Internet Protocols
Fall 2005

Lecture 6

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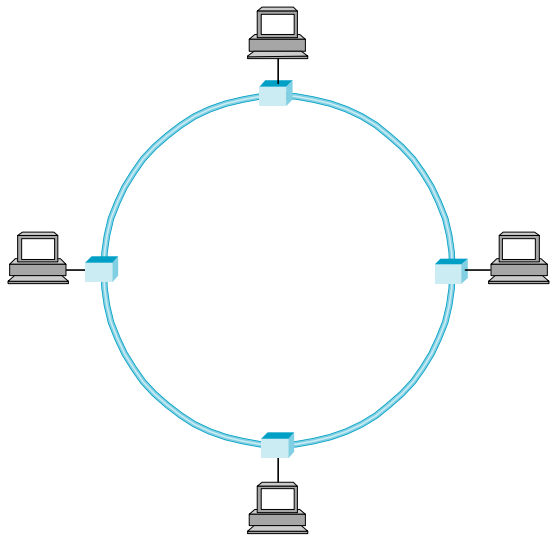
Outline

- MAC Protocols
  - Token Ring
  - 802.11
- Address Resolution Protocol (ARP)

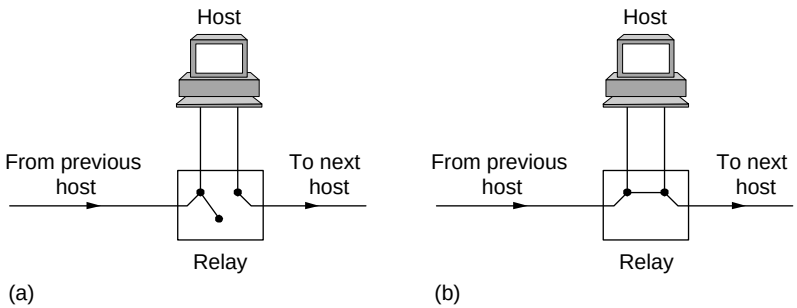
Token Ring Overview

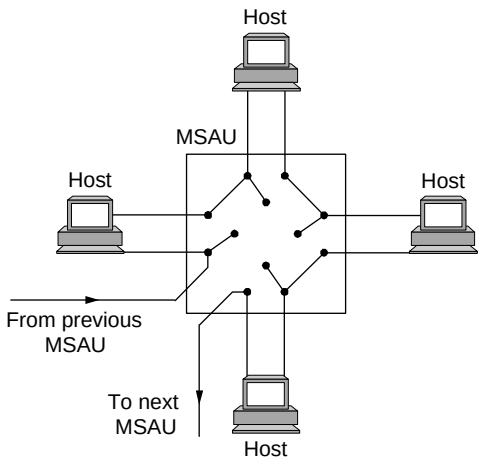
- Examples
  - 16Mbps IEEE 802.5 (based on earlier IBM ring)
  - 100Mbps Fiber Distributed Data Interface (FDDI)
  - Resilient Packet Ring MAN (802.17)



Token Ring (cont)

- Idea
  - Frames flow in one direction: upstream to downstream
  - special bit pattern (token) rotates around ring
  - must capture token before transmitting
  - release token after done transmitting
    - immediate release
    - delayed release
  - remove your frame when it comes back around
  - stations get round-robin service



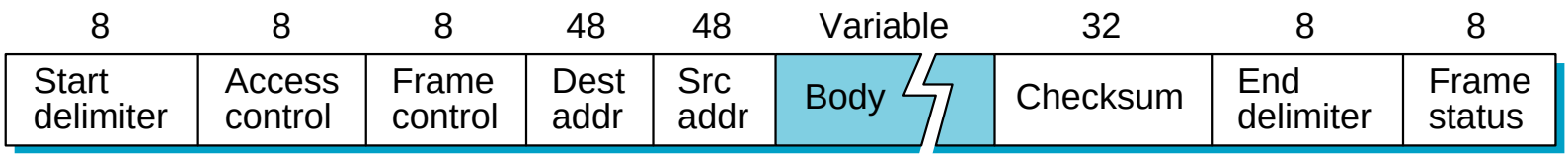


Timed Token Algorithm

- Token Holding Time (THT)
  - Upper limit on how long a station can hold the token
- Token Rotation Time (TRT)
  - Upper limit on how long it takes the token to traverse the ring
  - TRT <= ActiveNodes x THT + RingLatency

