Controlled Random Access Methods

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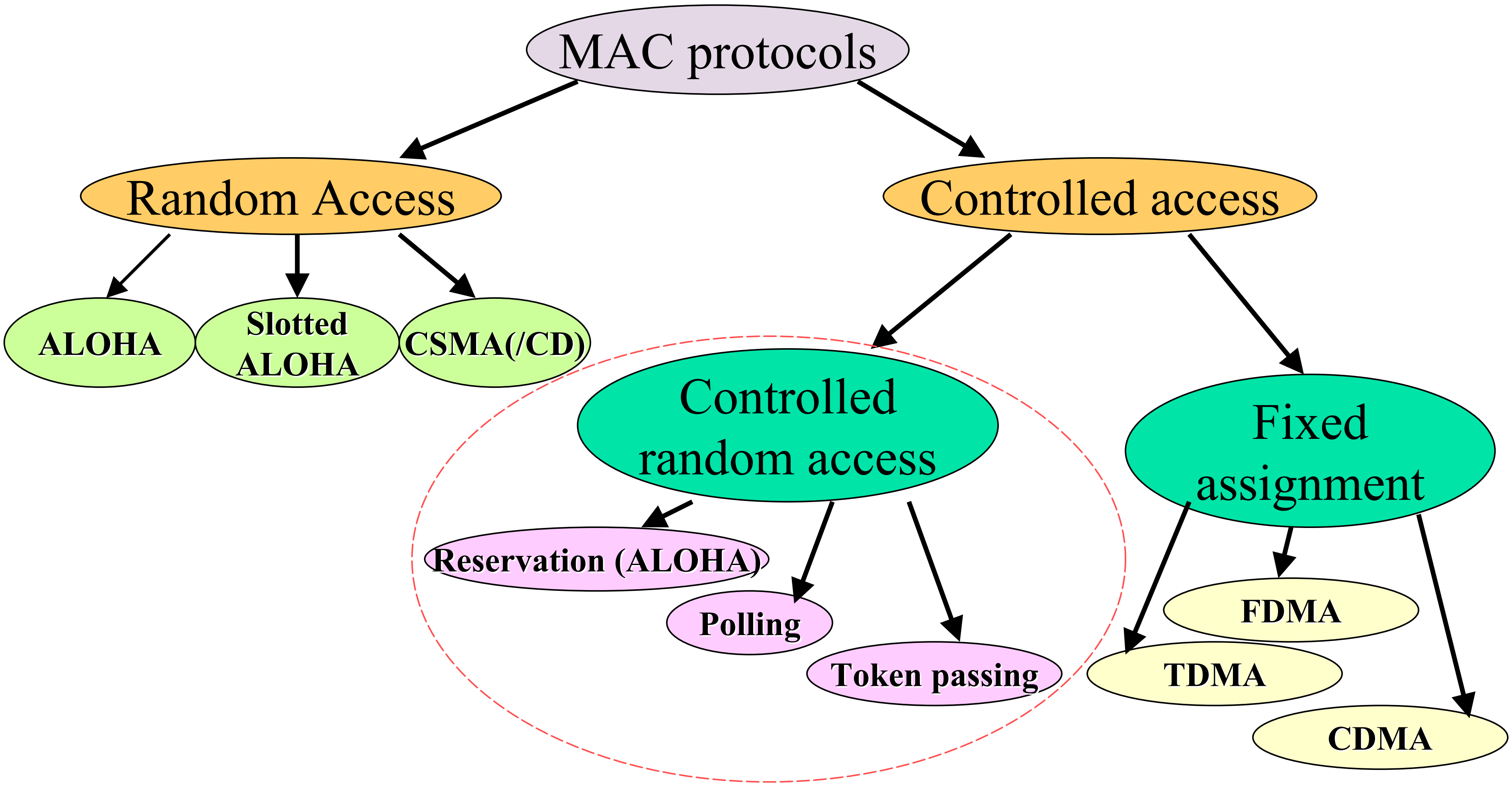
Content of Presentation

- Classification of MAC Protocols
- Motivations for controlled random access methods
- Controlled random access methods
  - Reservation Protocols
    - (Dynamic) R-ALOHA
    - Packet Reservation Multiple Access (PRMA)
  - Polling Techniques
    - Hub polling
    - Roll polling
  - Token Passing
    - Ring
      - FDDI
    - Bus

Classification of MAC Protocols



Motivations for Controlled Random Access

- Why not Fixed-assignment MAC protocols?
  - Efficient in steady flow of information
  - Resource wasting in bursty or intermittent transmission
- Why not Random-access MAC protocols?
  - Contention-based protocols
  - Flexible and efficient way for short message
  - Throughput: *ALOHA 37%*, *CSMA 50%* (Without capture effect)
  - High collisions in heavy traffic loads (Why: sender can't anticipate the collision)
- Why Controlled random access MAC protocols?
  - More control over access
  - Limited or free contention
  - Tradeoff between *Random-access* and *Fixed-assignment* access methods

