Token Ring
and
Fiber Distributed Data Interface
(FDDI)

IEEE 802.5 Token Ring

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

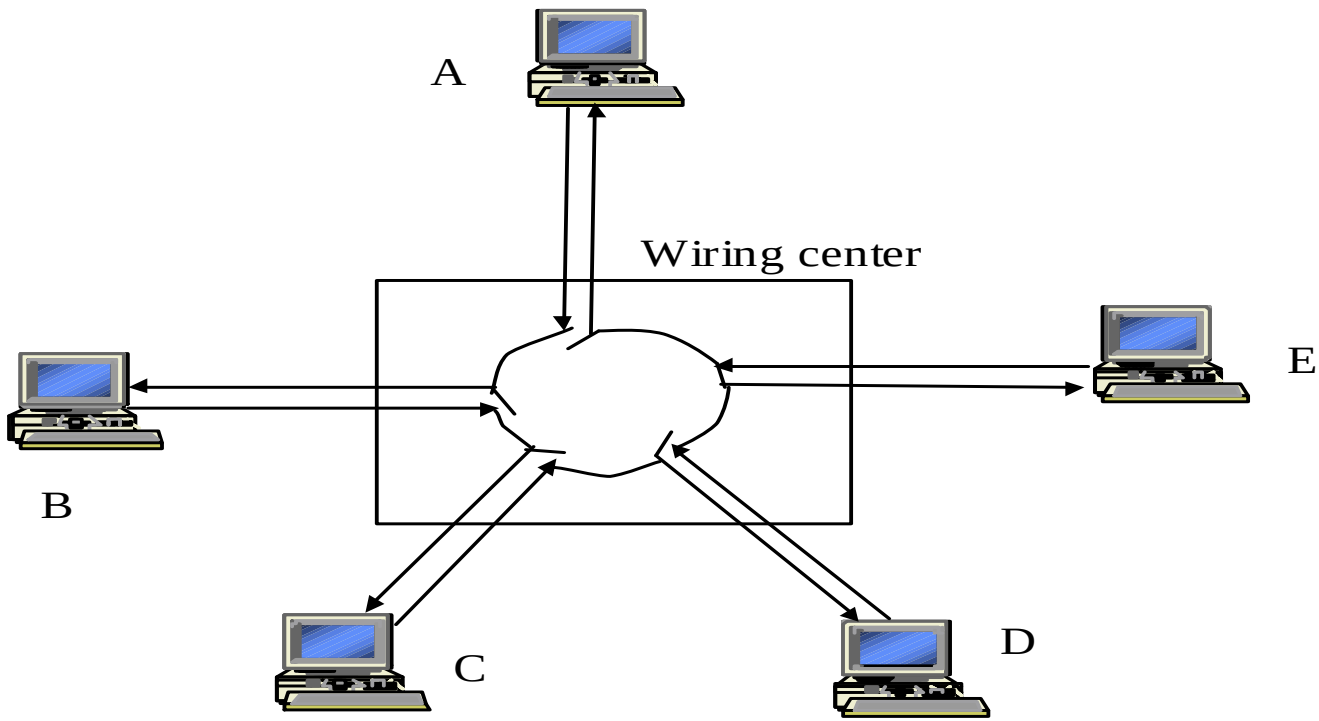
Token ring :: a number of stations connected by transmission links in a ring topology. Information flows *in **one** direction along the ring* from source to destination and back to source.

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 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