Additional Features

- Successful delivery notification
  - Frame returning to sending host contains ACK
- Different levels of service
  - Token contains *priority* field (3-bit)
  - Only frames with at least as high priority can be transmitted
  - Priority field is adjusted through reservation mechanism



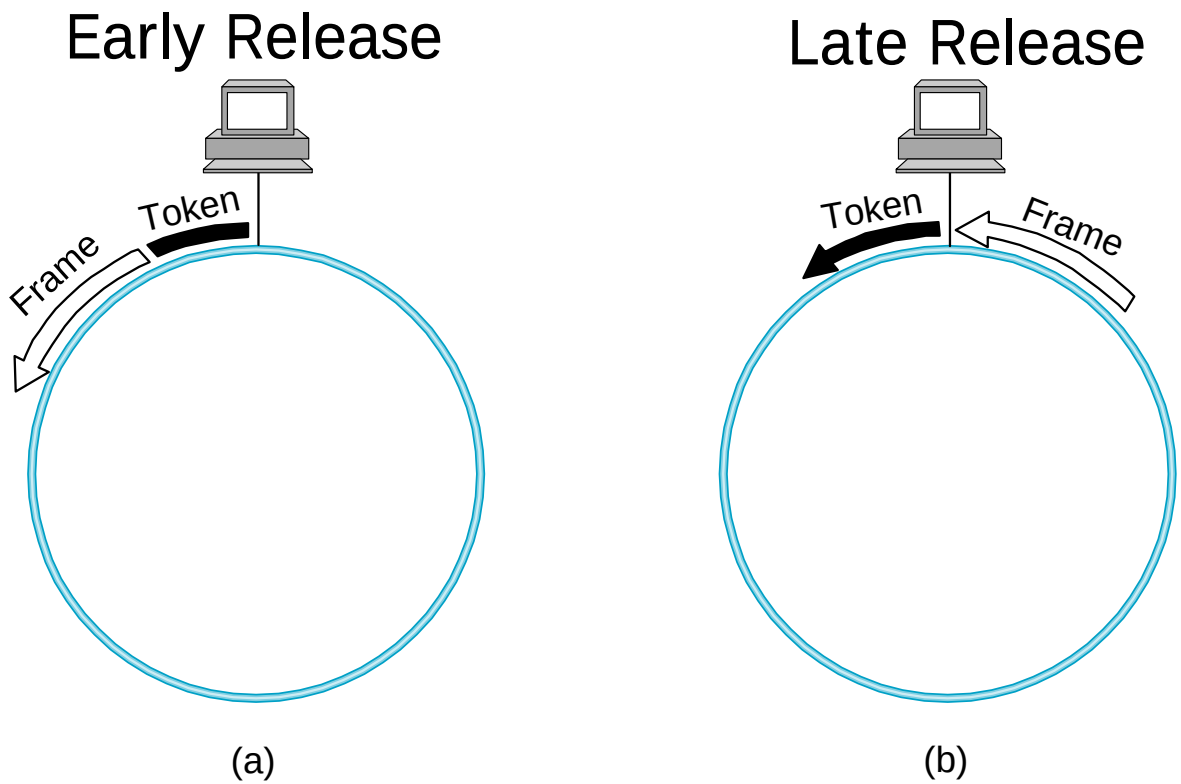
Token Maintenance

- Lost Token
  - No token when initializing ring
  - Bit error corrupts token pattern
  - Node holding token crashes
- Generating a Token (and agreeing on monitor)
  - Execute when join ring or suspect a failure
  - Send a claim frame that includes the node's MAC address
  - When receive claim frame forward if local MAC address smaller
  - If your claim frame makes it all the way around the ring:
    - Your are the ring monitor
    - You insert new token

Maintenance (cont)

- Monitor duties
  - Regenerate token if current one is destroyed
  - Remove corrupted or orphaned frames

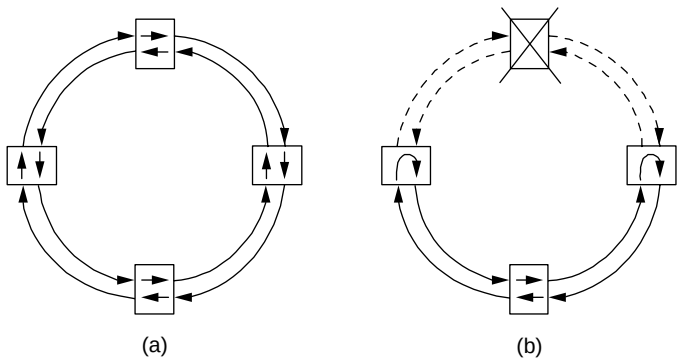
When to send token?