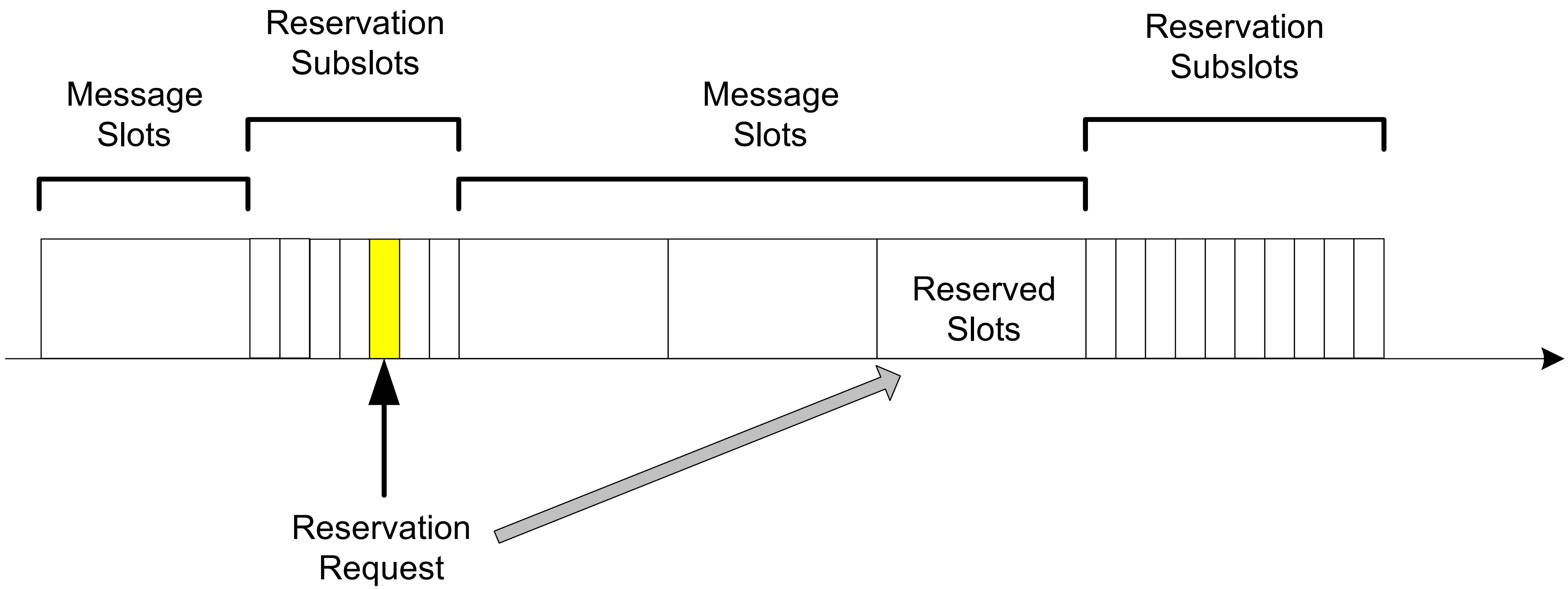
Controlled Random Access Methods

- Reservation Protocols
  - (Dynamic) R-ALOHA
  - Packet Reservation Multiple Access (PRMA)
- Polling Techniques
  - Hub polling
  - Roll polling
- Token Passing
  - Ring
    - FDDI
  - Bus

Reservation ALOHA

- R-ALOHA (Bit MAP)
  - Combination of Slotted-ALOHA & TDMA
  - Transmission time Vs traffic demand
  - Centralized control structure
- Applications:
  - Multi-user satellite system
  - Terrestrial radio system
  - WLAN
- R-ALOHA operation
  - Fixed frame length
  - Frame length >> longest propagation delay
  - Each frame is divided into equal-length slots
    - Reservation (sub) slots
    - Message slots
  - The number of message slots < the number of stations (in general)

Diagram of R-ALOHA



- Two operation modes
  - Unreserved mode
  - Reserved mode

Two operation models

- Unreserved mode
  - No message slots
  - Every slot is composed of reservation sub slots
  - Reservation request
  - Slotted ALOHA
  - Positive acknowledgement and slot assignment (single or multiple)
- Reserved mode
  - One frame
    - *One slot for reservation sub slots*
    - *Others for message slots, on reservation basis*
  - Only the station getting the reservation can send its packets
  - Reservation can be heard by all the stations
  - Sub slot number
    - *Small? --- low overhead*
    - *Large? --- accommodate the expected number of reservation requests*
    - *Reasonable choice: about 3 reservation sub slots / message slot*

