

Token Ring and Fiber Distributed Data Interface (FDDI)

IEEE 802.5 Token Ring

- Proposed in 1969 and initially referred to as a *Newhall ring*.

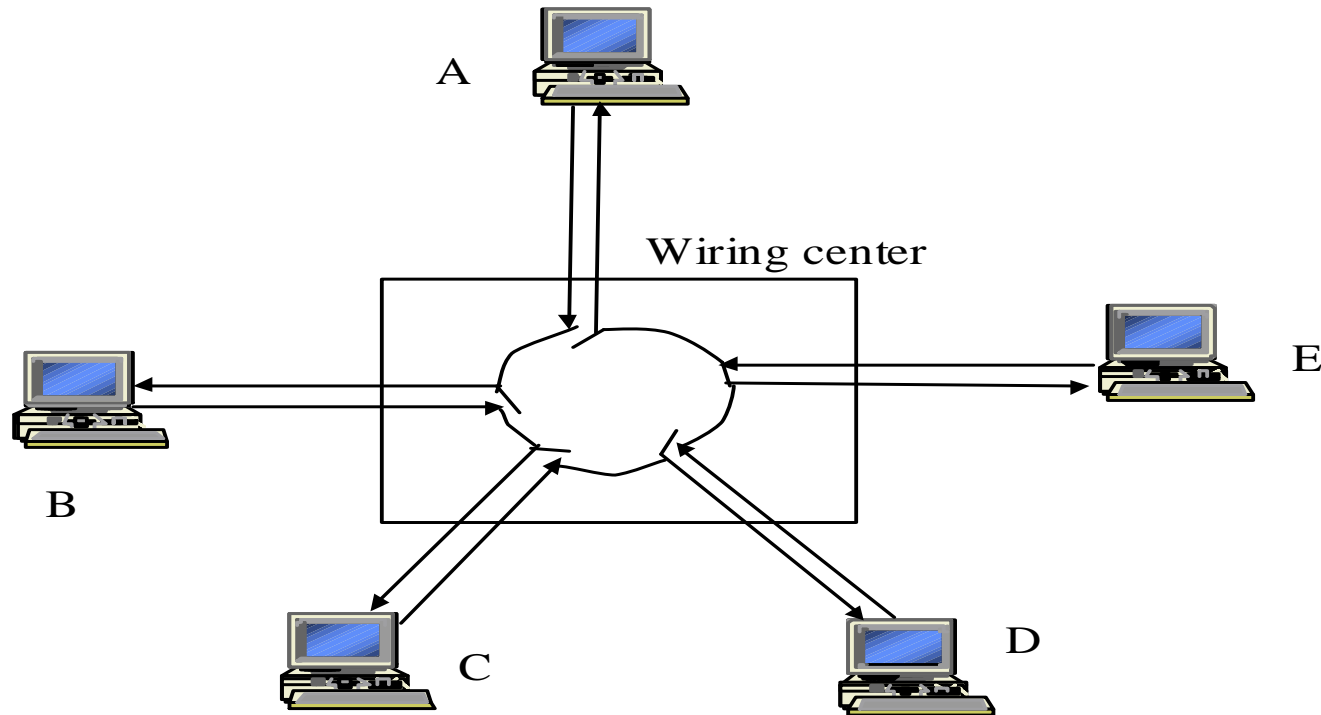
Token ring :: a number of stations connected by transmission links in a ring topology. Information flows *in one direction along the ring* from source to destination and back to source.

Medium access control is provided by a small frame, **the token**, that circulates around the ring when all stations are idle. *Only the station possessing the token is allowed to transmit at any given time.*

Token Ring Operation

- When a station wishes to transmit, it must wait for the **token** to pass by and *seize the token*.
 - One approach: change one bit in token which transforms it into a “*start-of-frame sequence*” and appends frame for transmission.
 - Second approach: station claims token by removing it from the ring.
- The data frame circles the ring and is removed by the transmitting station.
- Each station interrogates passing frame. If destined for station, it copies the frame into local buffer.
{Normally, there is a one bit delay as the frame passes through a station.}

Token Ring Network with Star Topology



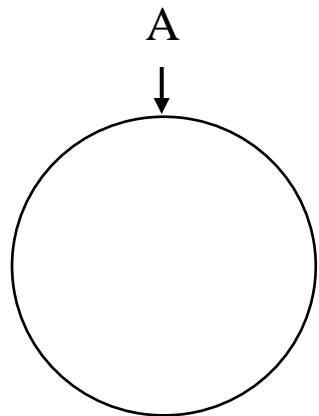
Token Insertion Choices

1. **multi-token:** insert token after station has completed transmission of the last bit of the frame.
2. **single-token:** insert token after last bit of busy token is received and the last bit of the frame is transmitted.
3. **single-frame:** insert token after the last bit of the frame has returned to the sending station.