Relative advantages and drawbacks?

FDDI

- Physical Properties
  - 100 Mbps, commonly uses fiber (although CDDI exists)
  - Two independent rings that transmit data in opposite directions
  - Second ring is used only when primary ring fails
    - Tolerate failure of a stations or single cable break
  - 500 hosts max, 2 km between any pair of hosts, 100 km total network size



FDDI Algorithm

- Target Token Rotation Time (TTRT)
  - agreed-upon upper bound on TRT
- Each node measures TRT between successive tokens
  - if measured-TRT > TTRT: token is late so don't send
  - if measured-TRT < TTRT: token is early so OK to send
- Two classes of traffic
  - synchronous: can always send
  - asynchronous: can send only if token is early
- Worse case: 2xTTRT between seeing token
- Back-to-back 2xTTRT rotations not possible

Wireless LANs

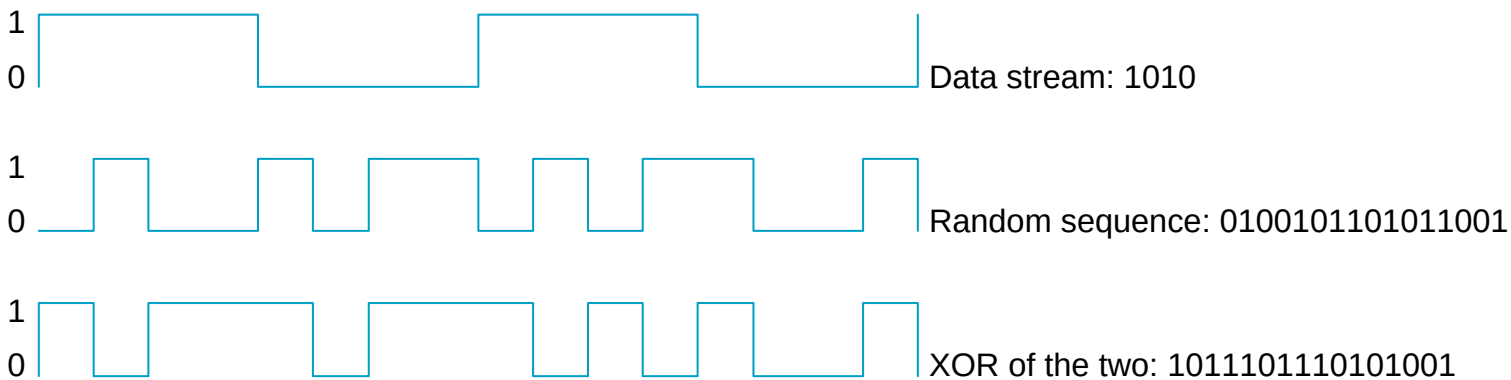
- IEEE 802.11
- Bandwidth: 1 - 54 Mbps
- Physical Media
  - Direct Sequence Spread Spectrum radio (2.4GHz, 5GHz for 802.11a)
  - diffused infrared (10m)

Spread Spectrum

- Idea
  - spread signal over wider frequency band than required
  - originally designed to thwart jamming
- Frequency Hopping
  - transmit over random sequence of frequencies
  - sender and receiver share...
    - pseudorandom number generator
    - seed
  - 802.11 uses 79 x 1MHz-wide frequency bands