Characteristics and Performance

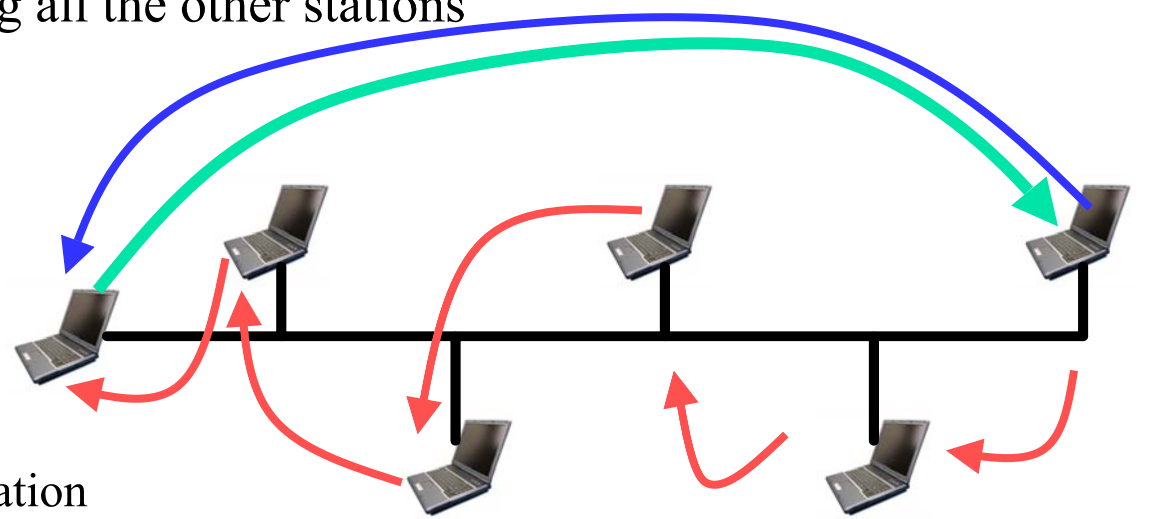
- Efficiently in handling bursty data traffic, and less contention then random access methods
- It also allows dynamic mixture of stream and bursty traffic
  - In bursty traffic ⟺ S-ALOHA
    - The performance is worse than S-ALOHA if the messages are one slot length
  - In stream traffic ⟺ TDMA
  - For high throughput, the R-ALOHA has good delay characteristic
- Station could be added or removed without affecting the mechanics of protocol
- Require queuing buffers
  - Keep the reservations for all the other stations
  - Slots at which its own reservation begins
  - *Queue length drops to zero, system switches to unreserved mode*
- If propagation delay is large, frame size could be excessive

Packet Reservation Multiple Access

- PRMA is closely related to R-ALOHA
- Centralized networks over short-range radio channels
- Integrate the voice and data service
- Frame rate is identical to the arrival rate of speech
- Each slot is either ”reserved” or ”available”
  - Reserved slots: only used by the user that reserved the slot
  - Available slots: can be used by any user that has information to transmit
- Terminals can send two types of information
  - Periodic: Voice packets and long unbroken data packets
  - Random: Isolated data packets

Polling Techniques (1)

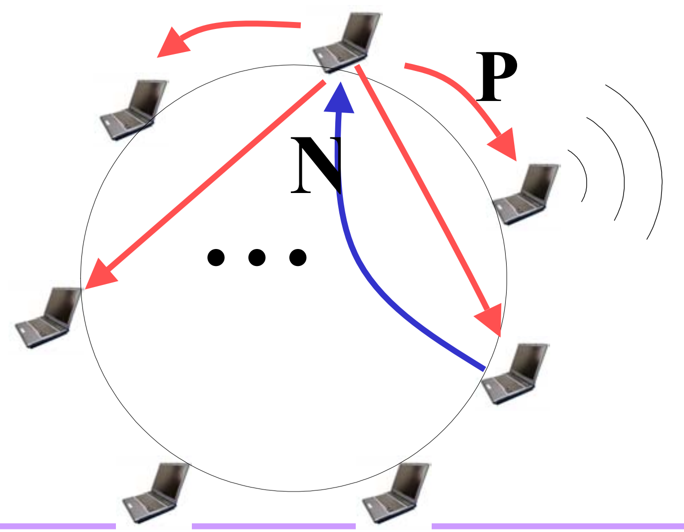
- Centralized control
  - One station is equipped as a controller
  - Periodically polling all the other stations
- Classification
  - Hub polling
  - Roll polling
- Polling procedure
  - Hub polling



    - From furthest station
    - Polled station starts sending if it has something to transmit
    - If not, a negative response is detected by the controller
    - The polled station transmits the poll message to its neighbor in upstream (control)
    - Control message finally is regained by the controller

Polling Techniques (2)

- Roll polling
  - Controller keeps a polling list, giving the order in which the terminals are polled
  - Polled station starts sending if it has something to transmit
  - If not, a negative reply is detected by the controller
  - Controller then polls the next terminals in the sequence
  - Initial exchange of short messages required (between a station and the controller)



