Token Ring

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Ring Networks

- A ring is not really a broadcast medium
- A ring is fair and has a known upper bound on channel access

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Dis/Advantages

- Advantages
  - The better utilization of bandwidth
    - no frame collision
  - Point-to-Point communication
    - The repeater will regenerate the input signal
    - The lower error rate
  - Easy to recover the breakdown station
- Disadvantages
  - Broken wires and broken repeaters will crash the whole ring
  - The installation is more complicated
  - More expensive than Ethernet

Types of Ring Networks

- Slotted ring
- Register insertion ring
- Token ring

Slotted Ring

- The ring is slotted into a few fixed-size slots
- Unless the physical distance of the ring is very large or there are many stations, it is unlikely that there will be enough delay to hold several slots
- Artificial delays are needed
  - put shift registers in the ring interface
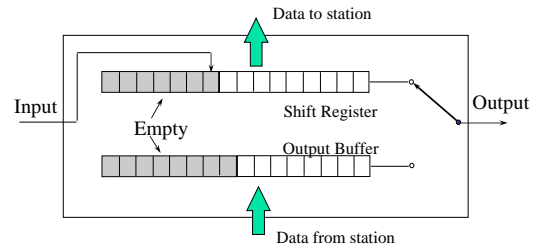 - result in the multiple-bit delay

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Slotted Ring (Continued)

- Each slot contains a bit denoted whether it is full or empty
- Want to transmit data
  - wait for an empty slot
  - mark it as full
  - put the data in the slot

Format of Slot

- Status
- DA (Destination Address)
- SA (Source Address)
- Data field
- Control field

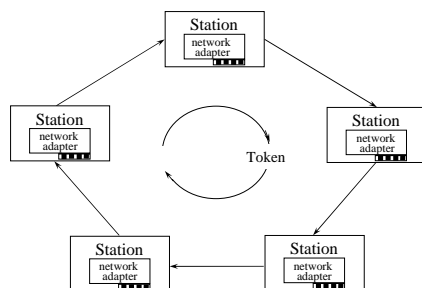## Register Insertion Rings

Register Insertion Rings (continued)

- When to Transmit Data
  - There are data to be transmitted
  - The available space in shift register is larger than the size of transmitted data in output buffer

Register Insertion Rings (continued)

- Fairness
- High utilization
- Allow messages with different size
- Allow more than one message in the ring
- Long delay time
  - Delay time is the time to transmit a message with DA+SA
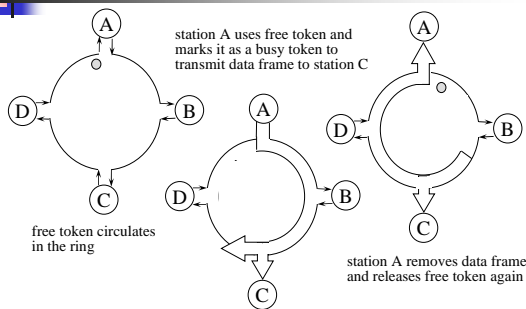 - The size of shift register is larger than that of DA+SA

Architecture of Token Ring Networks

Properties of Token Ring

- Fair
  - each station transmits data frame in round-robin style
- No frame collision
- Higher network utilization
- Automatic acknowledgment
- Maintaining the token is the critical issue

Transmission in Token Ring

station A uses free token and marks it as a busy token to transmit data frame to station C

free token circulates in the ring

station A removes data frame and releases free token again

Functions of the Interface (Repeater)

- Output frames to the network
  - after grasp the free token
- Copy frames from the network
  - the destination address of frames matches
- Remove frames from the network
  - by sender: automatic acknowledgment
  - by receiver: increase the utilization of network
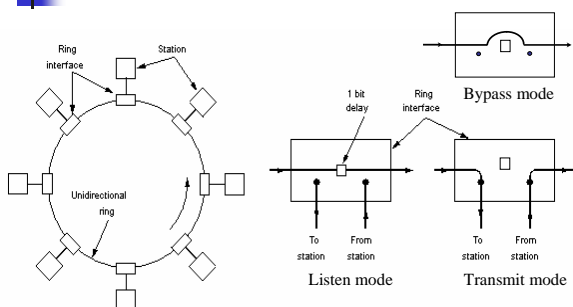
Catch Signal and Write out Signal

- Each bit arriving at an interface is copied into a 1-bit buffer and copied out the ring again
- While in the buffer the bit can be inspected and possibly modified before being written out
- This copying step will introduce a 1-bit delay at each interface

Operating Modes of Interface

- Listen mode
- Transmit mode
- Bypass mode
  - stations power down
  - better reliable
  - avoid the unnecessary delay

The Interface of Ring Networks

Listen Mode

- Scan the bit stream
  - recognize special bits
  - e.g. token or destination address
- Copy input bit to output
- Modify bit
  - transform free-token to busy-token

Transmit Mode

- The propagated back bits is removed from the ring by sender
- After a station has finished transmitting the last bit of its last frame, it has to regenerate the token
- When the last bit of the frame has gone around and come back, it must be removed and the interface must switch back to listen mode
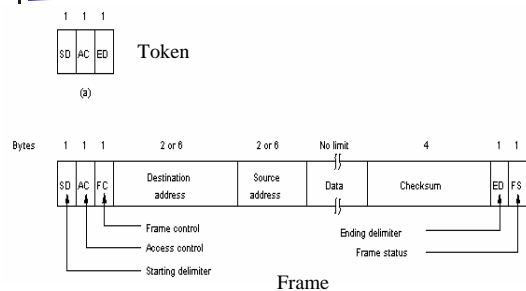
Consider the Token Length