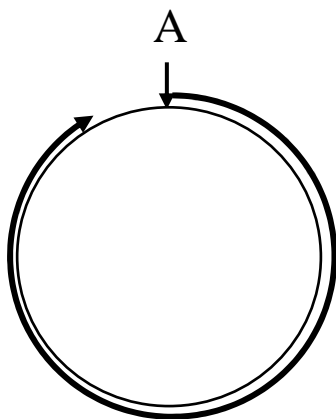
Performance is determined by whether more than one frame is allowed on the ring at the same time and the relative propagation time.

Single frame operation

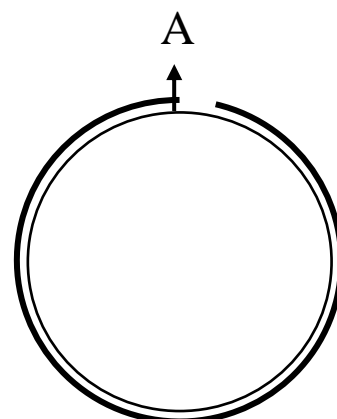
(a) Low Latency Ring



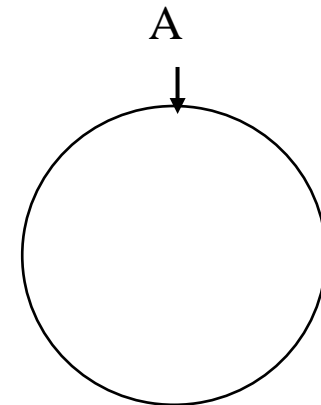
$t=0$, A begins frame



$t=90$, return of first bit

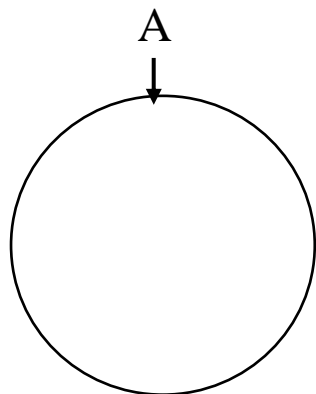


$t=400$, transmit last bit

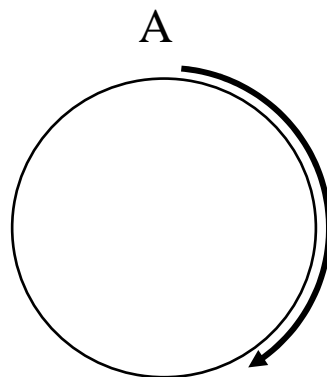


$t=490$, reinsert token

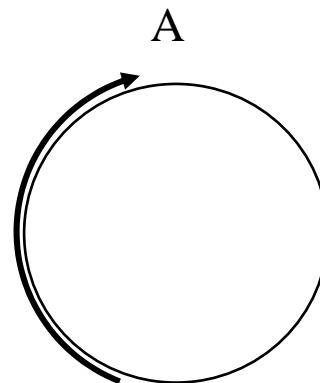
(b) High Latency Ring



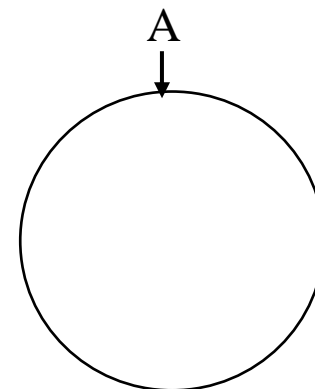
$t=0$, A begins frame



$t=400$, last bit of frame enters ring



$t=840$, return of first bit



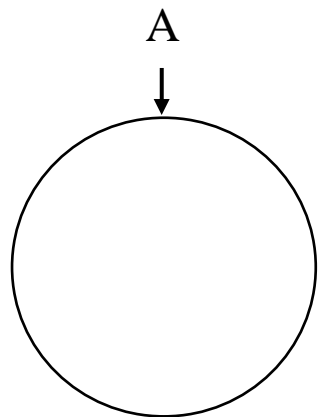
$t=1240$, reinsert token

Networks: Token Ring and FDDI

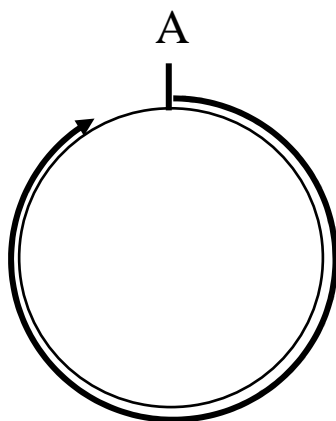


Single token operation

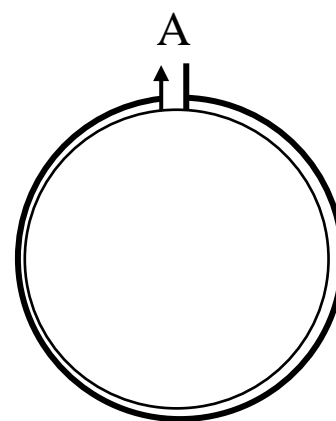
(a) Low Latency Ring



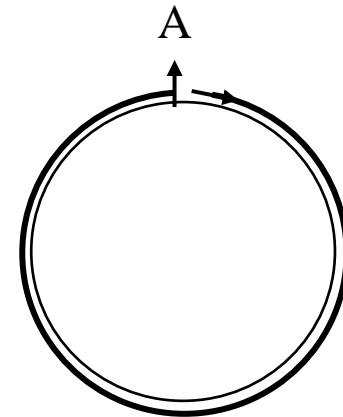