Characteristics and performance

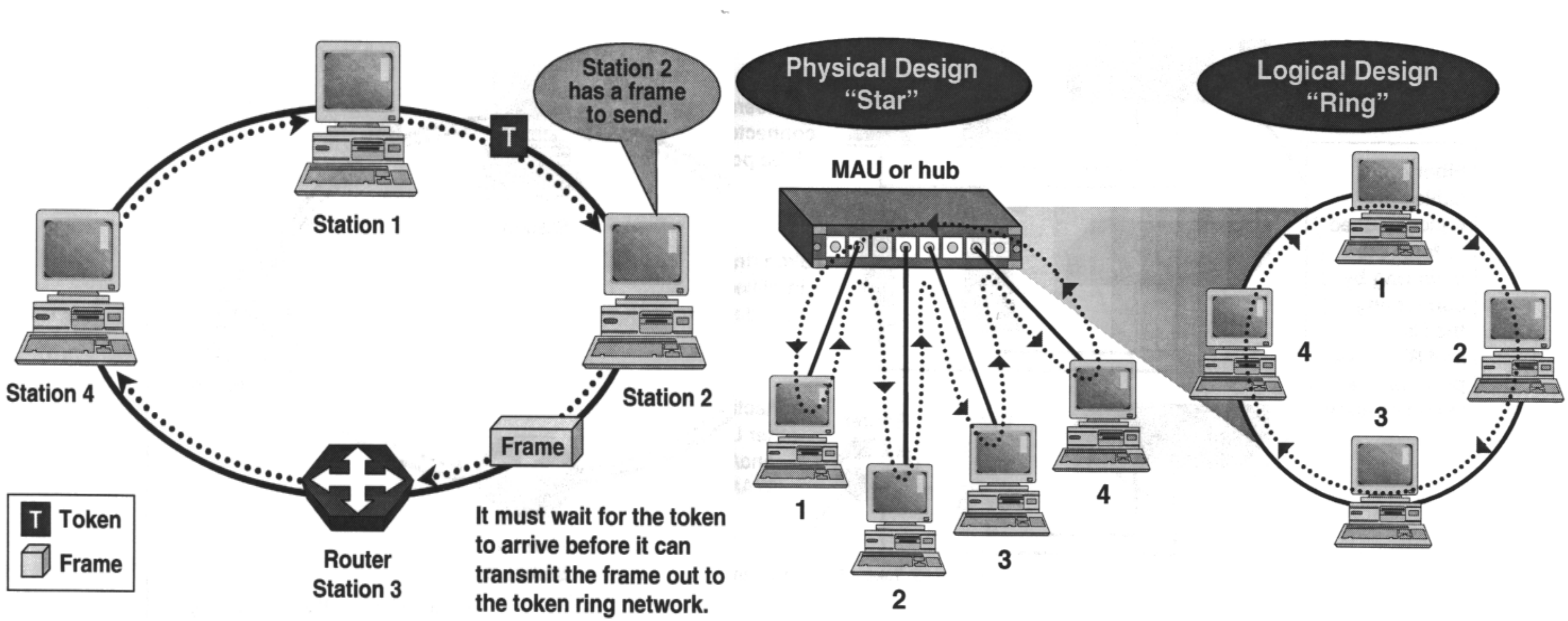
- Polling protocols are efficient in systems
  - Propagation delay is small
  - Overhead is low
  - Number of stations shouldn't be large (proportional to overhead)
- Polling protocols are inefficient
  - Lightly loaded
  - Part of stations have data to transmit
  - Subdivide stations into subsets (variations)
- Hub polling overhead is much smaller than that of roll polling
- Applications:
  - Widely used in dedicated telephone networks for data communications
  - Generally not been adopted in existing mobile data network or WLAN

Token Passing Protocol (1)

- Two logical topologies
  - Bus
  - Ring
- Token ring is originally developed by IBM, specified in IEEE 802.5
- Token ring protocol operation
  - Networks move a small frame, called a token, around the network
  - Possession of the token grants the right to transmit.
  - If the node, receiving the token, has no information to send, it passes the token to the next station.
  - If the node, possessing the token does have information to transmit
    - Seize the token
    - Alter 1 bit of the token
    - Append the information to be transmitted, and send to the next station in the ring
  - The intended destination station flips the recognized address and frame-copied bits in frame status field in the frame, and sends the modified frame back out to the ring

Token Passing Protocol (2)

  - When information reaches the sending station again, it examines and removed the frame from the ring
  - The source station then transmits a new token
- Physically ”star” topology, logically ”ring” topology



