

Data Link Layer, Part 3

Medium Access Control

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Preface

- ❑ In our earlier discussion about DLL, we assumed that a link is associated with two nodes.
- ❑ When a link/medium is shared among many nodes, we need to resolve the conflicts of multiple nodes transmitting at the same time.
- ❑ This issue is addressed by a sublayer within the DLL: the **medium access control (MAC)** sublayer.

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Two Approaches of MAC

- ❑ Compete for the medium
 - ALOHA
 - Carrier Sense Multiple Access with Collision Detection (CSMA/CD)
- ❑ Wait for Your Turn
 - Token Passing Ring
 - Token Passing Bus
 - FDDI

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Carrier Sense Multiple Access (CSMA)

- ❑ Station listens to channel for ongoing transmissions.
- ❑ If so, the station waits until the channel is idle.
- ❑ When the channel is idle, the frame is transmitted.
- ❑ Collisions may still occur. How ?



- ❑ If a collision occurs, the station waits random amount of time and retransmits.
- ❑ The longer the propagation delay, the longer the window of collisions and the worse the performance.

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Collision Detection

- ❑ During a transmission, the station also listens to the channel and, if it detects collisions, it immediately aborts the transmission with a jamming signal.
- ❑ This reduces the wasted time due to collisions.
- ❑ In the worst case, how long does a station take to detect a collision ?

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Binary Exponential Backoff

- ❑ To determine the number of time slots to wait before re-sending:
 - On the first collision, wait either 0 or 1 slots.
 - On the second, wait 0, 1, 2, or 3 slots.
 - On the third, wait 0 to 7 slots.
- ❑ In general, after n collisions, wait anywhere from 0 to $2^n - 1$ slots, if $n \leq 10$; or between 0 and 1023 slots, if $n > 10$.
- ❑ After 16 collisions, give up and report that packet could not be sent.

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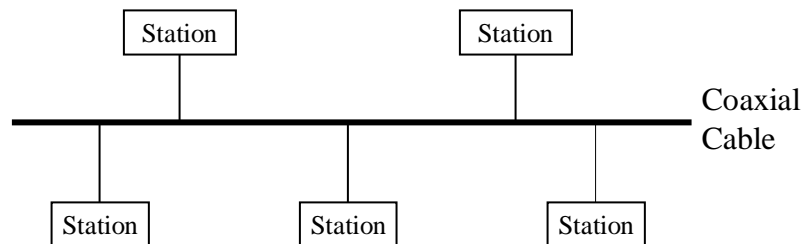
Ethernet

- ❑ A broadcast-based LAN technology using CSMA/CD
- ❑ The official standard is IEEE 802.3.
- ❑ The Ethernet technology comprises two parts:
 - a DLL/MAC layer that defines frame format, error detection, CSMA/CD parameters, etc.
 - a family of physical layer standards

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The “Classic” Ethernet



- ❑ 10 Mbps over coaxial cables
 - physical layer standard **10Base5** called “thick Ethernet”
 - standard **10Base2** called “thin Ethernet”

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10Base5

- ❑ each cable segment up to 500 meters
- ❑ 4 repeaters can be used to cascade 5 segments, resulting in a diameter 2,500 meters
- ❑ signal propagation delay in the cable is approximately 2×10^8 m/sec.
- ❑ each repeater introduces a $0.5 \mu\text{sec}$ delay
- ❑ the slot time in the exponential backoff algorithm is $51.2 \mu\text{sec}$, the transmission time of 64 bytes at speed 10 Mbps
- ❑ Manchester encoding

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10Base5 Continued

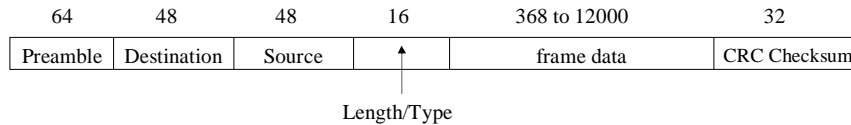
- ❑ enforce a minimum frame length of 64 bytes
 - Why ?



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Frame Format



□ Preamble:

- 7 10101010's followed by 10101011
- Marks the beginning of the frame and
- Establish understanding of “bit periods”

□ Source Address:

- 48 bits each; first 24 bits vendor ID;
second 24 bits assigned by the vendor
- all Ethernet addresses are globally unique

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□ Destination Address:

- due to the broadcast nature of Ethernet, every frame will be seen by the physical layer modules at all stations
- only the physical layer module at the destination station delivers the frame to its DLL layer
- this filtering is performed by hardware
- the destination address of all 1's is called the **broadcast address**; frames destined to the address will be delivered to the DLL modules of all stations