$t=0$, A begins frame



$t=90$, return of first bit

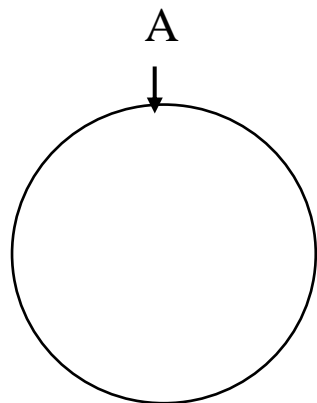


$t=210$, return of header

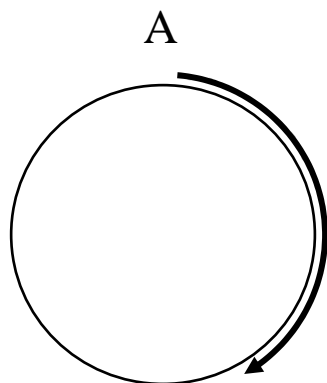


$t=400$, last bit enters ring, reinsert token

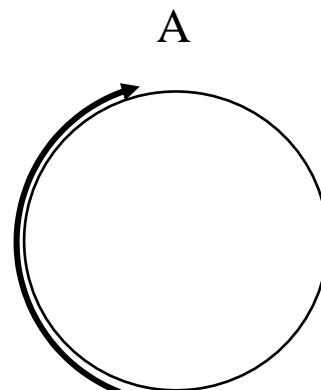
(b) High Latency Ring



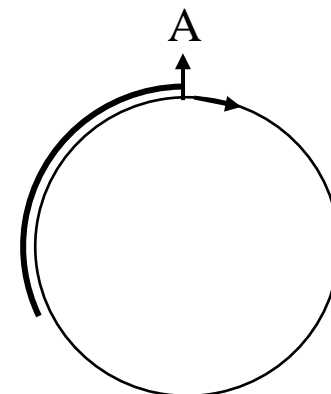
$t=0$, A begins frame



$t=400$, transmit last bit



$t=840$, arrival first frame bit



$t=960$, reinsert token

IEEE 802.5 Token Ring

- 4 and 16 Mbps using twisted-pair cabling with differential Manchester line encoding.
- Maximum number of stations is 250.
- **4Mbps 802.5 token ring** uses *single frame operation*.
- **4 Mbps IBM token ring** uses *single token operation*.
- Both 802.5 and IBM 16Mbps token rings use *multi-token operation*.
- 802.5 has 8 priority levels provided via two 3-bit fields (priority and reservation) in data and token frames.
- Permits 16-bit and 48-bit addresses (same as 802.3).