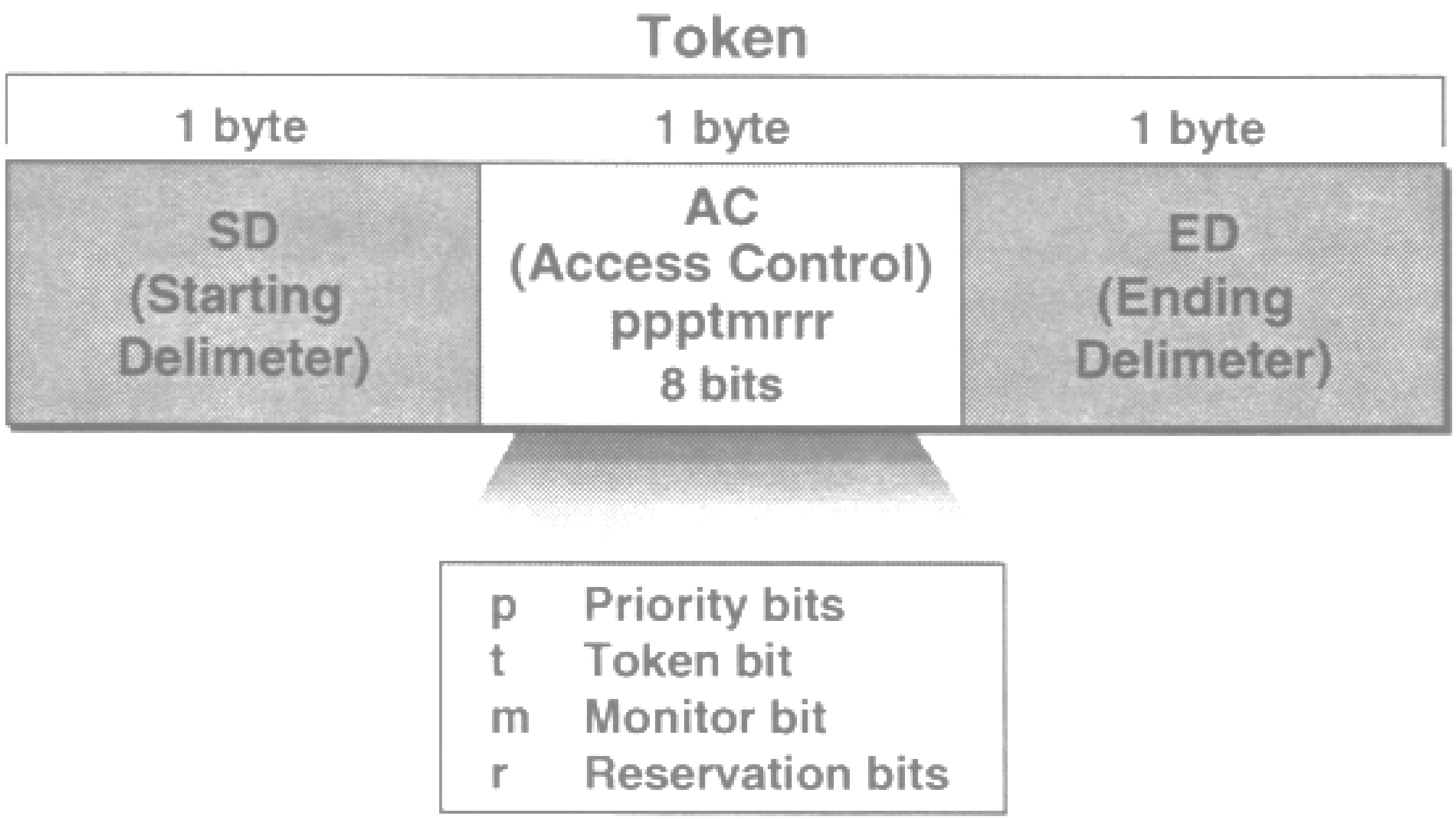
Token Ring Characteristics

- Token passing networks are deterministic, so the maximum propagation time is possibly calculated, more predictable than Ethernet
- Priority schemes can be deployed
  - User-designated, high priority station can use network more frequently
  - $Priority_{Station} >= Priority_{token}$ can capture the token
- Several mechanisms for detecting and compensating for network fault
  - One station is selected as *active monitor*
  - It provides centralized source of timing information for other stations
  - Ring-maintenance function
    - *Removal of continuously circulating frames*
    - *Generation of the new token*
- No collisions occur, contention-free!

IBM Token Ring *vs.* IEEE 802.5

	IBM Token Ring network	IEEE 802.5
Data rates	4.16 Mbps	4.16 Mbps
Stations/segment	260 (shielded) 72 (unshielded)	250
Topology	Star	Not specified
Media	Twisted pair	Not specified
Signaling	Baseband	Baseband
Access method	Token passing	Token passing
Encoding	Differential manchester	Differential manchester

Token Format (1)



