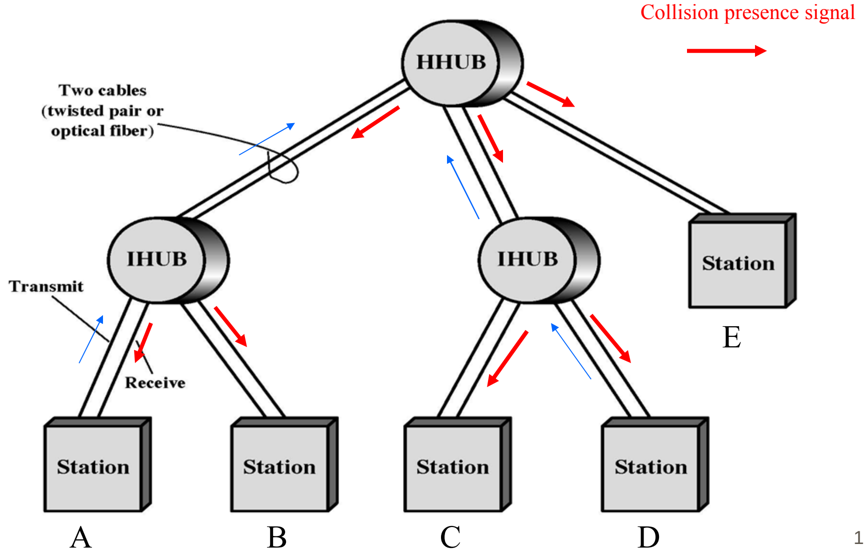
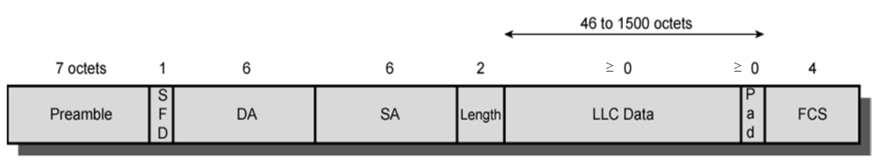
Collision in Star Topology: Case 3

A and D transmitting



IEEE 802.3 MAC Frame Format



SFD = Start of frame delimiter
DA = Destination address
SA = Source address
FCS = Frame check sequence

Figure 16.3

Ethernet frame format differs that "Length" field is used for other purposes, i.e. protocol.

IEEE 802.3 Specifications

- 10Base5: 10Mbps, coaxial (thick) cable, bus topology,
  - — maximum segment length 500m, segments may be connected with repeaters, up to 4 repeaters between any two stations, up to 2500m network span, and Manchester encoding
- 10Base2: 10Mbps, coaxial (thin) cable, bus, 200m segments
- 10Base-T: 10Mps, UTP, star, Manchester, 100m links
- 10Base-F: 10Mbps, 850 nm fiber, star, On/Off, 2000m links
- 100-Mbps Ethernet (Fast Ethernet), star topology, 100m links, 200m or 400m network spans, uses full-duplex mode with two physical links between nodes
  - —100BASE-TX uses two STPs or Cat. 5 UTPs
  - —100BASE-FX uses two optical fibers
- 1Gbit or 10Gbit Ethernet
  - —10GBASE-L (long) : 1310 nm on single-mode fiber, 10 km

g. babic Presentation E 3

"Taking Turns" MAC protocols

channel partitioning MAC protocols:

- —share channel efficiently at high load
- —inefficient at low load: delay in channel access, 1/N bandwidth allocated even if only 1 active node!

