

CPS 422  
Computer Networks

DATA LINK LAYER  
IEEE 802.4 (TOKEN BUS)  
AND IEEE 802.5 (TOKEN RING)  
STANDARDS

TEXT BOOK:- Andrew S. Tenenbaum 3<sup>rd</sup> Edition

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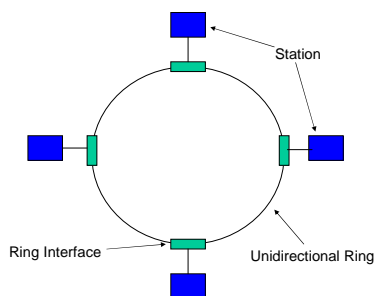
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IEEE 802.5 (TOKEN RING)  
STANDARD

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A Token Ring Layout

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TOKEN RING

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- ❑ Ring is not a broadcast medium but a collection of point-to-point links forming a circle
- ❑ Rings can be based on twisted pair, coaxial or a fiber optics cable
- ❑ Fair operation with an upper bound on channel access
- ❑ Channel access problem is solved with the help of a special frame called a "Token"
- ❑ Also, shutting down of stations should not impair ring functionality

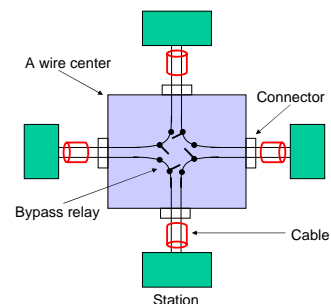
TOKEN RING

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- ❑ Bits of the frame that have traversed the ring must be removed from the ring by the sender
- ❑ Since the entire frame does not appear on the ring at one time, **there is no limit on frame size. It only needs to be pre-decided.** The only limit is the **token holding time.**
- ❑ Acknowledgements are sent by the receiver in the same received frame, by setting an Acknowledgement bit in the received frame.

Four Stations connected to a wire center

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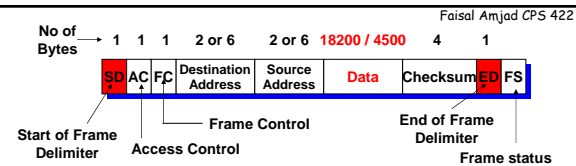
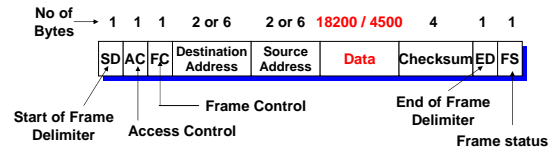
## USE OF WIRE CENTERS

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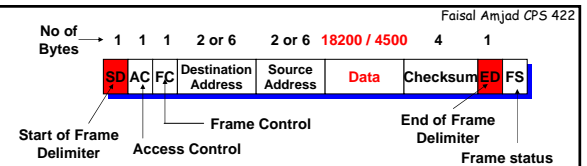
- ❑ Cable breaks can lead to ring failure
- ❑ This problem can be resolved with the help of a **Wire Center**.
- ❑ A wire center has bypass relays which draw current from the station
- ❑ If a station is powered down the relays close thereby removing the station from the ring and maintaining the ring
- ❑ Relays can be operated by software for network management
- ❑ wire centers make the ring a **star-shaped ring**.

## 802.5 FRAME FORMAT

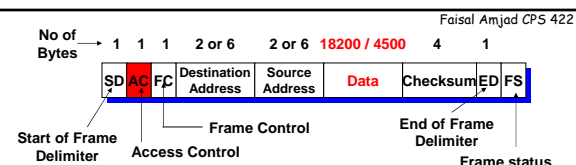
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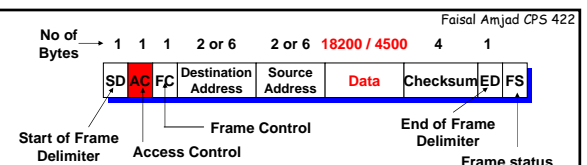
- ❑ Mark the frame boundaries
- ❑ Contain analog encoding of symbols **other than 0s and 1s (code violations)**
- ❑ So it **cannot** accidentally occur in data
- ❑ End delimiter contains two special bits
  - One to mark an error in frame (E bit)
  - Other to mark the last frame of a logical sequence



- ❑ J,K,0,J,K,0,0,0 are bits of Start Delimiter, where J and K are "code violations"
- ❑ J,K,1,J,K,1,I,E are bits of End delimiter, where I represents the last frame of a sequence of transmissions and E represents an error in the frame



- ❑ Contains **token, monitor, priority and reservation** bits
- ❑ Changing the token bit changes a token frame into the first three bytes of a data frame
- ❑ Monitor bit is used for ring maintenance
- ❑ Priority bits give the current priority of token
- ❑ To transmit a frame of priority n, a station has to capture a token of priority less than or equal to n.
- ❑ In a passing-by data frame, any station can try to reserve the next token, by writing the priority of its frame in the data frame's reservation bits.



