

Local Area Networks (LANs)

Token Ring (IEEE 802.5)
FDDI

Ring Local Area Network

The diagram illustrates a Ring Local Area Network topology. On the left, a circular ring is formed by four red square nodes, each connected to a gray square station. A blue arrow points to one of the red nodes with the label "Ring interface (1-bit buffer)". On the right, a detailed view of a station interface is shown as a red rectangle with a white square in the center. A horizontal arrow enters from the left and exits to the right, passing through the white square. A vertical arrow points down from the bottom of the rectangle, labeled "To station" in red. Another vertical arrow points up from the bottom of the rectangle, labeled "From station" in red. The top edge of the rectangle is labeled "Ring interface".

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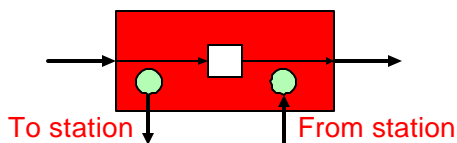
Ring LANs

- The ring is a series of bit repeaters, each connected by a unidirectional transmission link
- All arriving data is copied into a 1-bit buffer and then copied out again (1-bit delay)
- Data in the buffer can be modified before transmission
- Ring interface can be in one of three states:
 - Listen State
 - Transmit State
 - Bypass State

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States of the Ring Interface

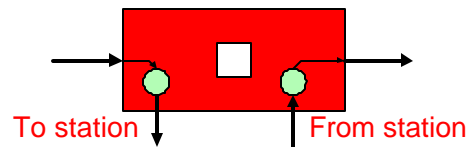
- **Listen State:** Incoming bits are copied to output with 1-bit delay



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States of the Ring Interface

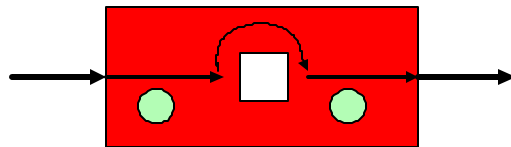
- **Transmit State:** Write data to the ring



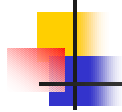
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States of the Ring Interface

- **Bypass State:** Idle station does not incur bit-delay



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Who Removes the Frame?

- If a frame has traveled once around the ring it is removed by the sender
- Ring LANs have a simple acknowledgment scheme:
 - Each frame has one bit for acknowledgment.
 - If the destination receives the frame it sets the bit to 1.
 - Since the sender will see the returning frame, it can tell if the frame was received correctly.

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What is the 'Length' of a Ring?

- The length of a ring LAN, measured in bits, gives the total number of bits which can be in transmission on the ring at a time
- Note: Frame size is not limited to the "length" of the ring since entire frame may not appear on the ring at one time.
- Bit length = $(\text{length} / \text{propagation speed}) \cdot \text{rate} + \text{No. of stations} \cdot \text{bit delay at repeater}$

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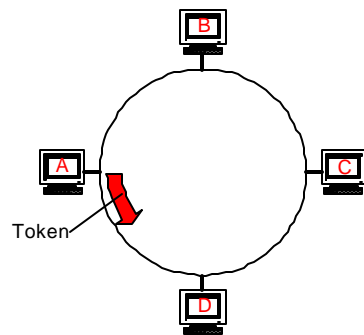
Example:

- Calculate the bit length of the following ring LAN:
 - 3 km ring
 - 1 Mbps data rate
 - 5 μ s/km propagation speed
 - 20 stations @ 1 bit delay

- Bit length =

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The Token



- Token is a small packet that rotates around the ring
- When all stations are idle, the token is "free" and circulates around the ring
- **Possible Problem:** All stations are idle and in the Bypass state. What is the problem?

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Token Ring MAC Protocol (802.5)

- In order to transmit a station must catch a “free” token
- The station changes the token from “free” to “busy”
- The station transmits its frame immediately following the busy token
- IF station has completed transmission of the frame AND the busy token has returned to the station THEN station inserts a new free token into the ring

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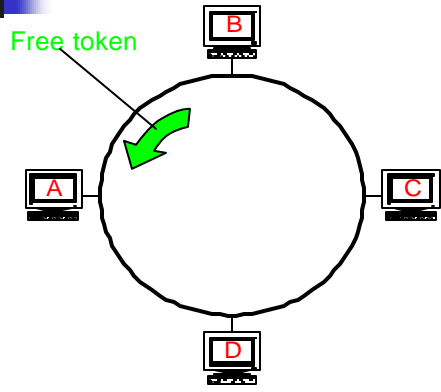