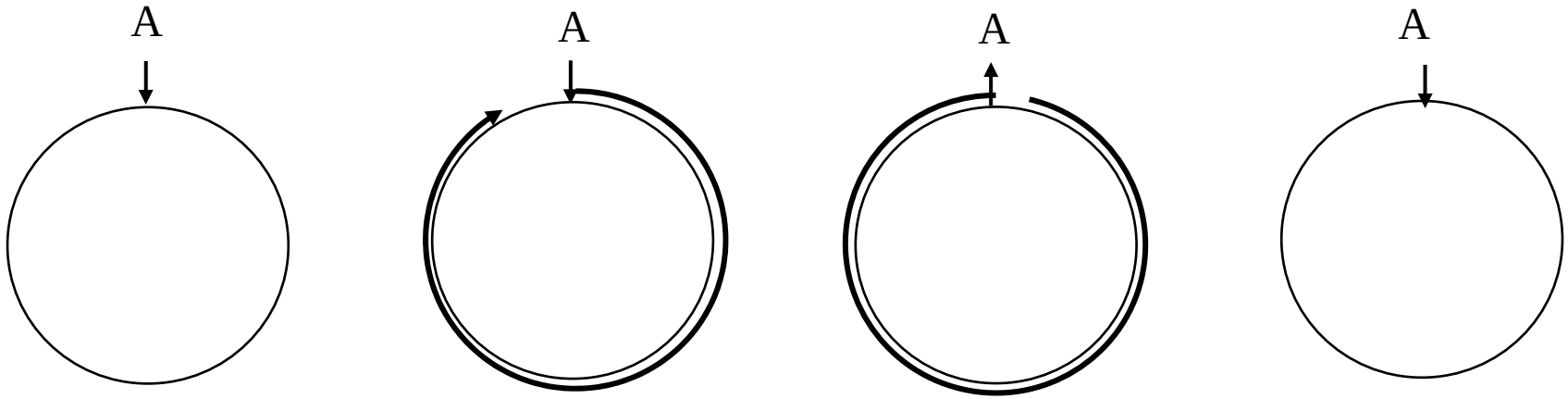
Token Insertion Choices

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



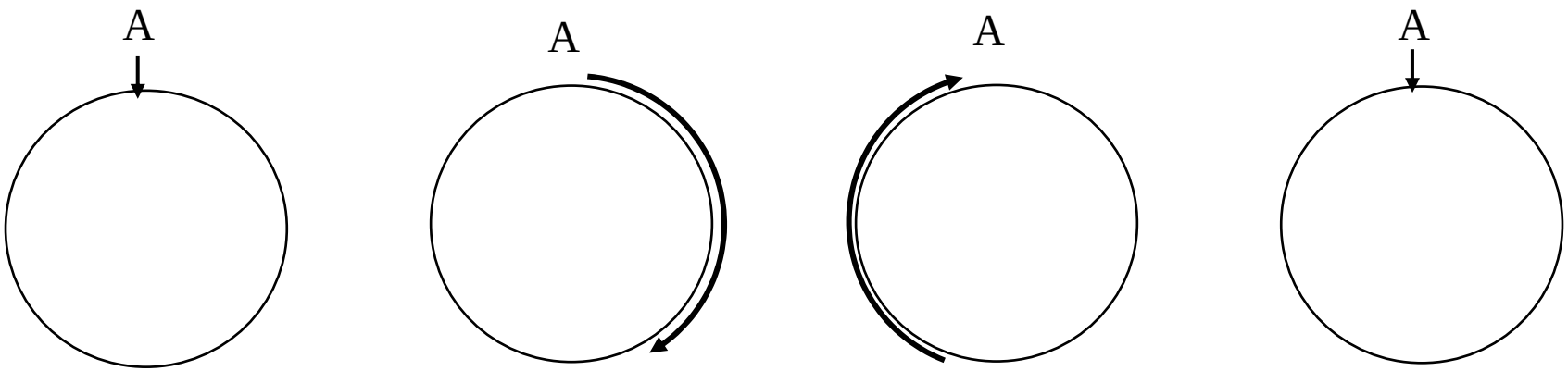
t=0, A begins frame

t=90, return of first bit

t=400, transmit last bit

t=490, reinsert token

(b) High Latency Ring



t=0, A begins frame