- ❑ bits (MSB to LSB): 0-2 | 3 | 4 | 5-7
- ❑ Purpose: Priority | Token | Monitor | Reservation
- ❑ When it is a token (token bit=0) Reservation bits have no meaning, since reservation bits are used for "booking" future claim as per priority of frames to be sent

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No of Bytes	1	1	1	6	6	18200 / 4500	4	1
	SD	AC	FC	Destination Address	Source Address	Data	Checksum	ED FS
	Start of Frame Delimiter	Access Control	Frame Control				End of Frame Delimiter	Frame status

- Used to distinguish data and control frames
- MSB '00' : MAC Control frame
- MSB '01' : LLC Control frame
- MSB '1x' : Undefined, Reserved

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No of Bytes	1	1	1	2 or 6	2 or 6	18200 / 4500	4	1
	SD	AC	FC	Destination Address	Source Address	Data	Checksum	ED FS
	Start of Frame Delimiter	Access Control	Frame Control				End of Frame Delimiter	Frame status

- Identical to 802.3 addressing

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No of Bytes	1	1	1	2 or 6	2 or 6	18200 / 4500	4	1
	SD	AC	FC	Destination Address	Source Address	Data	Checksum	ED FS
	Start of Frame Delimiter	Access Control	Frame Control				End of Frame Delimiter	Frame status

- Contains the data, 18200 or 4500 bytes
- Only limited by token holding time

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No of Bytes	1	1	1	2 or 6	2 or 6	18200 / 4500	4	1
	SD	AC	FC	Destination Address	Source Address	Data	Checksum	ED FS
	Start of Frame Delimiter	Access Control	Frame Control				End of Frame Delimiter	Frame status

- Same as 802.3

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No of Bytes	1	1	1	2 or 6	2 or 6	18200 / 4500	4	1
	SD	AC	FC	Destination Address	Source Address	Data	Checksum	ED FS
	Start of Frame Delimiter	Access Control	Frame Control				End of Frame Delimiter	Frame status

- Contains A and C bits (A,C,0,0,A,C,0,0)
- When a frame arrives at its destination, the station's interface sets the A bit to 1
- If the frame is correctly copied to the station, the C bit is also changed to 1
- A=0, C=0 → dest not present or powered down
- A=1, C=0 → dest present but frame not accepted
- A=1, C=1 → dest present and frame accepted

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## IEEE 802.4 (TOKEN BUS) STANDARD

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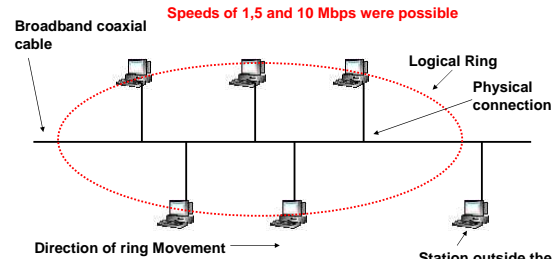
## Evolution of 802.4

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- ❑ People interested in factory automation were opposed to 802.3
- ❑ A station might have to **wait arbitrarily** to send a frame and
- ❑ 802.3 frames do not have **priorities**, so unsuited for real-time systems
- ❑ A ring topology has a known **worst-case** wait time of  $nT$
- ❑ But a ring has a **single** point of network breakdown
- ❑ Also, ring is a **poor** fit to the **linear** topology of an assembly line
- ❑ 802.4 was developed having **robustness** of a 802.3 broadcast cable and a **known worst-case** behavior of a ring

## A Token Bus Layout

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## 802.4 Ring Operation

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- ❑ Token is a special Frame which gives the holder station the **"Right to Transmit"**
- ❑ All stations are connected to a **linear cable (Bus)** but organized in a **Logical ring**
- ❑ Frames are passed from the Predecessor to the successor after a specified time interval
- ❑ When there is no data to be sent the token **circulates** around the **logical ring**
- ❑ Whenever a station has data to send, it waits for a token to arrive
- ❑ Station then **captures** the token and keeps transmitting data until allocated time for keeping the token expires
- ❑ After the specified time the token **must** be passed on to the successor

