IEEE 802.5 (Token Ring) LAN

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IEEE 802.5 (Token Ring): Ring Topology

- Shared ring medium: all nodes see all frames
- Round Robin MAC Protocol: determines which station can transmit
- A special 3-byte pattern, the token, circulates around the ring perpetually and represents the "right to transmit"
- This establishes round-robin media access
- Data flow is unidirectional
- All data flows in a particular direction around the ring; nodes receive frames from their upstream neighbor and forward them to their downstream neighbor
- Data rate: 4 or 16 Mbps
IEEE 802.5 Token Ring

- Ring Interface
- Listen Mode
- 1 bit delay
- Unidirectional Ring
- Transmit Mode
- To Station
- From Station
IEEE 802.5 (Token Ring) Operation

- The token bit sequence circulates around the ring.
- Each station forwards the token if it does not have a frame to transmit.
- A station with data to send seizes the token (repeater now in transmit state) and begins sending it's frame. It can transmit for length of time called the **Token Hold Time (THT)** = 10 mseconds.
- Each station forwards the frame.
- The destination station notices its address and saves a copy of the frame as it also forwards the frame.
- When the sender sees its frame return, it drains it from the ring and reinserts a token. When the last bit of the returning frame has been drained, the repeater switches immediately to the listen state.
IEEE 802.5 (Token Ring) using a Hub

- The star-wired ring topology uses the physical layout of a star in conjunction with the token-passing data transmission method. Data are sent around the star in a circular pattern. This hybrid topology benefits from the fault tolerance of the star topology and the reliability of token passing.
IEEE 802.5 (Token Ring): Bypass relays and Wire Center

- Bypass relays protect ring topology from node failure at the hardware level.
IEEE 802.5 (Token Ring) Frame Format

Start Delimiter | Access Control | End Delimiter

- **Start delimiter (1 byte):** serves the same basic purpose as the preamble in an Ethernet frame.
- **Access Control (1 byte):** contains the token bit, monitor bit, and priority bits
- **Frame Control (1 byte):** contains access control information
- **Destination Address (6 bytes)**
- **Source Address (6 bytes)**
- **Data (no size limit specified):** this is the actual data being sent (IP packet). Since the THT = 10 mseconds, practical size limit of the frame is 4500 bytes.
- **Frame Check Sequence (4 bytes):** CRC error checking bits
- **End Delimiter (1 byte):** signifies the end of the frame
- **Frame Status Field (1 byte):** serves as the ACK and indicates whether the address was recognized and the frame copied, which is done by the receiving computer before being sent back around the ring
IEEE 802.5 (Token Ring): Ring Maintenance

- There is a special station on the ring called a **monitor** station. It is responsible to identify and address situations dealing with a *lost token* and an *orphan frame*.

- **Lost Token:**
  - Monitor station knows the number of stations on the ring and so calculates $\text{maxTHT} = n \times \text{THT}$ (n is the number of stations on the ring). It keeps a timer of how long since it last saw the token pass by. If this is more than $\text{maxTRT}$, it drains the ring and inserts a new token in the ring.

- **Orphan frame:**
  - A frame can get orphaned if the sending station goes down before it can drain its frame. As a frame passes by the monitor, it sets the "monitor" bit in the header of the frame. If it sees a frame with this bit already set, it knows it is an orphan frame. Then the monitor drains the ring and inserts a new token in the ring.
IEEE 802.5 (Token Ring) Performance

- Under light load conditions where few stations have data to send, token ring performance is fair but there is an overhead of passing the token.

- Under heavy load condition where most of the stations have data to send, performance is excellent and utilization approaches 100%. The token is fully utilized in this case.
IEEE 802.3 (Ethernet) vs IEEE 802.5 (Token Ring)

- Ethernet is widely used at present (> 90% market share). People are experienced in using this technology.
- Ethernet uses CSMA/CD as the MAC protocol while Token Ring uses Round Robin protocol.
- Token Ring uses point-to-point connections between ring interfaces so that the electronic hardware can be fully digital and simple. There is no need for collision detection. The Ethernet NIC card requires some analog circuitry to be able to detect collisions.
- Token Ring has excellent throughput at high loads since there is no possibility of collisions unlike 802.3.
- Under light load, Token Ring experiences token passing overhead. Ethernet has no such overhead and has excellent performance at light loads.
IEEE 802.5 (Token Ring) Token Frame Format

- **Access Control (1 Byte)**
- **Start Frame Delimiter** (1 Byte)
- **End Frame Delimiter** (1 Byte)

**Priority Bits**
- 000 = lowest
- 111 = highest

**Token Bit**
- 0 = Token frame
- 1 = nontoken frame

**Monitor Bit**
- 0 = "clean" frame
- 1 = "orphaned" frame

**Reservation Bits**
- 3-bit field used for reserving a token at a prescribed priority level
IEEE 802.5 (Token Ring) Frame Format Details

- The *access control* byte contains the priority and reservation fields, as well as a token bit (used to differentiate a token from a data/command frame) and a monitor bit (used by the active monitor to determine whether a frame is circling the ring endlessly).

- The *frame control* byte indicates whether the frame contains data or control information. In control frames, this byte specifies the type of control information.

- The *frame status* byte is only present in Token Ring frames. It contains the A and C bits. When a frame arrives at the interface of a station with the destination address, the interface sets the A bit (=1), as it passes through. If the interface copies the frame to the station, it also sets the C bit (=1). A station might fail to copy a frame due to lack of buffer space or other reasons.

- When the station which sent the frame strips it from the ring, it examines the A and C bits. The three possible combinations are:
  1. A=0 and C=0; Destination not present or powered up.
  2. A=1 and C=0; Destination present but frame not accepted.
  3. A=1 and C=1; Destination present and frame copied.

- This arrangement provides an automatic acknowledgment of the delivery status of each frame.
IEEE 802.5 (Token Ring) Hierarchical Setup