Token Ring MAC Protocol (802.5)

- Note:
 - If the bit length of the ring is less than the packet length, then the completion of a packet transmission implies return of busy token
 - Only one station can transmit at a time. If a station releases a free token, the next station downstream can capture the token

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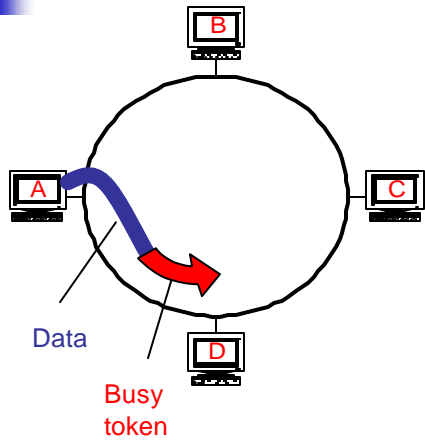
Transmission in a Token Ring



- Sender looks for free token

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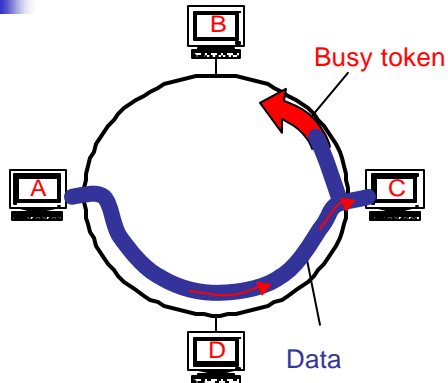
Transmission in a Token Ring



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

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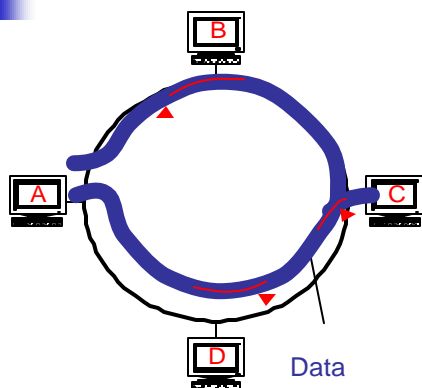
Transmission in a Token Ring



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

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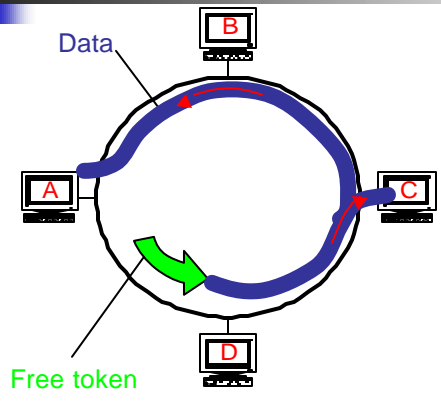
Transmission in a Token Ring



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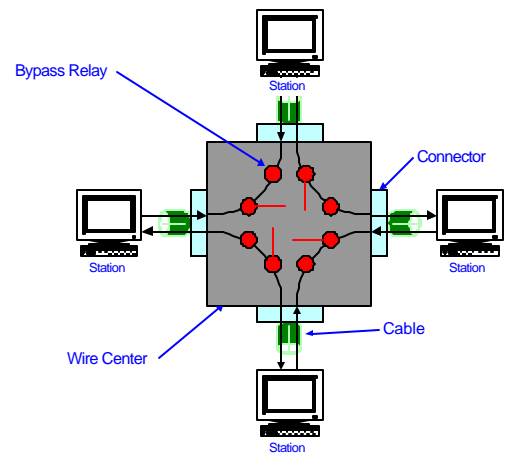
Transmission in a Token Ring



Sender generates free token when it is done transmitting (Note: The busy token has returned)

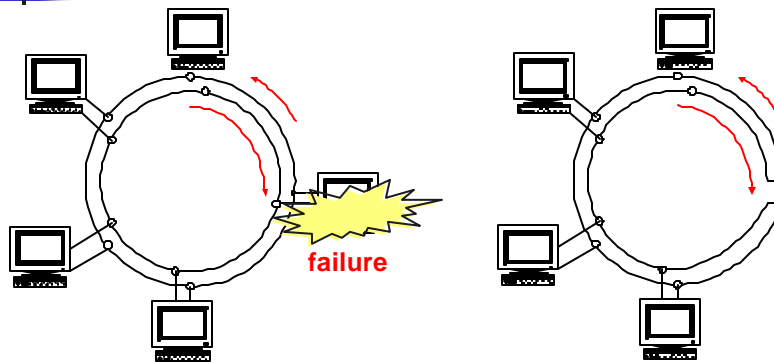
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Improving Reliability: Wire Center (802.5)