Token Ring

- Under light load – delay is added due to waiting for the token {on average delay is one half ring propagation time}.
- Under heavy load – ring is “*round-robin*”.
 - Performance is fairer and better than Ethernet!!
- The ring must be long enough to hold the complete token.
- Advantages – fair access, no collisions.
- Disadvantages – ring is single point of failure, ring maintenance is complex due to token malfunctions.

Token Maintenance Issues

What can go wrong?

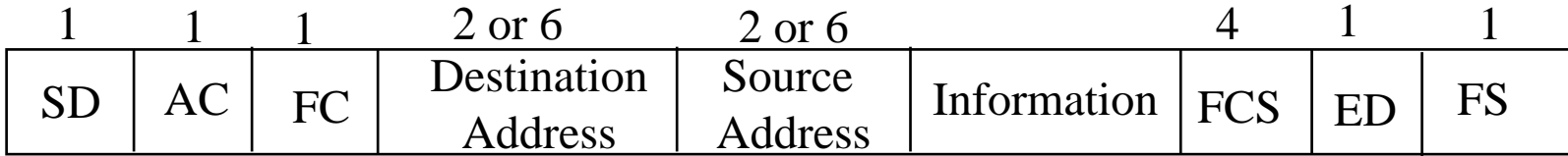
- Loss of token (no token circulating)
- Duplication of token (forgeries or mistakes)