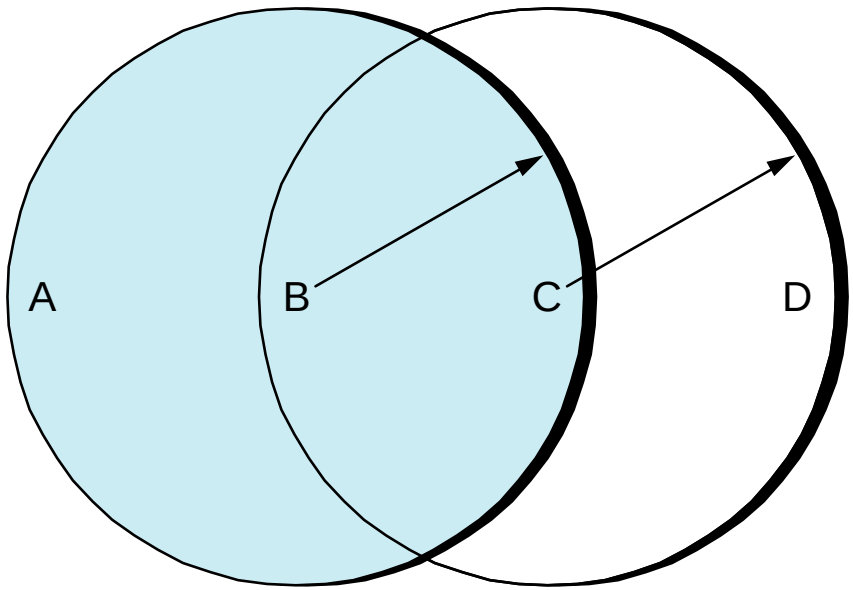
Spread Spectrum (cont)

- Direct Sequence
  - For each bit, send XOR of that bit and *n* random bits
  - Random sequence known to both sender and receiver
  - Called *n*-bit *chipping code*
  - 802.11 defines an 11-bit chipping code



Collisions Avoidance

- Similar to Ethernet
- Problem: *hidden* and *exposed* nodes

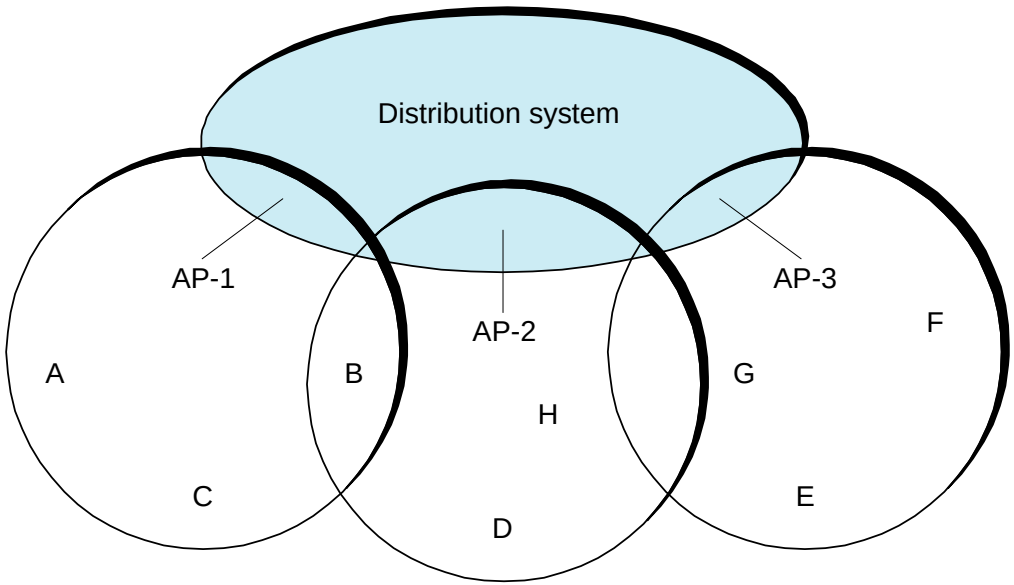


MACAW

- Sender transmits **`RequestToSend`** (RTS) frame
- Receiver replies with **`ClearToSend`** (CTS) frame
- Neighbors...
  - see CTS: keep quiet
  - see RTS but not CTS: ok to transmit
- Receive sends ACK when has frame
  - neighbors silent until see ACK
- Collisions
  - no collisions detection
  - known when don't receive CTS
  - exponential backoff

Supporting Mobility

- Case 1: *ad hoc* networking
- Case 2: *access points* (AP)
  - tethered
  - each mobile node associates with an AP



Mobility (cont)