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Improving Reliability: Use a second ring

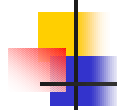


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Priority of Transmission in 802.5

- Eight levels of priorities
 - Priorities handled by 3-bit priority field and 3-bit reservation field
 - Define:
 - P_m = priority of the message to be transmitted
 - P_r = token priority of received token
 - R_r = reservation priority of received token

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Prioritizing Ring Access

1. A station wishing to transmit a frame with priority P_m must wait for a free token with $P_r \leq P_m$
2. The station can reserve a future priority- P_m token as follows:
 - If busy token comes by, then set $R_r \leftarrow P_m$ (if $R_r < P_m$)
 - If free token comes by, then set $R_r \leftarrow P_m$ (if $R_r < P_m$ and $P_m < P_r$)

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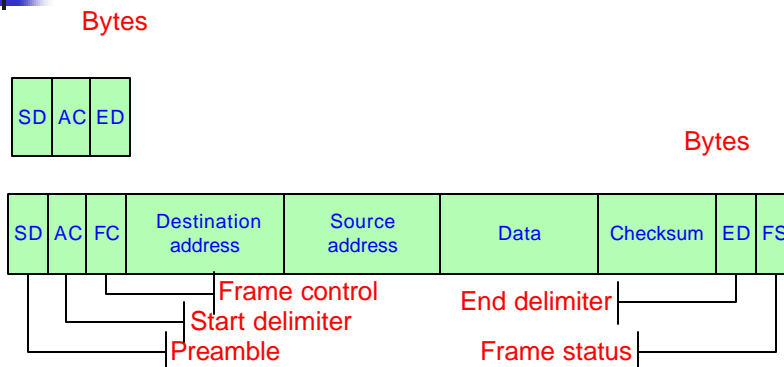


Prioritizing Ring Access

3. If a station gets a free token, it sets the reservation field to "0", and leaves the priority field unchanged and transmits
4. After transmission send a free token with
 - Priority = $\max(P_r, R_r, P_m)$
 - Reservation = $\max(R_r, P_m)$
5. Station which upgraded the priority level of a token must also downgrade the priority (if no one used the token)

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Token Format / Data Frame Format:



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IEEE 802.5 Frame Format

- One 3-byte token circulates if all stations are idle.
 - AC = "PPPTMRRR" where
 - "PPP" Priority fields
 - "RRR" Reservation fields
 - "T" Indicates "Token" or "Data frame"
- SD, ED: Start/End delimiter of a frame
- FC: Identifies type of a control frame
- FS: Contains address recognized bit (A bit) and frame copied bit (C bit)
 - Receiver sets A=1 when frame arrives
 - Receiver sets C=1 when frame has been copied

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Ring Maintenance

- Token ring selects one station as the monitor station
- Duties of the monitor:
 - Check that there is a token
 - Recover ring if it is broken
 - Detect garbled frames
 - Make sure the token (24-bit) is shorter than the ring length

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FDDI (Fiber Distributed Data Interface)

FDDI

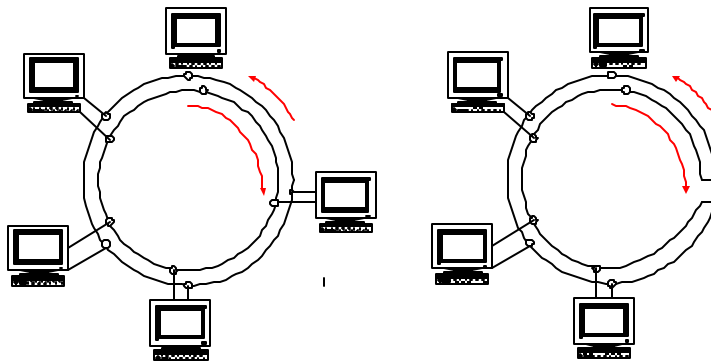
■ Some Facts:

- ANSI and ISO standard
- FDDI is a 100 Mbps token ring
- Dual redundant counter rotating ring topology
- Multimode fiber
- Maximum frame size is 4500 bytes
- Allows up to 1000 connected stations
- Maximum ring circumference 200 km