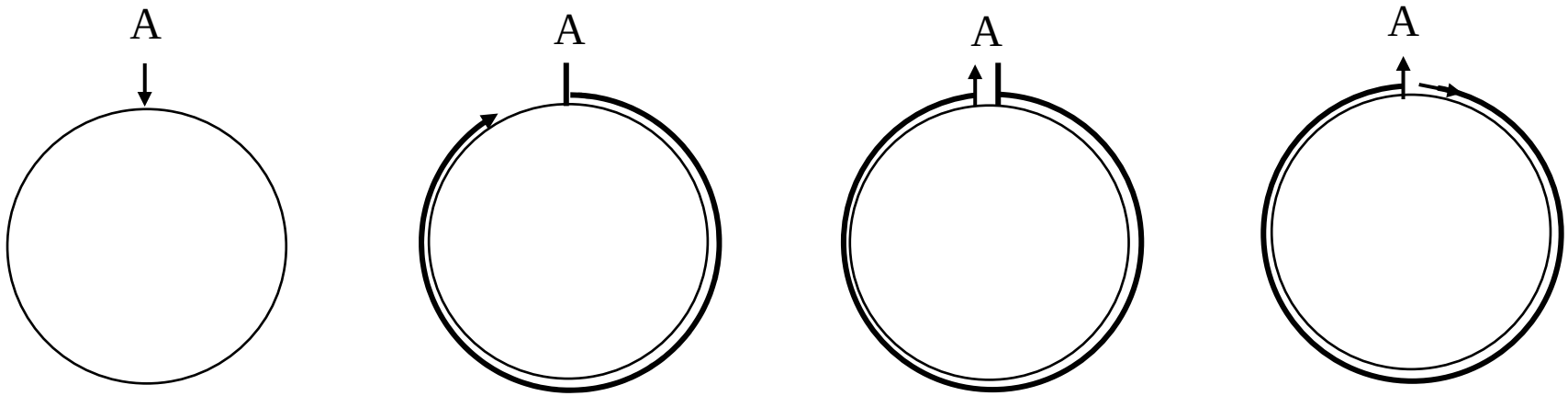
t=400, last bit of frame enters ring

t=840, return of first bit

t=1240, reinsert token

Single token operation

(a) Low Latency Ring



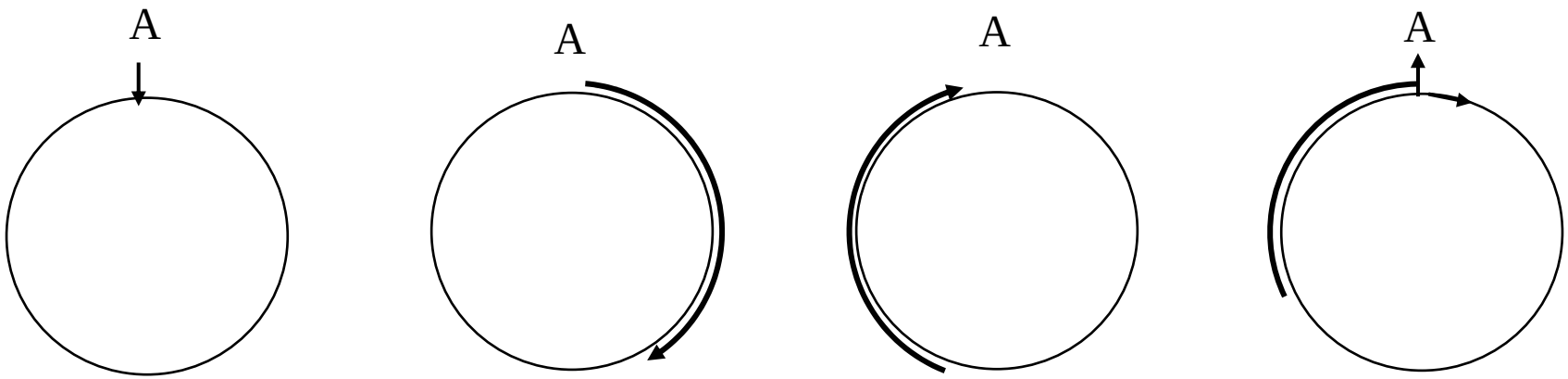
t=0, A begins frame

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)