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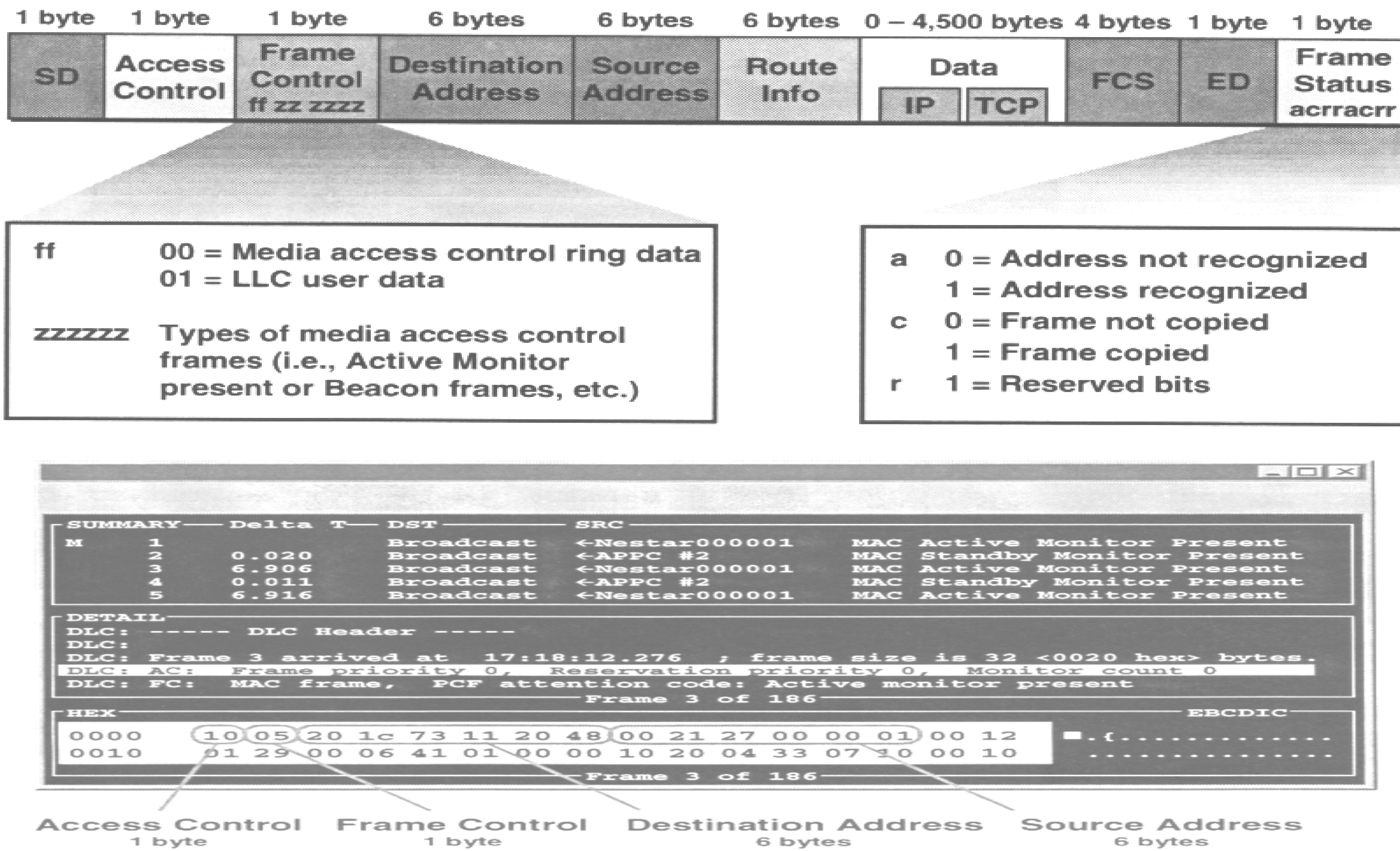
Token Format (2)

- SD (starting delimiter)
  - Identify the beginning of a transmission and for synchronization purpose
- The Access Control field
  - Priority field: at most *3 bits, ranging from 0-7*
  - Reservation field: *at least 3 bits*
  - Token bit
    - *Set to 0 if it is a token*
    - *Set to 1 if it is a data frame*
  - The monitor bit
    - *Set to 0 by the transmitting station*
    - *Set to 1 by the active monitor station*
    - *If the active monitor station sees the frame again, the frame is removed from the network*
- The ED (ending delimiter) – end of the frame

Token Ring Message Frame Format (1)