Random access MAC protocols

- —efficient at low load: single node can fully utilize channel
- —high load: collision overhead

"taking turns" protocols

look for best of both worlds!

d. xuan DataLink Layer 4

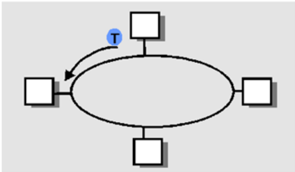
“Taking Turns” MAC protocols

Polling:

- master node “invites” slave nodes to transmit in turn
- Request to Send, Clear to Send msgs
- concerns:
  - polling overhead
  - latency
  - single point of failure (master)

Token passing:

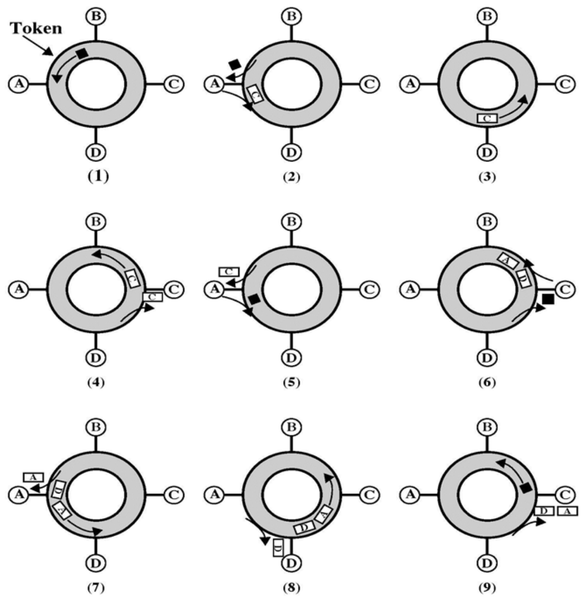
- control **token** passed from one node to next sequentially.
- token message
- concerns:
  - token overhead
  - latency
  - single point of failure (token)



IEEE 802.5 Token Ring

- Small frame (token) circulates when idle
- Station waits for token
- Changes one bit in token to make it SOF for data frame
- Append rest of data frame
- Frame makes round trip and is absorbed by transmitting station
- Station then inserts new token when transmission has finished.

Token Ring Operation



Bridges

- Ability to expand beyond single LAN
- Bridge connects two identical (or similar) LANs
  - — Identical protocols for physical and link layers
  - — Minimal processing
- Router more general purpose
  - — Interconnect various LANs and WANs
- Functioning of bridge
  - — Read all frames transmitted on one LAN and accept those address to any station on the other LAN
  - — Using MAC protocol for second LAN, retransmit each frame
  - — Do the same the other way round