- Scanning (selecting an AP)
  - node sends **`Probe`** frame
  - all AP's w/in reach reply with **`ProbeResponse`** frame
  - node selects one AP; sends it **`AssociateRequest`** frame
  - AP replies with **`AssociationResponse`** frame
  - new AP informs old AP via tethered network
- When
  - active: when join or move
  - passive: AP periodically sends **`Beacon`** frame

LAN Addresses and ARP

32-bit IP address:

- *network-layer* address
- used to get datagram to destination IP network (recall IP network definition)

LAN (or MAC or physical or Ethernet) address:

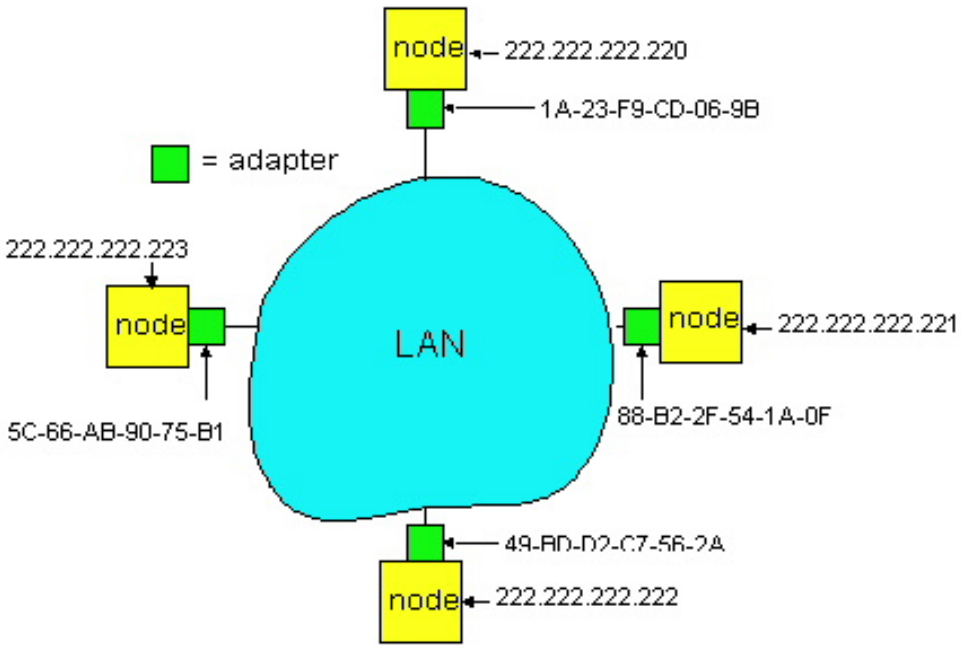
- used to get datagram from one interface to another physically-connected interface (same network)
- 48 bit MAC address (for most LANs)
  "burned" in the adapter EPROM

LAN Address (more)

- MAC address allocation administered by IEEE
- manufacturer buys portion of MAC address space (to assure uniqueness)
- Analogy:
  - (a) MAC address: like Social Security Number
  - (b) IP address: like postal address
- MAC flat address => portability
  - can move LAN card from one LAN to another
- IP hierarchical address NOT portable
  - depends on IP network to which node is attached

ARP: Address Resolution Protocol

Question: how to determine MAC address of B knowing B's IP address?



- Each IP node (Host, Router) on LAN has ARP table
- ARP Table: IP/MAC address mappings for some LAN nodes

  < IP address; MAC address; TTL>
  - TTL (Time To Live): time after which address mapping will be forgotten (typically 20 min)

ARP protocol

- A wants to send datagram to B, and A knows B's IP address.
- Suppose B's MAC address is not in A's ARP table.
- A broadcasts ARP query packet, containing B's IP address
  - all machines on LAN receive ARP query
- B receives ARP packet, replies to A with its (B's) MAC address
  - frame sent to A's MAC address (unicast)

- A caches (saves) IP-to-MAC address pair in its ARP table until information becomes old (times out)
  - soft state: information that times out (goes away) unless refreshed
- ARP is "plug-and-play":
  - nodes create their ARP tables without intervention from net administrator

ARP Protocol (II)

- Proxy ARP
  - Reply on behalf of another node
- Gratuitous ARP
  - Node sends ARP asking for its own IP address
    - Find out if address has been claimed
    - Change the mapping between MAC<->IP addr
- Do you see any problem with this?