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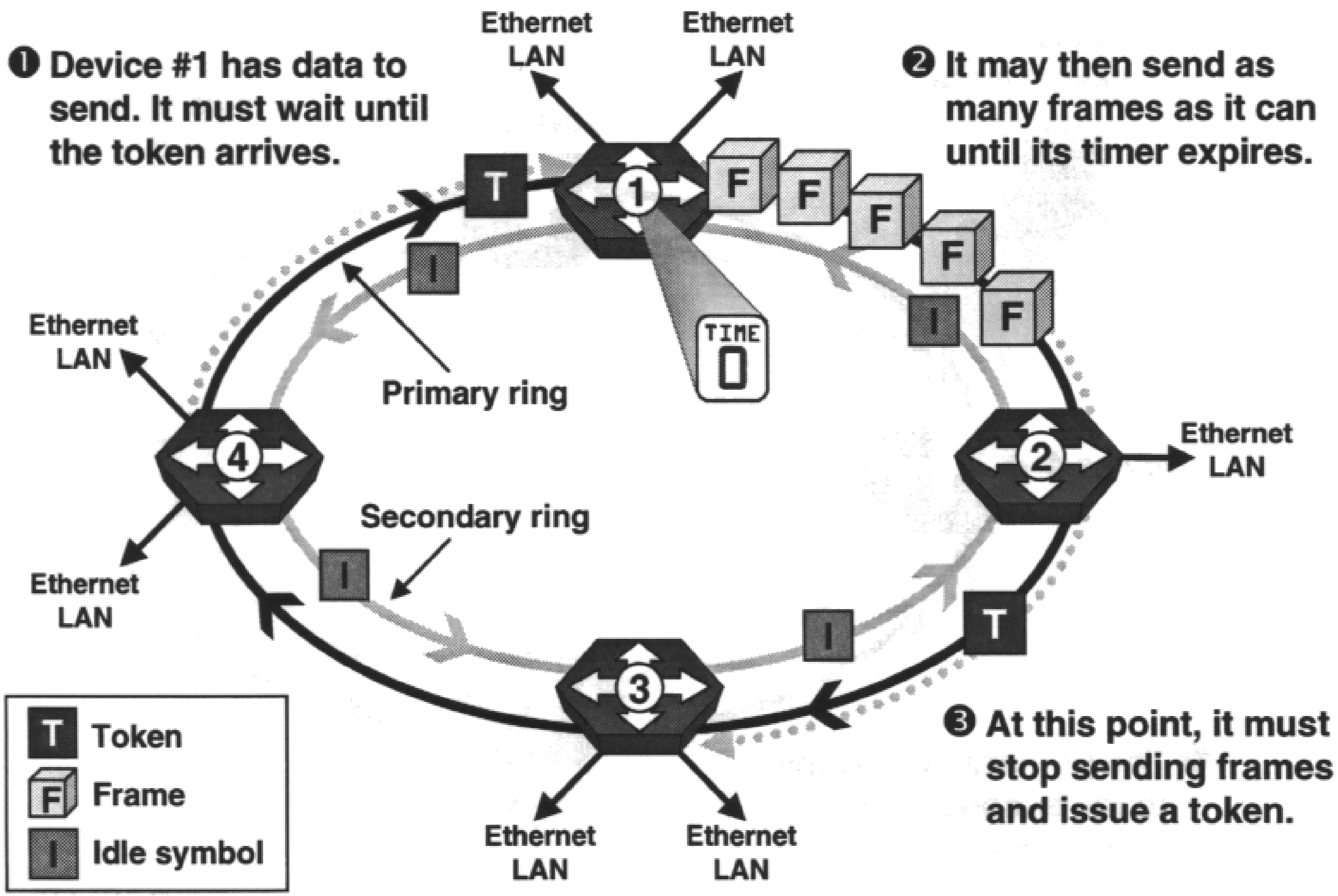
Token Ring Frame Format (2)

- The access control field is the same as the token format (the token bit is set to 1)
- The frame control field specifies the types of information
  - Control information
  - Data information
- The route info field is used in the network with multiple token ring LANS
- The data field contains the data (generally, the data is between 0 -4,500 bytes)
- The FCS (frame check sequence) is used to detect an error
- The FS (frame status) field us to indicate to the transmitter if the frame was copied by the intended destination