Bridge Operation

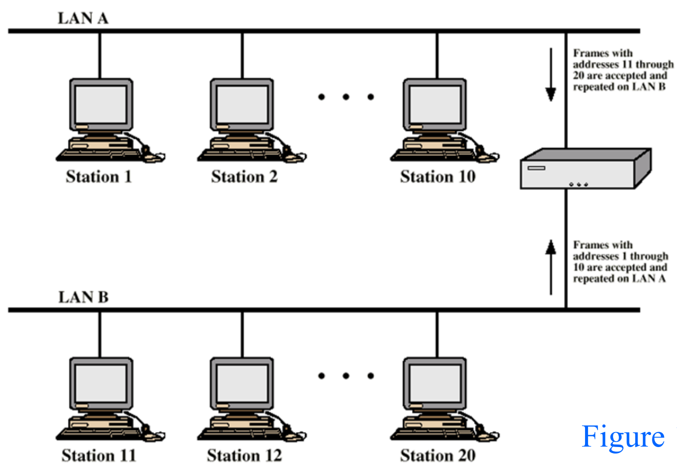


Figure 15.8

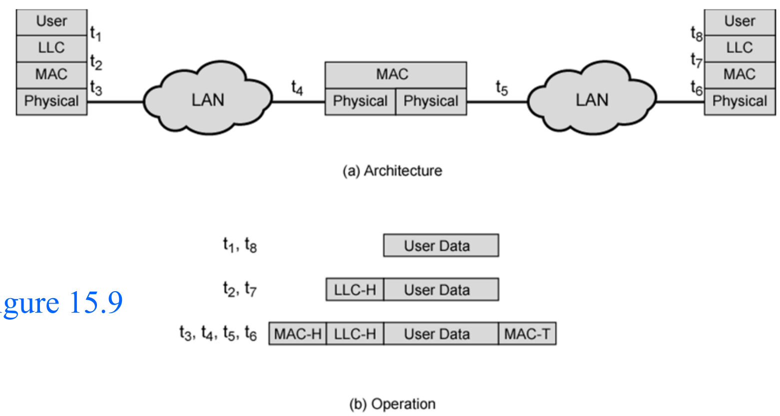
Bridge Design Aspects

- No modification to content or format of frame (for identical LANs)
- No encapsulation
- Exact bitwise copy of frame
- Minimal buffering to meet peak demand
- Bridging is transparent to stations
  - Appears to all stations on multiple LANs as if they are on one single LAN
- Collision does not propagate through bridge
- Contains routing and address intelligence
  - Must be able to tell which frames to pass
  - May be more than one bridge to cross
- May connect more than two LANs

Bridge Protocol Architecture

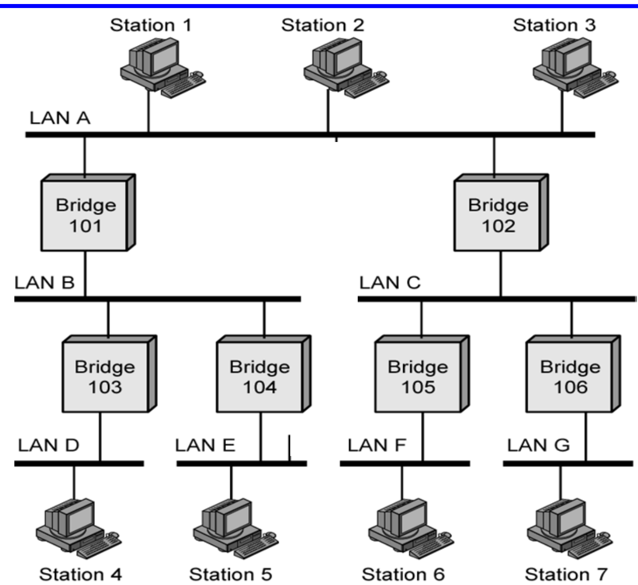
- IEEE 802.1D
- MAC level: station address is at this level
- Bridge does not need LLC layer: it is relaying MAC frames

Figure 15.9



LANs Connected by Bridges

Figure 15.10



Alternative routes may be possible

Repeaters, Hubs and Bridges

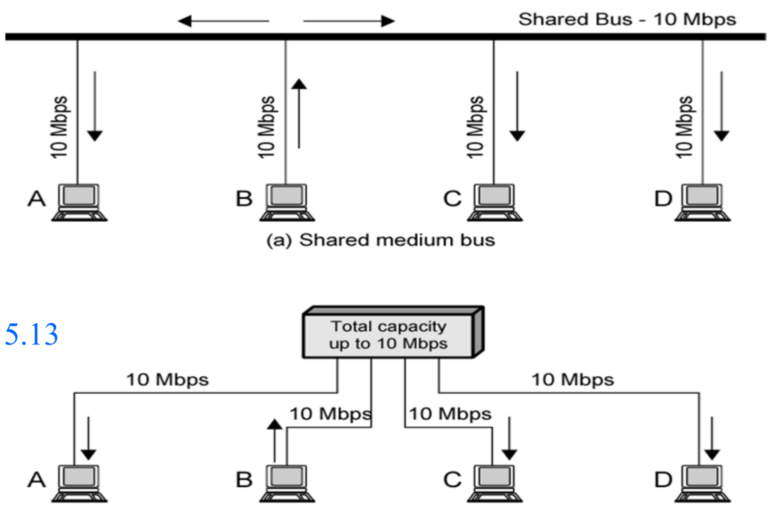
- Repeater: a device that restores data and collision signal
- Hubs: a multi-port repeater with collision detection
- Both a repeater and a hub
  - are physical devices, i.e. they function at the physical layer
  - a main function to extend the length of LAN and/or resolve wiring problem
- Bridges: a device that connects two LANs that use identical or similar protocols at physical layer and MAC sublayer
- Bridge uses MAC sublayer for relaying
  - Transparent bridge: a bridge that connect LANs with identical MAC protocols
  - Translation bridge: a bridge that connects LANs with different MAC protocols
  - Encapsulation bridge: two LANs some distance apart can be connected by two bridges that are in turn connected by communication facilities