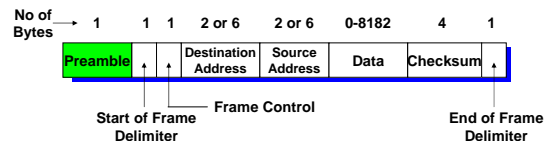
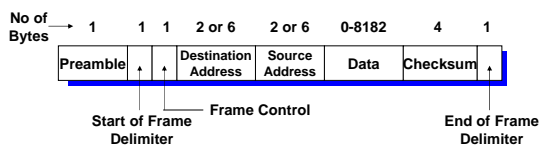
## Token Bus MAC Protocol

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- ❑ Stations inserted into the ring in the order of descending addresses
- ❑ Token passing also done from high to low addresses
- ❑ Defines 4 priority classes 0,2,4 and 6 for traffic, 0 being the lowest
- ❑ The token holding time can be **sub-divided for frames with different priority classes**
- ❑ A station may have frames with different priorities
- ❑ High priority frames get transmitted first and if token time remains lower priority frames get transmitted in the left over time

## 802.4 FRAME FORMAT

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- ❑ Has a fixed bit pattern 10101010 of 1 byte, used to synchronize the receiver's clock.

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No of Bytes	1	1	1	2 or 6	2 or 6	0-8182	4	1
	Preamble	↑	↑	Destination Address	Source Address	Data	Checksum	↑
	Start of Frame Delimiter			Frame Control			End of Frame Delimiter	

- ❑ Mark the frame boundaries
- ❑ Contain analog encoding of symbols **other than 0s and 1s**
- ❑ So it **cannot** accidentally occur in data

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No of Bytes	1	1	1	2 or 6	2 or 6	0-8182	4	1
	Preamble	↑	↑	Destination Address	Source Address	Data	Checksum	↑
	Start of Frame Delimiter			Frame Control			End of Frame Delimiter	

- ❑ Used to distinguish data and control frames
- ❑ For data frames, it carries frame's priority
- ❑ It can also contain an indicator for the receiver to acknowledge a correctly received frame, immediately, since it cannot otherwise do so.
- ❑ For control frames, it specifies frame types, e.g. Token, frames for ring maintenance (addition/removal) fig 4-27 for details

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No of Bytes	1	1	1	2 or 6	2 or 6	0-8182	4	1
	Preamble	↑	↑	Destination Address	Source Address	Data	Checksum	↑
	Start of Frame Delimiter			Frame Control			End of Frame Delimiter	

- ❑ **Identical to 802.3 addressing**

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No of Bytes	1	1	1	2 or 6	2 or 6	0-8182	4	1
	Preamble	↑	↑	Destination Address	Source Address	Data	Checksum	↑
	Start of Frame Delimiter			Frame Control			End of Frame Delimiter	

- ❑ Contains the data, max **8182** bytes when **2-byte** addresses used
- ❑ When **6-byte** addresses used data can be a max of **8174** bytes
- ❑ All 2-byte or 6-byte addresses used on a LAN, **no mixture**

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No of Bytes	1	1	1	2 or 6	2 or 6	0-8182	4	1
	Preamble	↑	↑	Destination Address	Source Address	Data	Checksum	↑
	Start of Frame Delimiter			Frame Control			End of Frame Delimiter	

- ❑ Same as 802.3

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**Logical Ring Maintenance**

### Joining the Ring (adding new stations to ring)

- ❑ Predecessor and successor addresses maintained by all
- ❑ Periodically token holder sends a SOLICIT\_SUCCESSOR frame giving its successor's address
- ❑ Any station wishing to join the ring with address within the range of sender's and its successor's address can do so, becoming the predecessor of sender's successor
- ❑ Ring initialization is special case of adding new stations to the ring
- ❑ Descending order of stations is maintained thereby
- ❑ If no station bids to enter the ring, the response window closes and token holder continues its operation

### Joining the Ring (Contd.....)

- ❑ If two or more stations bid to enter the ring, their frames will collide
- ❑ To reduce the collisions, stations must wait for a random number of time slots between 0,1,2 or 3 for next bidding
- ❑ Previous bidding activity is recorded through timers and when the new token is captured, new bidding may not be done if too much time has already been spent on bidding for new stations
- ❑ No guarantees on how long a station may have to wait to join the ring. A weakness of the protocol

### Leaving the Ring

- ❑ Much easier than joining the ring
- ❑ Leaving station X, with predecessor P and successor S, sends a SET\_SUCCESSOR frame to P
- ❑ It tells P to reset its successor to S, rather than X

### Reading Assignment

- ❑ Study the Ring Maintenance section of the Token Bus and Token Ring, and find out the detail of problems and their solutions for various possibilities of transmission errors in ring / token frame or any hardware failure