- ➔ The need to designate one station as the **active ring monitor**.
- Persistently circulating frame
- Deal with active monitor going down.

IEEE 802.5 Token and Data Frame Structure

Token Frame Format



Data Frame Format



Starting
delimiter



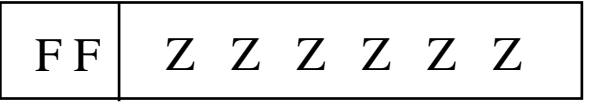
J, K non-data symbols (line code)

Access
control



PPP Priority; T Token bit
M Monitor bit; RRR Reservation

Frame
control



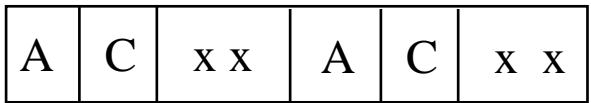
FF frame type
ZZZZZZ control bit

Ending
delimiter



I intermediate-frame bit
E error-detection bit

Frame
status



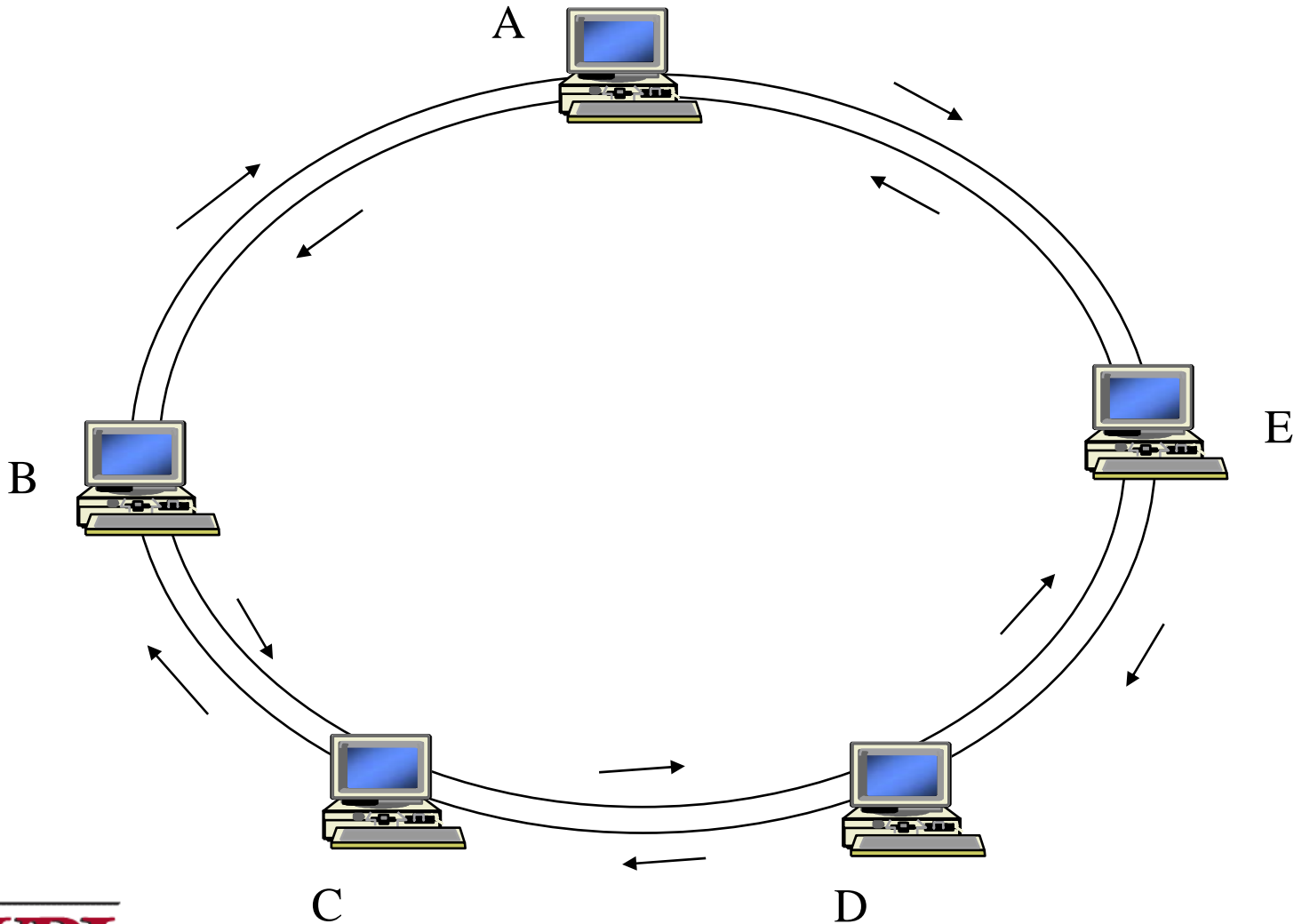
A address-recognized bit
xx undefined
C frame-copied bit



