

Token Ring

- Developed by IBM, adopted by IEEE as 802.5 standard
- Token rings latter extended to FDDI (Fiber Distributed Data Interface) and 802.17 (Resilient Packet Ring) standards
- Nodes connected in a ring
 - Data always flows in one direction around ring
 - Like Ethernet, all nodes see all frames, and protocol is necessary to decide when to send



Tokens

- Token ring named because token (a special sequence of bits) is passed around the ring
 - Each node receives and retransmits token
 - A node with something to transmit can take token off ring and insert frame
 - Destination node copies frame, but sends on
 - When sender receives frame, node drops it and reinserts the token
 - All nodes get chance to transmit (round-robin)



Physical Properties

 Nodes connected to ring using electromechanical relay

- Prevents node failure from crashing ring

- Several relays often packed into one multistation access unit (MSAU)
 - Provide easy addition and removal of nodes
 - Required by IBM Token Ring, not 802.5





Physical Properties (cont.)

- Data rate either 4 or 16 Mbps
- Uses Manchester encoding
- IBM Token Rings can have up to 260 stations per ring, 802.5 up to 250
- Physical medium for IBM is twisted pair, not specified for 802.5



Media Access Control

- Each node includes receiver, transmitter, one or more bits of memory between
- Ring must contain enough memory to hold entire ring
 - 802.5 token is 24 bits long, so if each station can hold only 1 bit, must have at least 24 stations, or more than one bit-time distance between stations
 - Alternative is *monitor* station that adds delay



Seizing token

- When node wants to send, modifies one bit in second byte of token – this changes first two bytes into transmission preamble
- Station then inserts one or more packets onto ring
- Each packet contains destination address, can also contain multicast or broadcast address



Receiving

- If node recognizes address, copies data from transceiver into buffer, but still forwards it
- Sending station responsible for removing packet from the ring
- Station might be draining first part of packet from ring while transmitting end of packet, if ring is small enough



Transmission Limits

- Control how long sender can transmit (token hold time, THT)
- The more bits a node can send, the better the ring utilization, but the poorer the response time for other nodes
- In 802.5, THT defaults to 10 ms
 - Sender responsible for knowing how long it has already held token, how long next packet will take to transmit



Transmission Limits (cont.)

- Nodes also compute token rotation time
 (TRT)
 - TRT ≤ ActiveNodes * THT + RingLatency
 - ActiveNodes are # that have data to send
 - RingLatency is time to send token around ring if no node has anything to send





Reliable Delivery

- Receiver sets the A bit in packet trailer if it recognizes itself as addressed node
- Sets the C bit in the trailer when it finishes copying packet into its buffer
- Sender can check for missing A or C bits when it gets packet back to verify that sender was there and was able to buffer entire packet



Priority

- Token includes 3-bit priority field
 - Each device assigns priority to each packet it needs to send
 - Only captures token if packet priority >= token's
- Frame header includes 3 reservation bits
 - Node X can set reservation bits to priority of its packet if bits don't already have >= value
 - Token holder escalates priority to that value when it releases token
 - Node X must reset priority to old value when done



Ring Maintenance

- Any node can become monitor
 - Procedure defined to elect monitor when ring first connected or monitor fails
- Monitor periodically announces its presence
- If this is missed, another station will send claim token to attempt to become monitor

 Tie broken by rule like "highest address wins"
 If sender gets claim back, it becomes monitor



Ring Monitor

- Monitor can insert delay into ring if needed
- Makes sure that there is always a token

 Timeout after NumStations*THT+RingLatency
 - Generate new token
- Removes packets if sender dies
 - Monitor bit in header set first time packet passes monitor
 - Packet with bit set is removed by monitor



Ring Monitor (cont.)

- Also detects dead stations
 - Catch more subtle errors than MSAU switch
 - Send beacon packet to suspected dead node
 - Instruct MSAU to bypass malfunctioning node





Frame Format



- Start and end delimiters use invalid Manchester codes
- Access control includes priority and reservation bits
- Frame control indicates higher level
 protocol



Frame Format (cont.)

- Addresses identical to Ethernet addresses

 Standard allows for 16-bit addresses, but they
 are not typically used
- Frame status byte includes A and C bits