Hubs

- Active central element of star layout
- Each station connected to hub by two lines (usually two unshielded twisted pairs
  - Transmit and receive
- Limited distances if high data rate and poor transmission qualities of UTP
- Optical fiber may be used for larger distances
- Physically star, logically bus
- Transmission from any station received by all other stations
- Hub acts as a repeater
- When single station transmits, hub repeats signal on outgoing line to each station (that is a header hub; an intermediate hub functions differently)
- If two stations transmit at the same time, collision

Shared Medium Bus and Hub

Figure 15.13

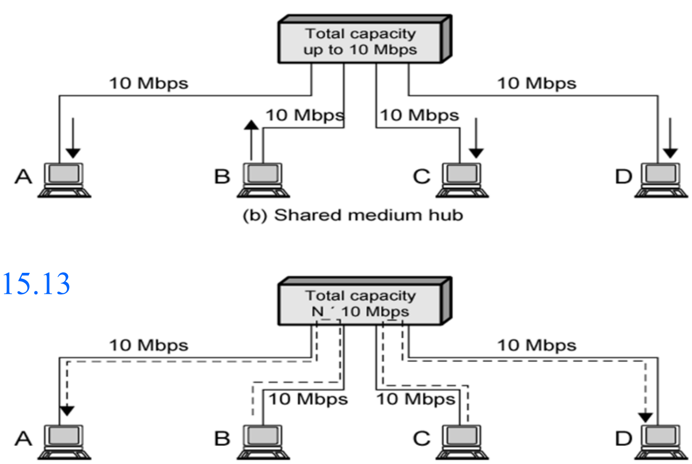


(a) Shared medium bus

(b) Shared medium hub

Shared Medium Hub and Layer 2 Switch

Figure 15.13



(b) Shared medium hub

(c) Layer 2 switch

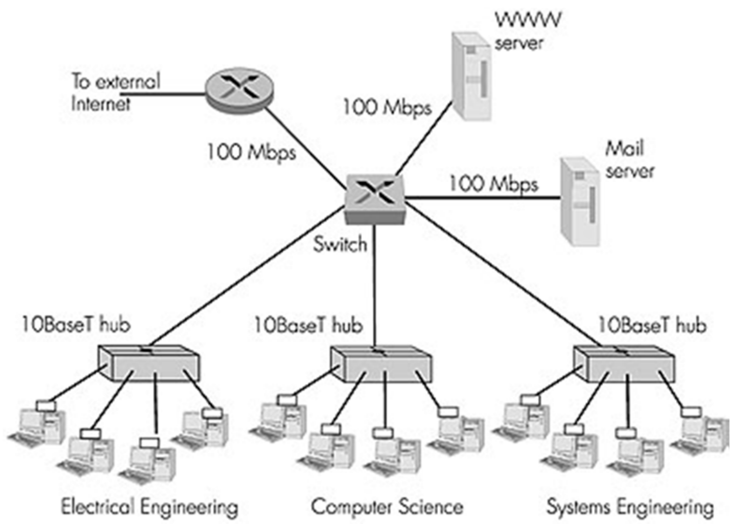
Layer 2 Switches

- Incoming frame from particular station switched to appropriate output line
- Relaying at MAC layer
- Unused lines can switch other traffic
- More than one station transmitting at a time
- Multiplying capacity of LAN
- No change to attached devices to convert bus LAN or hub LAN to switched LAN, e.g. for Ethernet LAN, each device still uses Ethernet MAC protocol
- Each device has dedicated capacity equal to original LAN, assuming switch has sufficient capacity to keep up with all devices
- A layer 2 switch can be thought as a multi-port bridge with each LAN having only one device; a layer 2 switch selectively forwards frames from one LAN port to another.