Fiber Distributed Data Interface (FDDI)

- **FDDI** uses a ring topology of multimode or single mode optical fiber transmission links operating at 100 Mbps to span up to 200 kms and permits up to 500 stations.
- Employs **dual** counter-rotating rings.
- 16 and 48-bit addresses are allowed.
- In FDDI, token is absorbed by station and released as soon as it completes the frame transmission {**multi-token operation**}.

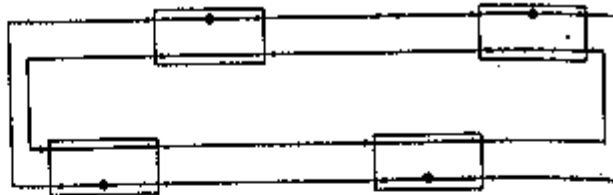
FDDI: Dual Token Ring



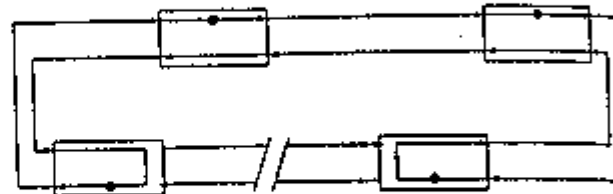
Networks: Token Ring and FDDI

FDDI Repair

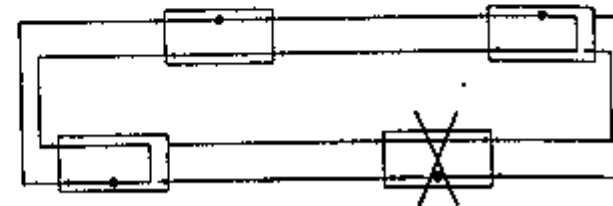
(a) Normal Operation



(b) Reconfigured After Link Failure



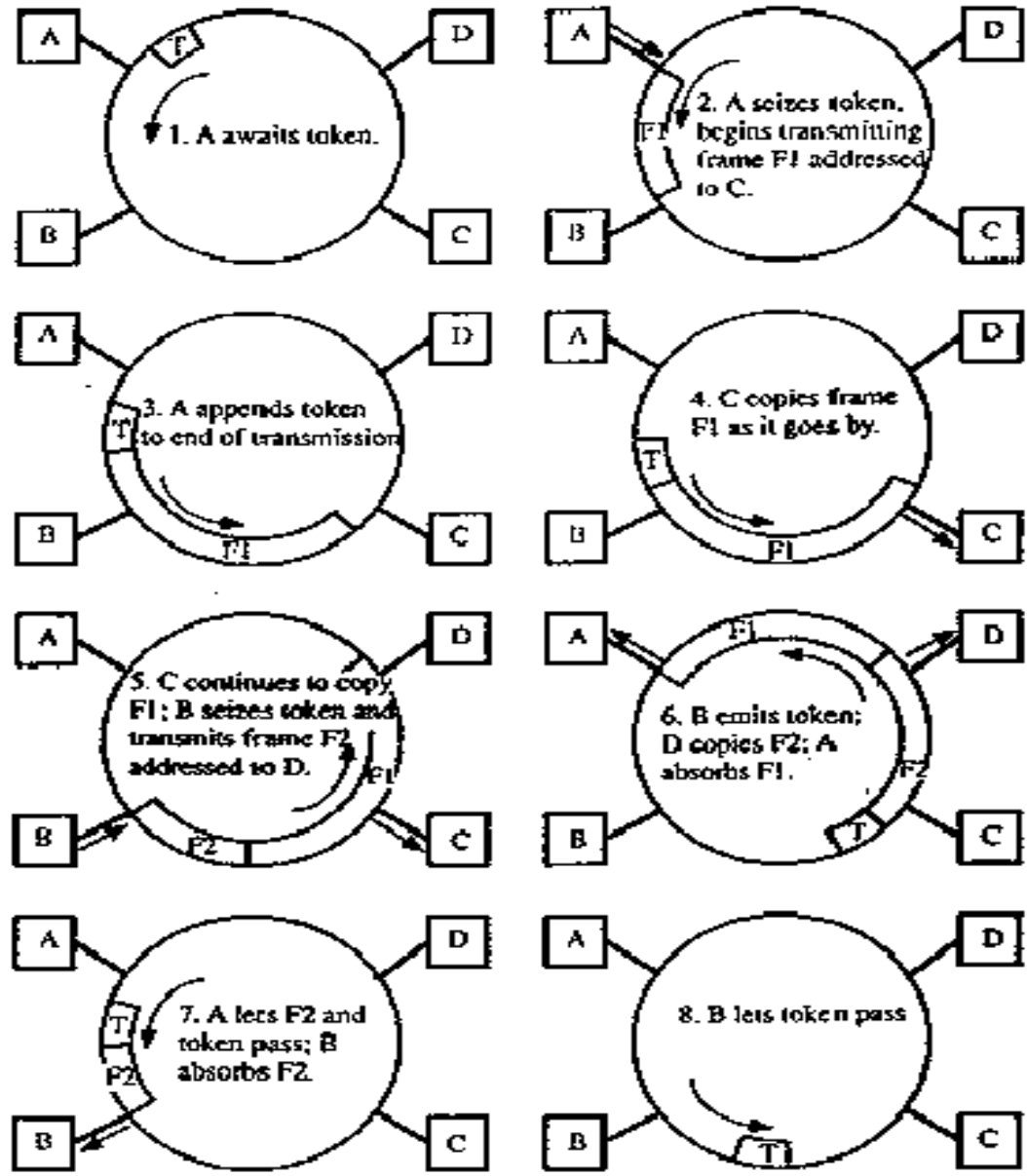
(c) Reconfigured After Station Failure



● = MAC Entry

FIGURE 6.7 FDDI Dual-Ring Operation

FDDI Ring Operation



FDDI

- To accommodate a mixture of stream and bursty traffic, FDDI is designed to handle two types of traffic:
 - **Synchronous** frames that typically have tighter delay requirements (e.g., voice and video)
 - **Asynchronous** frames have greater delay tolerances (e.g., data traffic)
- FDDI uses **TTRT (Target Token Rotation Time)** to ensure that token rotation time is less than some value.