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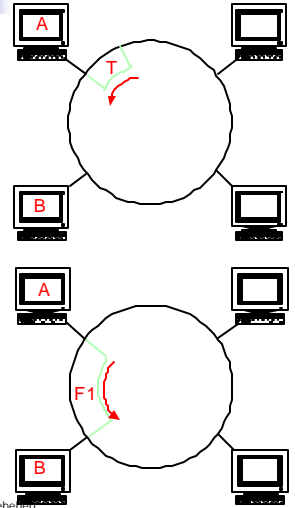
FDDI Topology: Dual Counter Rotating Ring

- Second ring adds a certain level of fault tolerance



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FDDI Token Ring Protocol

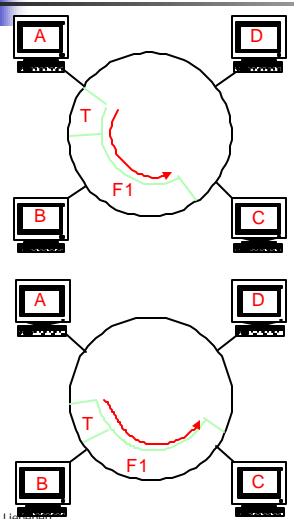


1. A awaits token

2. A seizes token, begins transmitting frame F1 addressed to C

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FDDI Token Ring Protocol

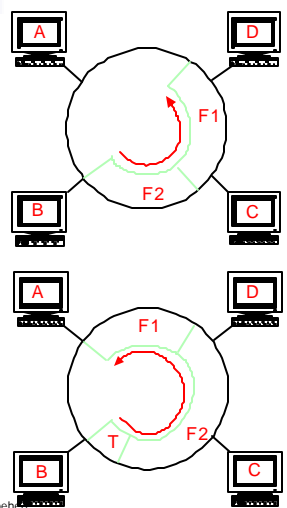


3. A appends token to end of transmission

4. C copies frames F1 as it goes by

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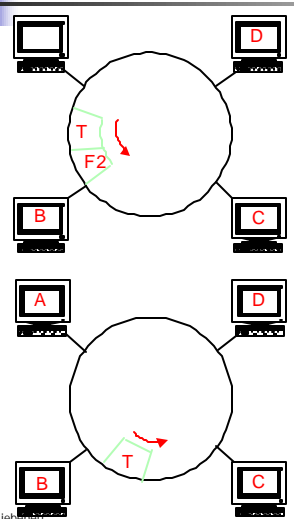
FDDI Token Ring Protocol



5. C continues to copy F1; B seizes token and transmits frame F2 addressed to D
6. B emits token; D copies F2; A absorbs F1

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FDDI Token Ring Protocol

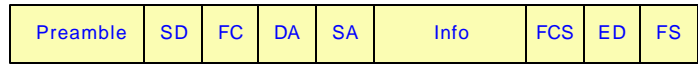


7. A lets F2 and token pass; B absorbs F2
8. B lets token pass

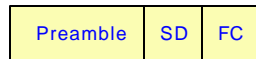
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Frame and Token Format



General Frame Format



Token Frame Format

- SD Starting Delimiter
- FC Frame Control (type of frame)
- DA Destination Address
- SA Source Address
- FCS Frame Check Sequence (CRC)
- ED End Delimiter
- FS Frame Status
- Total Frame length \leq 4500bytes

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Timed Token Protocol

- FDDI uses a timed token protocol which determines how long a station can transmit
- Each station has timers to measure the time elapsed since a token was last received
- TTRT: Target Token Rotation Time
 - Value of TTRT is negotiated during initialization (default is 8 ms)
 - Set to the maximum desired rotation time

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Parameters of Timed Token Protocol

- Each station has two timers:
 - TRT (Token Rotation Time)
 - Time of the last rotation of the token.
 - If $TRT < TTRT$, then token is "early", asynchronous traffic can be transmitted
 - If $TRT > TTRT$ then token is "late", asynchronous traffic cannot be transmitted.
 - THT (Token Holding Time)
 - Controls the time that a station may transmit asynchronous traffic.
 - f_i Percentage of the TTRT that is allocated for synchronous traffic at station i .

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Timed Token Protocol

- If a station receives the token it sets
 - $THT := TRT$
 - $TRT := TTRT$
 - Enable TRT (i.e., start the timer)
- If the station has synchronous frames are waiting the transmit synchronous traffic for up to time $TTRT \cdot f_i$ (with $\sum f_i < 1$)
- If the station has asynchronous traffic
 - enable THT
 - while $THT > 0$ transmit asynchronous traffic.

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