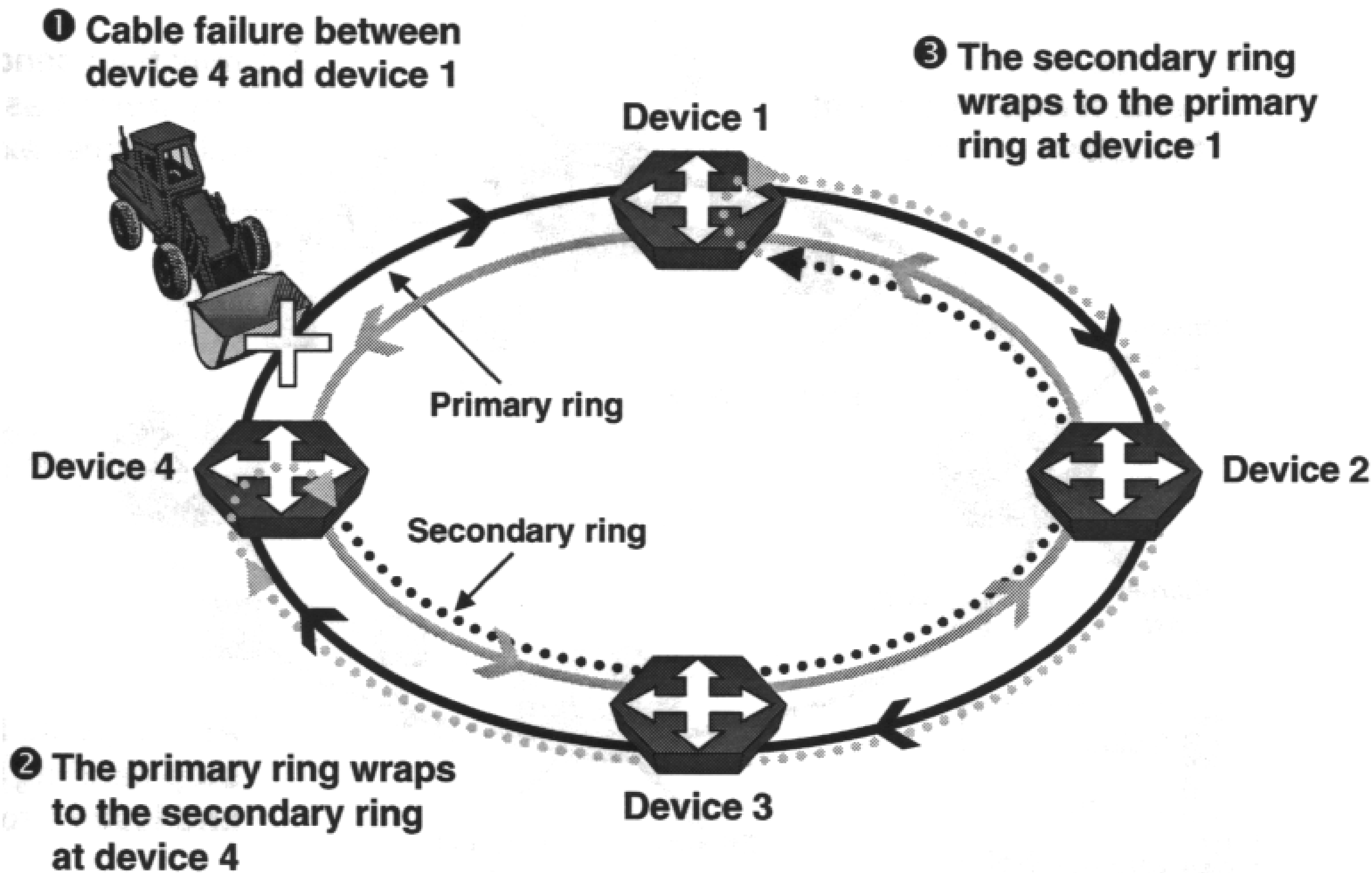
Token Ring Example ---- FDDI

- **FDDI (Fiber Distributed Data Interface)**
  - Developed by ANSI in mid 1980s
  - Serving as a backbone due to its high bandwidth and long transmission distance
  - 100 Mbps transmission
  - Up to 500 network attachments
  - Uses a token passing protocol
  - Dual ring topology (primary and secondary rings)
- Normal operation
  - The token and frames travel only on the primary ring in a single direction.
  - The secondary ring transmits idle signals in the opposite direction

FDDI Token Ring Protocol



FDDI Wrap Condition



FDDI Dual Ring Topology

- Wrap condition (Fault tolerance)
  - Cable or a device becomes disabled
  - The primary ring wraps back into the secondary ring
  - Fault tolerance is for single failure only
  - When two or more failures occur, ring segments into independent rings, that are incapable of communicating with each other

Token Bus Protocol

- IEEE 802.4
  - The network implements token passing protocol over bus topology
  - The token bus standard uses a linear topology more suitable for factory assembly lines.
  - The token bus standard does not specify the physical topology. When powered up, the station with the highest address has the right of the channel.
  - When the station has finished transmitting its data frame (if there is one), it sends a token frame specifically addresses to its successor.
  - Now the next station gets the token, and the channel. After finishing data transmission, the token is sent to the next station etc.

Summary

- Controlled random access methods
  - Reservation Protocols
    - (Dynamic) R-ALOHA
    - Packet Reservation Multiple Access (PRMA)
  - Polling Techniques
    - Hub polling
    - Roll polling
  - Token Passing
    - Ring
      - FDDI
    - Bus

Reference

[1] Kaveh Pahlavan & Allen H. Levesque, ”Wireless Information Networks,” John Wiley & Sons, inc 1995.

[2] Tin Yi Jang, ”Investigation of A Polling MAC Protocol with Capture Effect for Wireless LANs,” Master thesis, California State Polytechnic University, 2002 www.csupomona.edu/~cs/ms/thesis/TJang.doc .

[3] Web material, ”Token passing protocols” http://courses.csusm.edu/htm426jl/Lecture%20notes/3.%20Token%20Passing%20Protocols.ppt (07/03/2004).

[4] IEEE 802 website http://standards.ieee.org/getieee802/

Homework

- 1. Please list some systems using polling access methods
- 2. What is CDDI? How it works? Please give a detailed description on its MAC protocol operation.

Any questions?

Thanks!