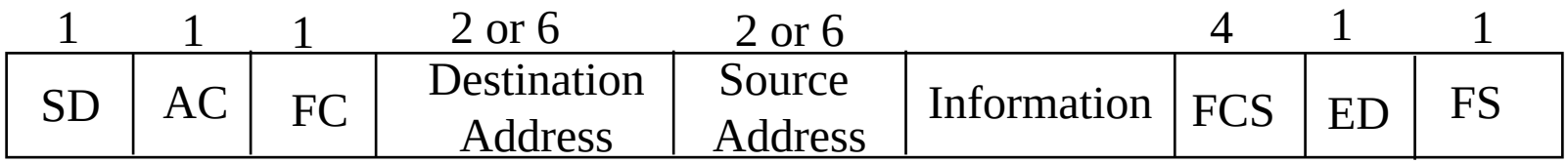
➔The need to designate one station as the *active ring monitor*.

- Persistently circulating frame
- Deal with active monitor going down.

IEEE 802.5 Token and data frame structure

Token Frame Format

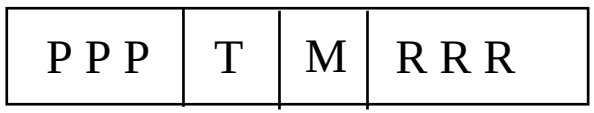
Data Frame Format



Starting delimiter

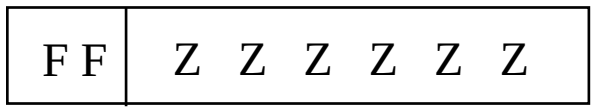
J, K non-data symbols (line code)