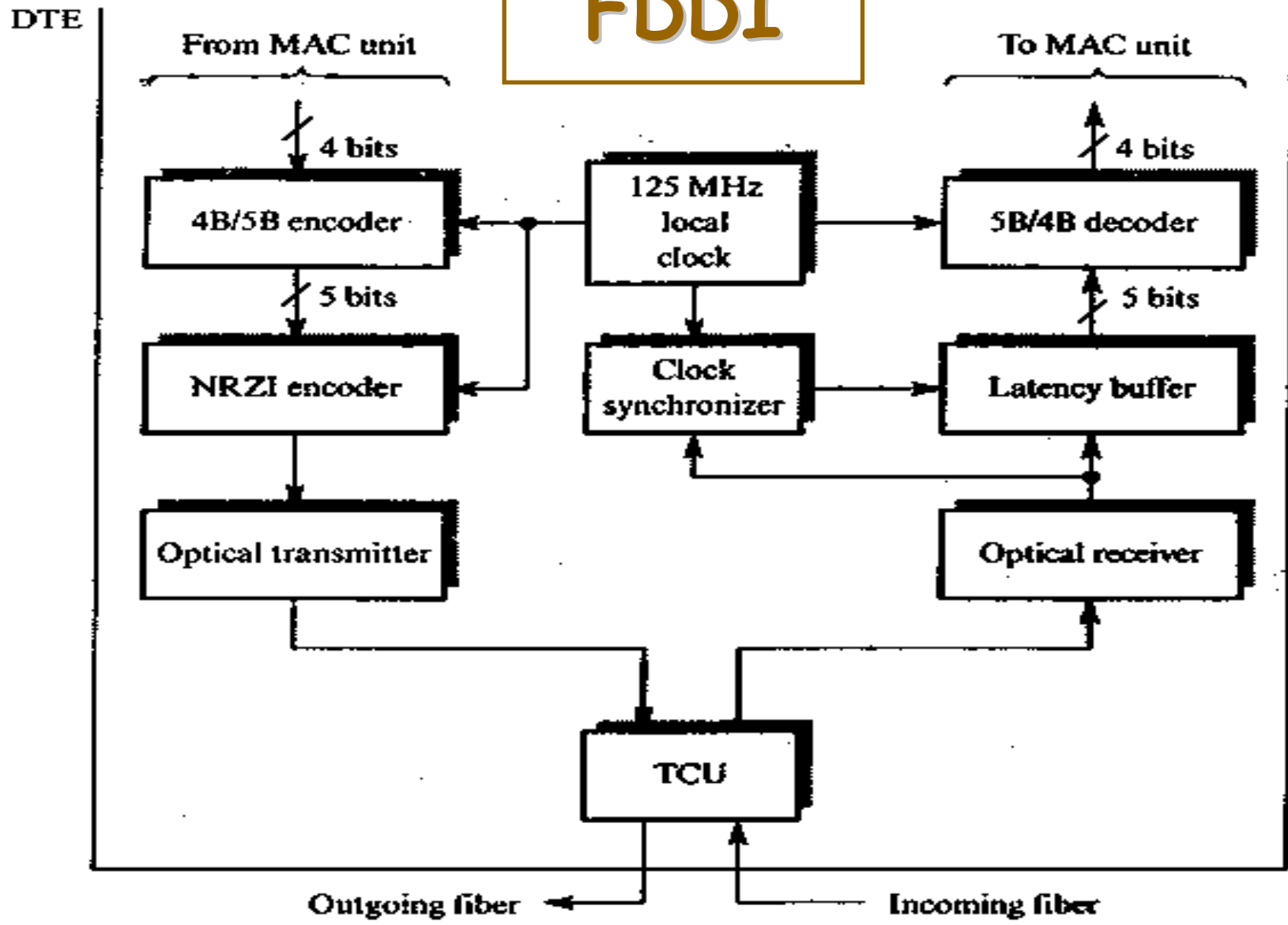
FDDI Data Encoding

- Cannot use **differential Manchester** because 100 Mbps FDDI would require 200 Mbaud!
- Instead each ring interface has its own local clock.
 - Outgoing data is transmitted using this clock.
 - Incoming data is received using a clock that is frequency and phase locked to the transitions in the incoming bit stream.

FDDI Data Encoding

- Data is encoded using a **4B/5B encoder**.
 - For each four bits of data transmitted, a corresponding 5-bit **codeword** is generated by the encoder.
 - There is a maximum of two consecutive zero bits in each symbol.
- The symbols are then shifted out through a NRZI encoder which produces a signal transition whenever a 1 bit is being transmitted and no transition when a 0 bit is transmitted.
- Local clock is 125MHz. This yields 100 Mbps (80% due to 4B/5B).

