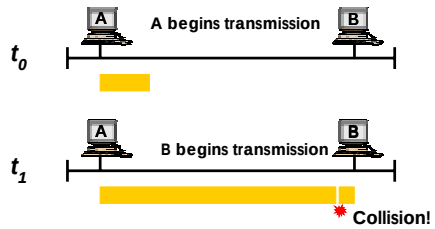
- Carrier Sensed Multiple Access/Collision Detected
- Widely used for Bus topology LANs
- Random access
  - no predictable or scheduled time for any station to transmit.
- Speed :
  - baseband/broadband coaxial : 10 Mbps
  - optical fibre : 100 Mbps
  - shielded twisted pair : 100 Mbps
  - unshielded twisted pair : 10 , 100 Mbps

CSMA/CD

- Station senses to the medium before transmitting: CS
- Topology supports multiple access (listening): MA
- Rules
  - any stations want to transmit have to listen to the medium,
    - if the medium idle, transmit
    - if the medium busy, wait and continue to listen until the channel becomes idle
  - If a collision is detected during transmission, transmit a jamming signal
  - After transmitting the jamming signal, wait random amount of time, then attempt to transmit again
- The frame is eventually absorbed by terminators

Collision

- Occur when more than two stations send frame at the same time



- Data from both transmissions will be garbled and not received successfully

Collision Detection

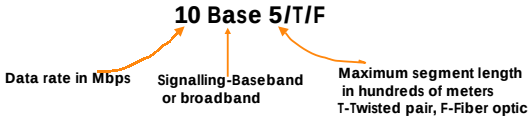
- Collision is detected if
  - Station senses power exceeding the transmitted signal strength (coax)
  - There is signal on more than one port (UTP)
- How stations react
  - Transmit a jamming signal to notify all other stations
- Uses *exponential backoff algorithm* to determine when a station can retransmit after a collision

CSMA/CD Performance

- Works efficiently under light traffic
- Heavy traffic will cause high number of collisions, thus reduce the efficiency of the medium dramatically

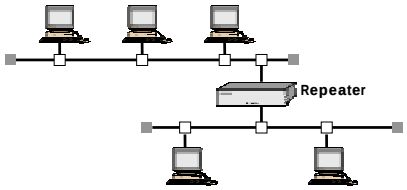
IEEE 802.3 Specification

- **10-Mbps specification - Ethernet**
  - **10Base2** **Thinwire coaxial**
  - **10Base5** **Thickwire coaxial**
  - **10BaseT** **Twisted pair**
  - **10BaseF** **Fiber optics**
  - **10Broad36** **Broadband**
- **100-Mbps specification - Fast Ethernet**
  - **100BaseTX** **Twisted pair**
  - **100BaseFX** **Fiber optics**
  - **100BaseT4** **twisted pair**



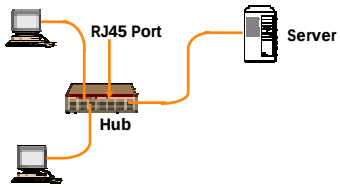
IEEE 802.3 Specification

- **10Base5 and 10Base2**
  - Have a bus topology
  - Maximum segment length is 500m and 200m respectively
  - Maximum span can be extended by connecting segments via repeaters
  - Repeaters do not isolate collisions



IEEE 802.3 Specification

- **10BaseT**
  - Stations are connected to a hub in star
  - Station are connected to hub by category 5 UTP cable with RJ45 connector
  - Widely used in office LANs
  - Distance of a station to the hub must be ≤ 100m



IEEE 802.5- Token Ring

- Ring topology
- Using token as a mean of access control
- Token is a special frame and circulates around the ring
- Any station want to transmit must wait until a *free* token passes the station. Only stations that hold the token can use the medium
- Speed:
  - STP, UTP, fiber optic: 4, 16, 100 Mbps

  (see Table 16.4 in the 7th edition or Table 14.3 in the 6th edition)