Access control



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

Frame control

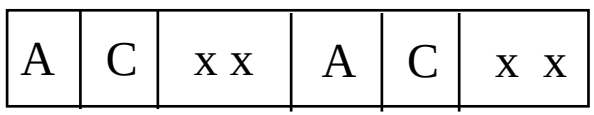


FF frame type
ZZZZZZ control bit

Ending delimiter

I intermediate-frame bit
E error-detection bit

Frame status

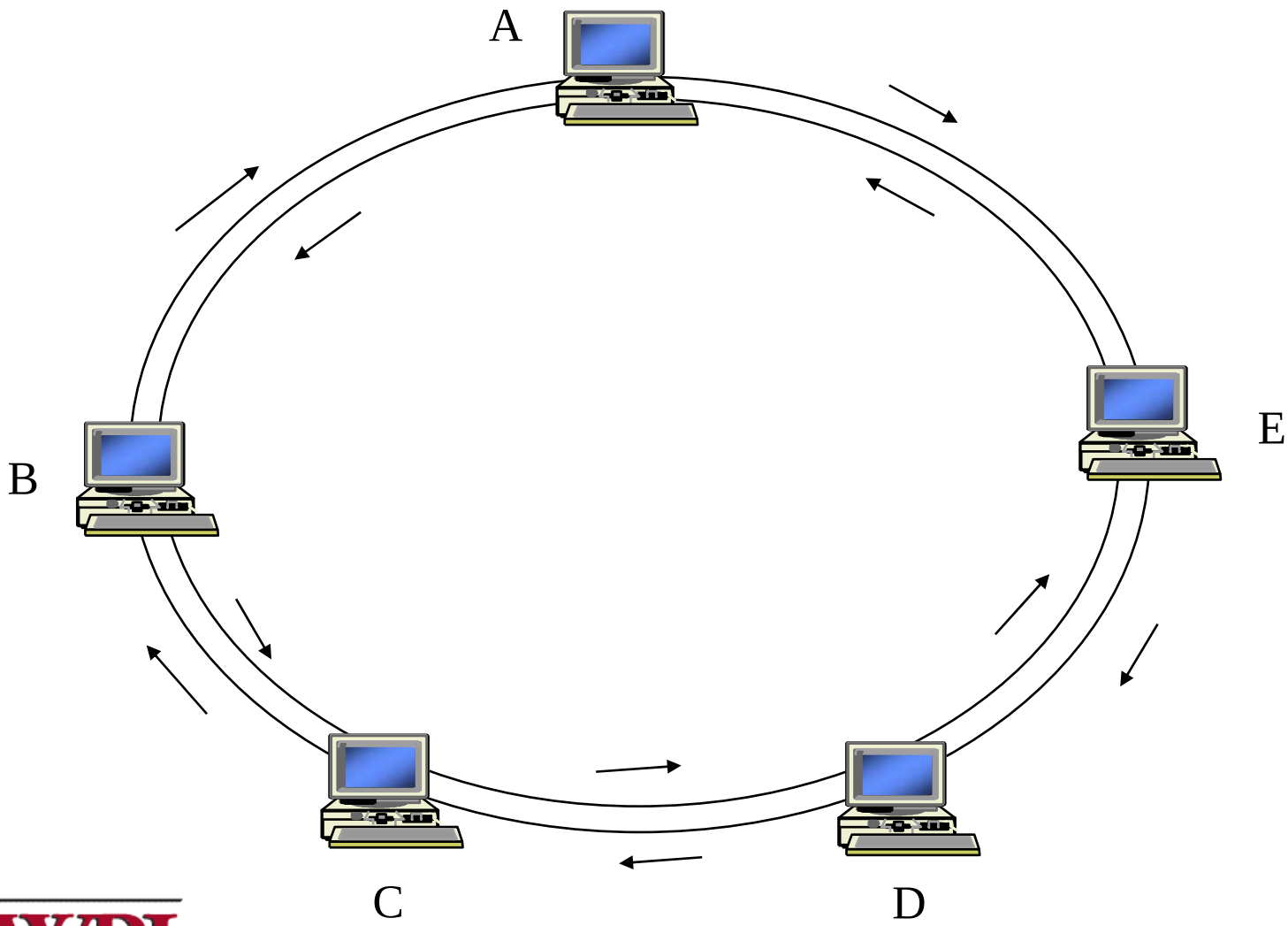


A address-recognized bit
xx undefined
C frame-copied bit

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



FDDI Repair

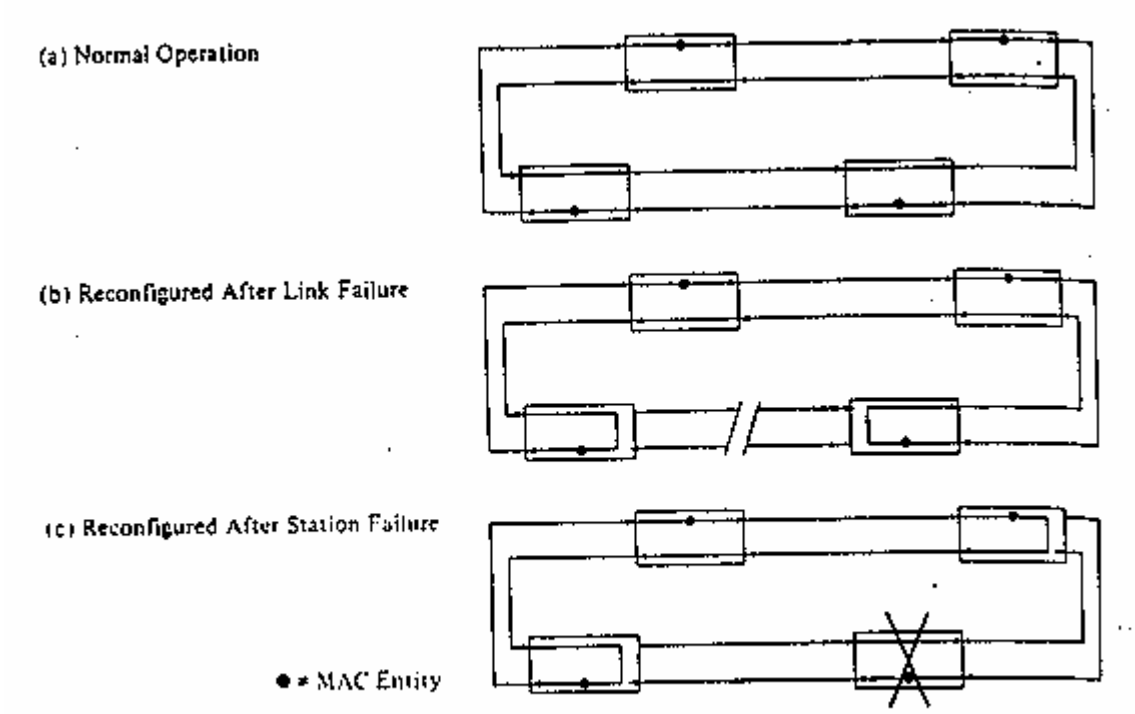
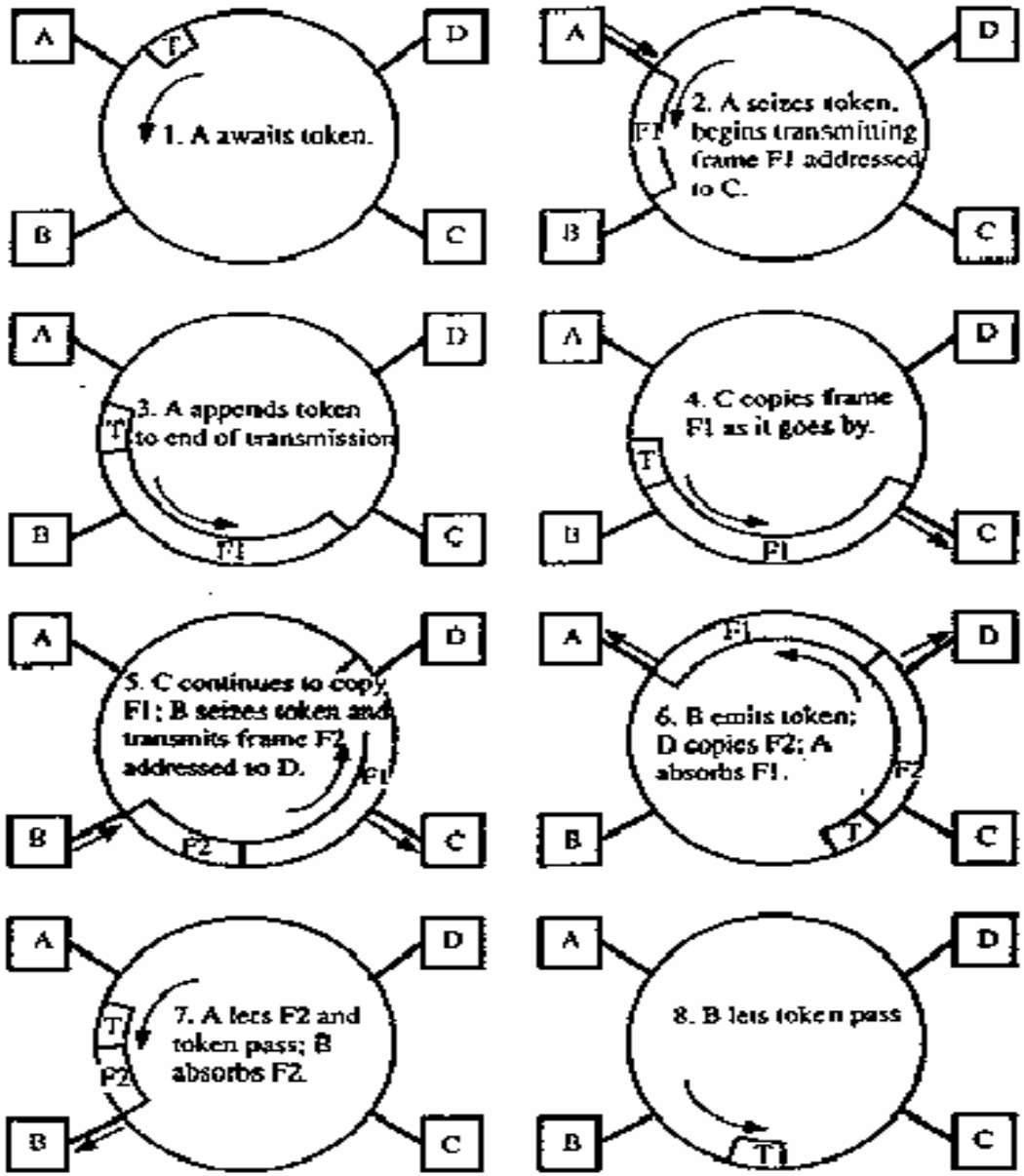