FDDI



FDDI

(a)

Data symbols		Control symbols	
4-bit data group	5-bit symbol		
0000	11110	IDLE	11111
0001	01001	J	11000
0010	10100	K	10001
0011	10101	T	01101
0100	01010	R	00111
0101	01011	S	11001
0110	01110	QUIET	00000
0111	01111	HALT	00100
1000	10010		
1001	10011		
1010	10110		
1011	10111		
1100	11010		
1101	11011		
1110	11100		
1111	11101		

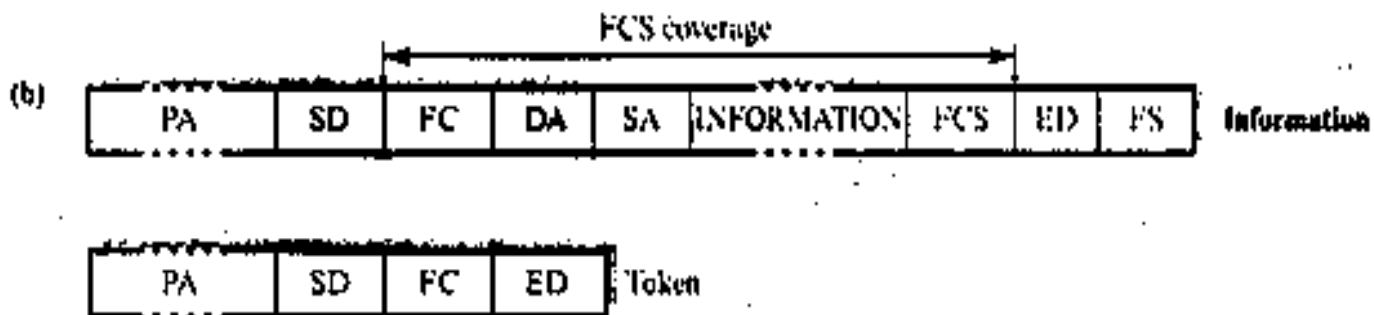


Figure 7.15

FDDI line coding and framing detail:

(a) 4B5B codes;

(b) frame formats.

PA = Preamble (16 or more symbols)

SD = Start delimiter (2 symbols)

FC = Frame control (2 symbols)

DA = Destination address (4 or 12 symbols)

SA = Source address (4 or 12 symbols)

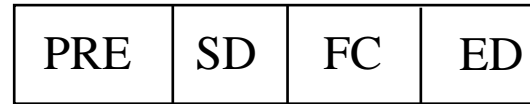
FCS = Frame check sequence (8 symbols)

ED = End delimiter (1 or 2 symbols)

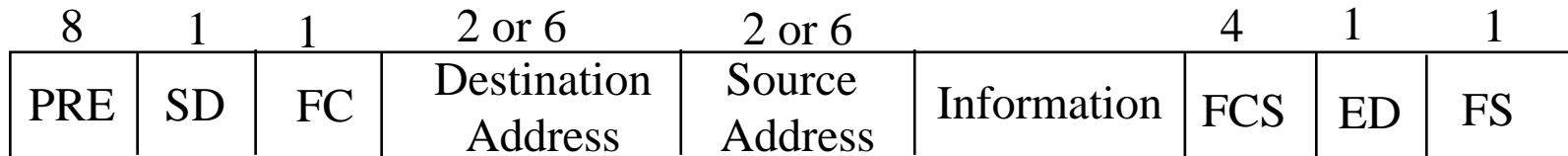
FS = Frame status (3 symbols)

FDDI Frame Structure

Token Frame Format



Data Frame Format



Preamble

Frame
Control

CLFFZZZZ

C = Synch/Asynch

L = Address length (16 or 48 bits)

FF = LLC/MAC control/reserved frame type

More FDDI Details

- FDDI Transmission on optical fiber requires ASK.
- The simplest case: coding is done via the absence or presence of a carrier signal {**Intensity Modulation**}.
- Specific 5-bit codeword patterns chosen to guarantee no more than **three zeroes in a row** to provide for adequate synchronization.
- 1300 nm wavelength specified.
- Dual rings (primary and secondary) – transmit in opposite directions.
- Normally, second ring is **idle** and used for redundancy for automatic repair (self-healing).

IEEE 802.5 and FDDI Differences

Token Ring

- Shielded twisted pair
- 4, 16 Mbps
- No reliability specified
- Differential Manchester
- Centralized clock
- Priority and Reservation bits
- All three token operations possible

FDDI

- Optical Fiber
- 100 Mbps
- Reliability specified (dual ring)
- 4B/5B encoding
- Distributed clocking
- Timed Token Rotation Time
- Multi-token operation