IEEE 802.5- Token Ring

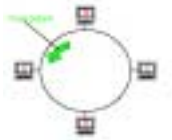
- Rules
  - Station wants to transmit has to wait for a *free* token to pass by
    - If a token is detected
      - the station seizes the token by changing one bit in the token, which transforms it into a start-of-frame sequence for a data frame
      - Appends and transmits the remainder of the fields needed to construct a data frame. The token turns *busy*
    - If a token is not detected, waits until the token is released by other stations

IEEE 802.5- Token Ring

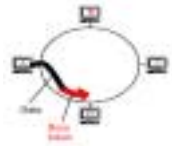
- All stations always listen to medium, as the data frame (with *busy* token) travels around the ring, the message's designated address is compared with the station's address
- The designated station copies the frame, the other stations ignores the frame
- When the frame returns to the transmitting station, it will be absorbed by the station and the station will release a new free token

Transmission in a Token Ring

- **Sender looks for free token**

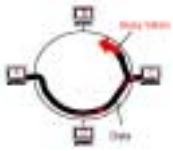


- **Sender changes free token to busy token and appends data to the token**

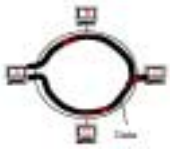


Transmission in a Token Ring

- **Receiver recognizes that it is the destination of the frame**
- **Receiver copies frame to station**
- **Note: Frame also returns to sender**

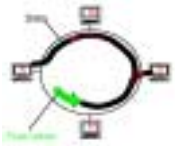


- **Sender absorbs the frame**



Transmission in a Token Ring

- **Sender generates free token when it is done transmitting**
- **Note: The busy token has returned**



IEEE 802.5- Token Ring

- **Ring Maintenance**
  - Token ring selects one station as the monitor station
  - Duties of the monitor:
    - check that there is exactly one token on the ring
    - recover token if it is broken/lost/damaged
    - detect garbled frames
    - make sure the token (24-bit) is shorter than the ring length

IEEE 802.5- Token Ring

- No collision of frames
- Full utilization of bandwidth is possible
- Transmission can be controlled by controlling access to token
- Less efficient than CSMA/CD under light traffic condition
  - Station has to wait for a token to come around before it can transmit
- More efficient than CSMA/CD under heavy traffic condition
- Major consideration: token maintenance
  - Recovery protocol is needed if token is not handled properly, eg, token is corrupted, lost or duplicated

Token Ring with Priority

- A station that has a higher priority frame to transmit than the current frame can reserve the next token for its priority level as the frame passes by
- When the next token is issued , it will be on the reserved priority level
- Station with lower priority cannot seize the token

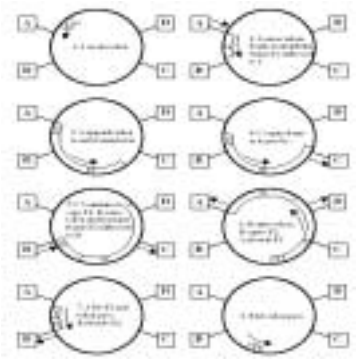
Token Ring with Priority

- Only the reserved priority station or any intermediate stations that have equal or higher level than the reserved priority can seize the token
- The original station that upgraded the priority level has responsibility for down grading the priority level back to the original level when all higher-priority stations are finished

FDDI- Fiber Distributed Data Interface

- Similar concept to token ring
- Support high data rate : 100Mbps
- Designed for both LAN and MAN applications
- Used to build high speed backbone network
- The main differences with token ring:
  - station seizes the token by aborting the token transmission as soon as the token frame is recognized
  - The new token frame is released as soon as the data frame is transmitted completely
- Unlike token ring, FDDI may have several frames circulating on the network

FDDI- Fiber Distributed Data Interface



FDDI- Fiber Distributed Data Interface

- Implements Dual Counter Rotating Ring
  - Second ring adds fault tolerance
  - In case of failure, data is routed to the secondary ring