Types of Layer 2 Switches

- Store-and-forward switch
  - Accepts frame on input line
  - Buffers it briefly,
  - Then routes it to appropriate output line
  - Delay between sender and receiver
  - Boosts integrity of network
- Cut-through switch
  - Takes advantage of destination address appearing at beginning of frame
  - Switch begins repeating frame onto output line as soon as it recognizes destination address
  - Highest possible throughput
  - Risk of propagating bad frames, since switch unable to check CRC prior to retransmission

Ethernet Switches



d. xuan DataLink Layer 19

Ring and Star Topologies Usage

- Ring topology
  - Very high speed links over long distances
  - Used in MANs
  - Single link or repeater failure disables network
- Star topology
  - Uses natural layout of wiring in building
  - Best for short distances
  - High data rates for small number of devices

g. babic Presentation E 20

Choice of Topology and Medium

- Choice of topology influenced by:
  - — Reliability
  - — Expandability
  - — Performance
  - — Needs considering in context of:
    - Medium
    - Wiring layout
    - Medium access control
- Choice of medium constrained by:
  - — LAN topology
  - — Capacity
  - — Reliability
  - — Types of data supported
  - — Environmental scope

Aloha

- Used in packet radio network
- When station has frame, it sends
- Station listens (for maximum round trip time) plus small increment
- If frame OK and address matches receiver, send ACK
- Frame may be damaged by noise or by another station transmitting at the same time (collision)
- Frame check sequence (as in HDLC) detects error
- If ACK received, fine. If no ACK received, retransmit.
- If no ACK after repeated transmissions, give up

- Each station has to have different retransmission time out. Why? How?
- Any overlap of frames causes collision
- Max utilization 18% of channel capacity

Slotted Aloha

- Time in uniform slots equal to frame transmission time
- Need central clock (or other sync mechanism)
- Transmission begins at slot boundary
- Everything else as in Aloha
- Frames either miss or overlap totally
- Max utilization 37% of channel capacity

Values of P?

- If n stations waiting to send, at the end of transmission, expected number of stations attempting to transmit is
  - $n \times P$
- If $n \times P > 1$ then on average there will be a collision
- Repeated attempts to transmit almost guaranteeing more collisions, since retries compete with new transmissions
- Eventually, all stations trying to send
  - Continuous collisions; zero throughput
- So to void instability $n \times P < 1$ for expected peaks of n
- If heavy load expected, P small
- However, as P made smaller, stations wait longer
- At low loads, this gives very long delays

Binary Exponential Backoff

- In first 10 retransmission attempts, mean value of random delay doubled
- Value then remains same for 6 further attempts
- After 16 unsuccessful attempts, station gives up and reports error
- As congestion increases, stations back off by larger amounts to reduce the probability of collision.
- 1-persistent algorithm with binary exponential backoff efficient over wide range of loads
  - Low loads, 1-persistence guarantees station can seize channel once idle
  - High loads, at least as stable as other techniques
- Backoff algorithm gives last-in, first-out effect
- Stations with few collisions transmit first

100Mbps Ethernet Specifications

- Traditional Ethernet half duplex
- With full-duplex, station can transmit & receive simultaneously
  - Two physical links between nodes: transmission and reception
- 100-Mbps Ethernet (Fast Ethernet) uses full-duplex mode, theoretical transfer rate 200 Mbps, star topology, 100m links, 200m or 400m network spans
- 100BASE-TX uses two STPs or Cat. 5 UTPs
- 100BASE-FX uses two optical fibers
- 100BASE-T4 uses 4 Cat. 3 (low quality voice-grade) UTP;
  - Taking advantage of large installed base
  - Data stream split into three separate streams; Each with an effective data rate of 33.33 Mbps

10Gbit Ethernet Specifications

- 1Gbit or 10Gbit Ethernet uses full-duplex mode only
- Fiber links used
- 10GBASE-S (short):
  - 850 nm on multimode fiber and up to 300 m
- 10GBASE-L (long)
  - 1310 nm on single-mode fiber and up to 10 km
- 10GBASE-E (extended)
  - 1550 nm on single-mode fiber and up to 40 km
- 10GBASE-LX4:
  - 1310 nm on single-mode or multimode fiber and up to 10 km
  - Wavelength-division multiplexing (WDM) bit stream across four light waves