FIGURE 6.7 FDDI Dual-Ring Operation

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.

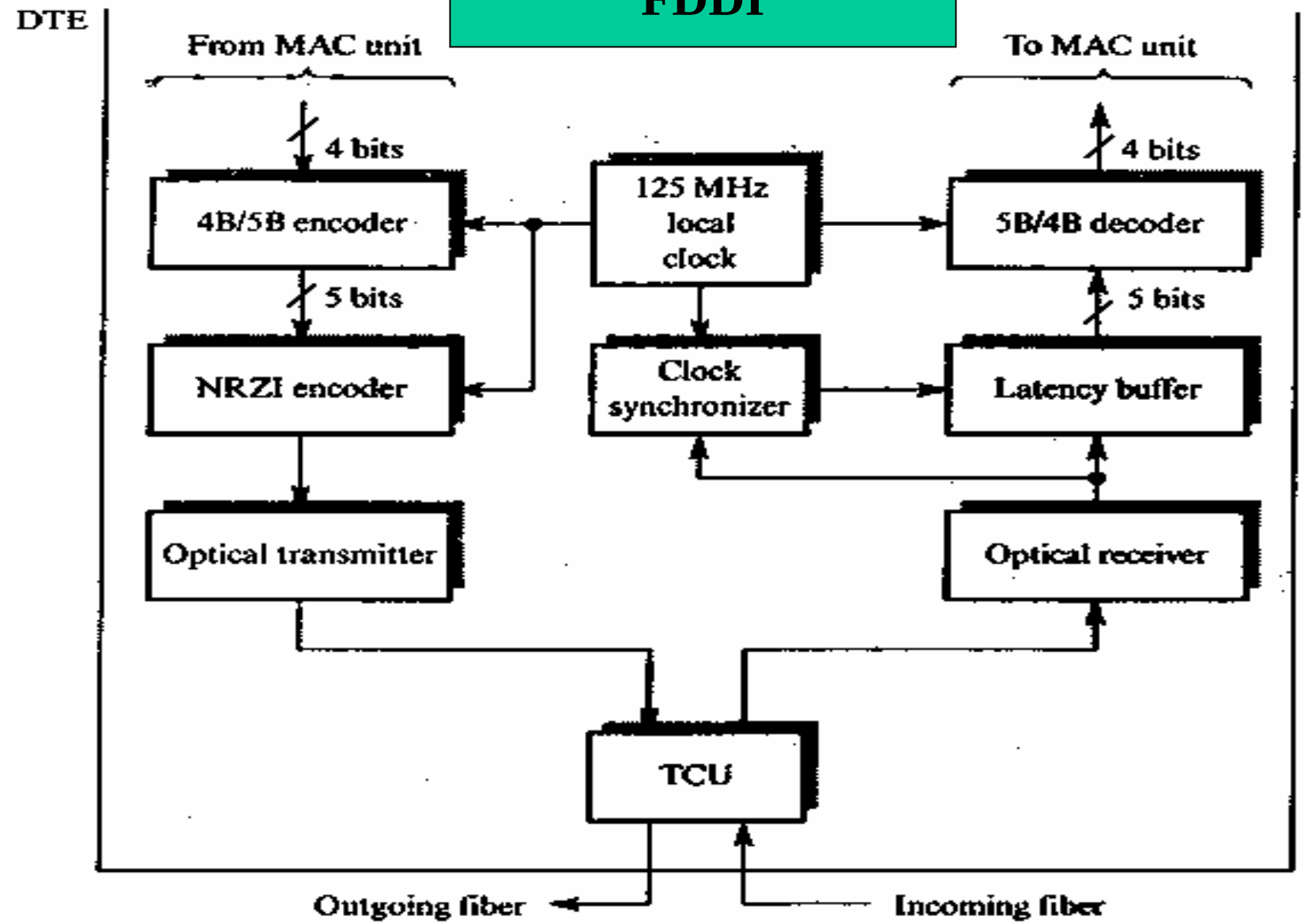
FDDI Data Encoding

- 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).

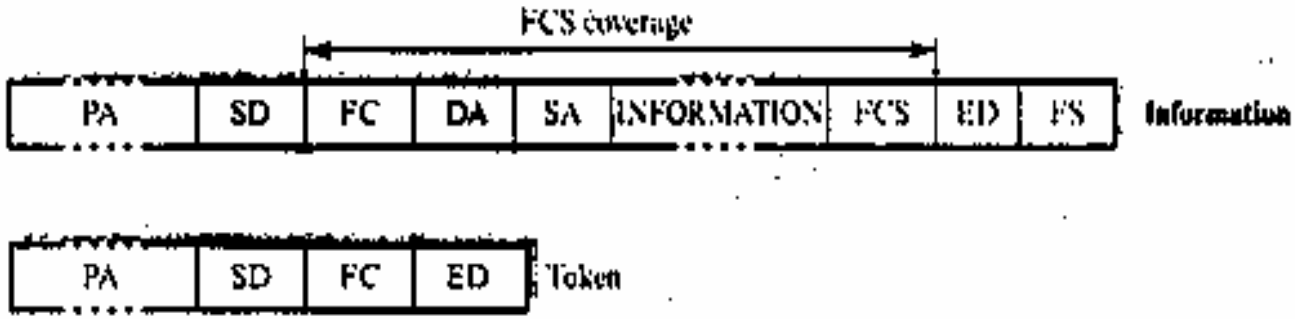
FDDI


DTE
From MAC unit
To MAC unit
4 bits
4 bits
4B/5B encoder
125 MHz local clock
5B/4B decoder
5 bits
5 bits
NRZI encoder
Clock synchronizer
Latency buffer
Optical transmitter
Optical receiver
TCU
Outgoing fiber
Incoming fiber

(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		

(b)

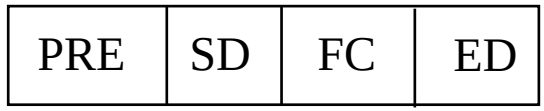