- The ring must have a sufficient delay to contain a complete token to circulate when all stations are idle
- Delay is made up of two components
  - 1-bit delay
  - the propagation delay
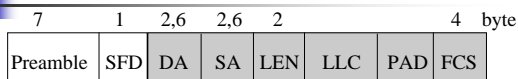- Sometimes the station is powered down, its 1-bit delay should be omitted

Calculation of Bit Length

- The data rate is R Mbps
- The signal propagation speed is about 200 m/μsec
- Each bit occupies $(200*10^6 m/s) / (R*10^6 bit/s)$ meters on the ring
- For example
  - 100 workstations and the length between them is 10 m
  - data rate is 10 Mbps and signal propagation speed is 200 m/μsec
  - bit length between stations is $10m/(200*10^6 m/s)*10*10^6 bit/s = 0.5$ bit
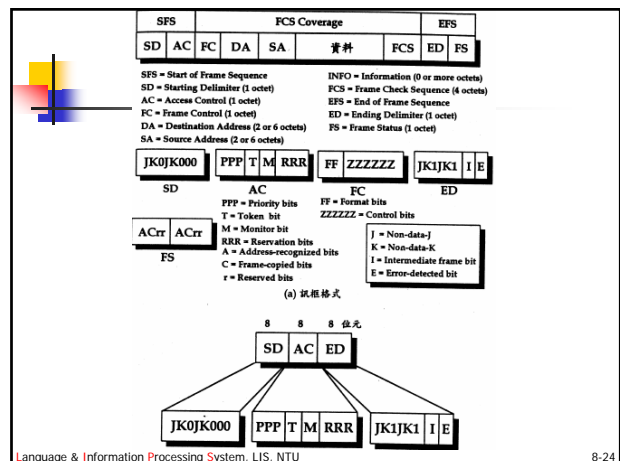 - the bit length of this ring is 0.5 bit *100+100=150 bits

Token Ring Frame Format

Ethernet Frame Format

Preamble: 7 bytes, 101010...1010, synchronization
SFD (Start Frame Delimiter): 1 byte, 10101011
DA (Destination Address): 2 or 6 bytes
SA (Source Address): 2 or 6 bytes
LEN: 2 bytes, the length of LLC PDU
LCC: at most 1500 bytes
PAD (Padding): if the length of LLC is less than 46 bytes, this field is stuffed with some meaningless data
FCS (Frame Check Sequence): CRC-32

Control Bits

- Priority (PPP): 訊標優先權
- Token (T): 0:訊標；1:訊框
- Monitor (M): 監督位元
- Reservation (RRR): 預約優先權

- Frame Type (FF): 辨識MAC frame或是LLC frame

- Intermediate Frame (I): 0:此訊框為唯一訊框或最後一筆訊框；1:還有其他訊框跟隨在後
- Error Detected (E): 由任何發現訊框錯誤的工作站設定

- Address Recognized (A): 由目的工作站設定，表示工作站仍在網路上
- Frame Copied (C): 由目的工作站設定，表示訊框已接收（Acknowledgment）

Frame Format (Continued)

- Start Delimiter (SD)
  - signifies the beginning of data. It has a unique code to differentiate it.
- Access Control (AC)
  - contains information about the priority of the frame and a need to reserve future tokens, which other stations will grant if they have a lower priority.

Frame Format (Continued)

- Frame Control (FC)
  - defines the type of frame, either Media Access Control (MAC) information, or information for an end station.
  - If the frame is a MAC frame, all stations on the ring read the information.
  - If the frame contains information, it is only read by the destination station.

Frame Format (Continued)

- Destination Address (DA)
  - contains the address of the station that is to receive the frame. The frame can be addressed to all stations on the ring.
- Source Address (SA)
  - contains the address of the station that sent the frame.
- Data
  - contains the data "payload." If the frame is a MAC frame, this field may contain additional control information.

Frame Format (Continued)

- Frame Check Sequence (FCS)
  - contains error checking information to ensure the integrity of the frame to the recipient.
  - CRC-32
- End delimiter (ED)
  - indicates the end of the frame.
- Frame status (FS)
  - provides indications of whether one or more stations on the ring recognized the frame, whether the frame was copied, or whether the destination station is not available.

Acknowledgment

- The frame format need only include a 1-bit field for acknowledgments
- Initialize it as zero
- When the destination station has received a frame, the bit is inverted

Ring Maintenance

- Each token ring has a monitor station that oversees the ring
- If the monitor station crashes, a contention protocol insures another station to be monitor quickly
  - any station can transmit a CLAIM TOKEN frames
  - while it circulates back before any other CLAIM TOKEN are sent, the sender becomes the new monitor

Responsibility of Monitor

- Drain the orphan frame
  - set the monitor bit in the AC field whenever a frame pass through
  - If an incoming frame has this bit set, something is wrong
- Check for lost token
  - set timer
  - if timer goes off, monitor issues a new token

Frame Control for MAC Messages

FC Field	Name	Meaning
00000000	Duplicate address test	Test if two stations have same address
00000010	Beacon	Used to locate breaks in the ring
00000011	Claim token	Attempt to become monitor
00000100	Purge	Reinitialize the ring
00000101	Active monitor present	Issued periodically by the monitor
00000110	Standby monitor present	Announces the presence of potential monitors

The Ring Length

- The token is 24 bits long
- If the 1-bit delay in stations plus the ring length add up to less than 24 bits, monitor inserts extra delay bits so that a token can circulate