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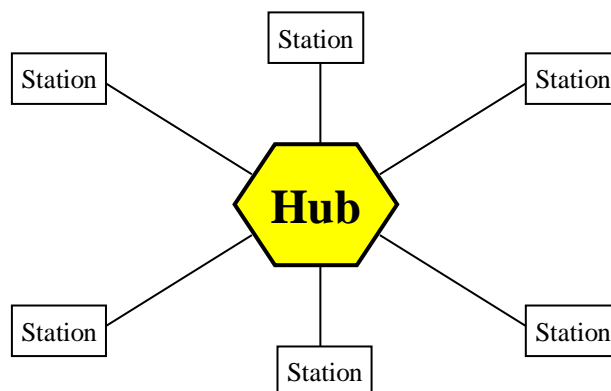
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- ❑ Length/Type:
 - If value < 1536 (0x0600), length of data
 - Otherwise, protocol type of data
 - ☞ 0x0800 for IP, 0x0806 for ARP, etc.
- ❑ Frame Data:
 - 46 to 1500 bytes
 - when necessary, this field is padded to 46 bytes, to ensure the 64-byte minimum frame length from destination address to checksum
- ❑ CRC Checksum
 - using the CRC-32 generator polynomial
- ❑ The frame ends with a HH bit period.

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10Base-T: Twisted-pair Ethernet



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- ❑ Uses twisted pairs as the physical medium.
- ❑ uses the star topology
- ❑ A hub is basically a multiway repeater; it relays incoming signals to all ports
 - This is still a broadcast technology

Fast Ethernet

- ❑ 100 Mbps
- ❑ use the original Ethernet MAC and format but operates at ten times the speed
- ❑ The network diameter is reduced by a factor of 10. Why ?
- ❑ Again, different physical layer standards support different transmission media:
 - 100Base-T and 100Base-T4 for twisted pairs
 - 100Base-F for fibers
- ❑ Use the star topology.

Gigabit Ethernet

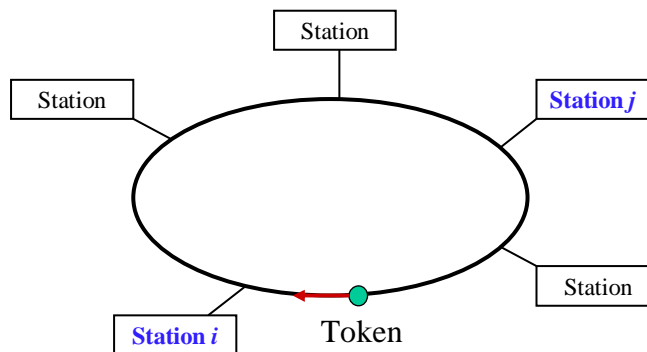
- ❑ 1 Gbps
- ❑ Basically the original Ethernet MAC and frame format operating at 100 times the speed.
- ❑ However, this extremely high speed forces two changes:
 - Frames padded to a minimum length of 4K bits.
 - Allows burst transmission: transmitting multiple frames once a station gains the “right of the road.”

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MAC Approach Two: Wait for Your Turn

- ❑ A token circulates among all stations.
 - the token is a miniature, 3-byte frame (including start and end flags)



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- ❑ When the token arrives, a station either seizes the token and sends a frame or passes the token to the next station.
- ❑ Assuming that station i has a frame f to send to station j .
- ❑ Station i waits for the arrival of the token and seizes the token.
- ❑ Station i sends f to station $i + 1$, which in turn passes f to station $i + 2$

- ❑ When frame f arrives at station j , station j picks up f and simultaneously forwards f to station $j + 1$.
- ❑ Eventually, f returns to station i , which passes the token, rather than f , to station $i + 1$

Discussion

- ❑ This is a broadcast-based technology because all stations see every frame.
- ❑ The forwarding of both the token and data frames is performed by NICs in hardware.
- ❑ Three token-based LAN technologies
 - 802.4 token bus
 - 802.5 token ring
 - Fiber Distributed Data Interface (FDDI)

Token-Based MAC vs CSMA/CD

- ❑ When the medium is quiet, a sending station
 - wastes no time in waiting with CSMA/CD
 - must wait for the arrival of the token with token-based approaches
 - thus, CSMA/CD outperforms token-based approaches in light traffic.
- ❑ Token-based MAC handles heavy loads better than CSMA/CD.
 - no waste of bandwidth due to collisions

- Moreover, token-based MAC has advantages in handling real-time traffic
 - **fairness**: stations access the medium in a round-robin manner
 - **bounded delays**: a station can predict the next time the token returns to it (in CSMA/CD, a station waits for a “random period of time” before retransmission)

A Word about LAN and MAC

- The Broadcast/MAC technologies discussed in this talk are inherently LAN technologies.
- However, the reverse is not always true; many LANs are based on switching .
 - ATM
 - switched Ethernet