PA = Preamble (16 or more symbols)
SD = Start delimiter (2 symbols)
FC = Frame control (2 symbols)
DA = Destination address (4 or 12 symbols)
SA = Source address (4 or 12 symbols)
FCS = Frame check sequence (8 symbols)
ED = End delimiter (1 or 2 symbols)
FS = Frame status (3 symbols)

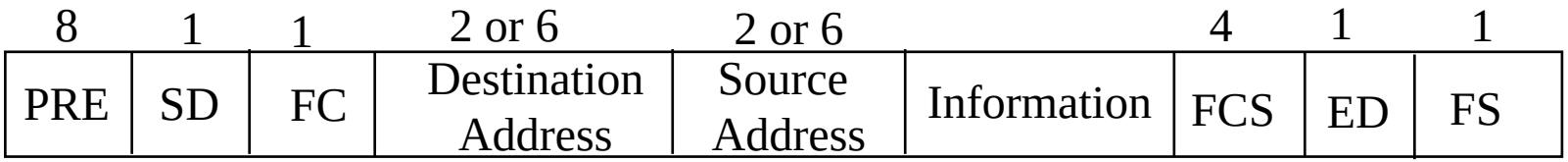
Figure 7.15
FDDI line coding and framing detail:
(a) 4B5B codes;
(b) frame formats.

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).

Differences between **802.5** and **FDDI**

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