

TOKEN RINGS / IEEE 802.5

Introduction

Token ring local area network (LAN) technology is a local area network protocol which resides at the data link layer (DLL) of the OSI model. It uses a special three-byte frame called a token that travels around the ring. Token ring frames travel completely around the loop.

Stations on a token ring LAN are logically organized in a ring topology with data being transmitted sequentially from one ring station to the next with a control token circulating around the ring controlling access. This token passing mechanism is shared by ARCNET, token bus, and FDDI, and has theoretical advantages over the stochastic CSMA/CD of Ethernet.

Physically, a token ring network is wired as a star, with 'hubs' and arms out to each station and the loop going out-and-back through each.
IBM hermaphroditic connector with locking clip

Cabling is generally IBM "Type-1" shielded twisted pair, with unique hermaphroditic connectors, commonly referred to as IBM data connectors. The connectors have the disadvantage of being quite bulky, requiring at least 3 x 3 cm panel space, and, composed of many complex plastic pieces, being quite fragile.

More technically, token ring is a local area network protocol which resides at the data link layer (DLL) of the OSI model. It uses a special three-byte frame called a token that travels around the ring. Token ring frames travel completely around the loop.

Each station passes or repeats the special token frame around the ring to its nearest downstream neighbor. This token-passing process is used to arbitrate access to the shared ring media. Stations that have data frames to transmit must first acquire the token before they can transmit them. Token ring LANs normally use differential Manchester encoding of bits on the LAN media.

Speed

Token ring LAN speeds of 4 Mbit/s and 16 Mbit/s have been standardized by the IEEE 802.5 working group. An increase to 100 Mbit/s was standardized and marketed during the wane of token ring's existence while a 1000 Mbit/s speed was actually approved in 2001, but no products were ever brought to market.

Token frame

When no station is transmitting a data frame, a special token frame circles the loop. This special token frame is repeated from station to station until arriving at a station that needs to transmit data. When a station needs to transmit data, it converts the token frame into a data frame for transmission. Once the sending station receives its own data frame, it converts the frame back into a token. If a transmission error occurs and no token frame, or more than one, is present, a special station referred to as the Active Monitor detects the problem and removes and/or reinserts tokens as necessary (see Active and standby monitors). On 4 Mbit/s Token Ring, only one token may circulate; on 16 Mbit/s Token Ring, there may be multiple tokens.

Token Priority

Token ring specifies an optional medium access scheme allowing a station with a high-priority transmission to request priority access to the token.

8 priority levels, 0-7, are used. When the station wishing to transmit receives a token or data frame with a priority less than or equal to the station's requested priority, it sets the priority bits to its desired priority. The station does not immediately transmit; the token circulates around the medium until it returns to the station. Upon sending and receiving its own data frame, the station downgrades the token priority back to the original priority.

Active and standby monitors

Every station in a token ring network is either an active monitor (AM) or standby monitor (SM) station. However, there can be only one active monitor on a ring at a time. The active monitor is chosen through an election or monitor contention process.

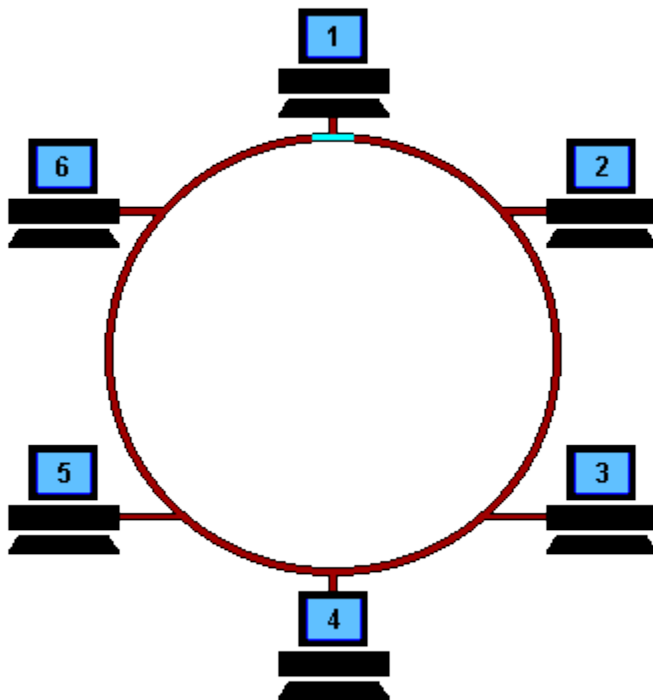
When a Token Ring network starts up, the machines all take part in a negotiation to decide who will control the ring, or become the 'Active Monitor' to give it its proper title. This is won by the machine with the highest MAC address who is participating in the contention procedure, and all other machines become 'Standby Monitors'.

The job of the Active Monitor is to make sure that none of the machines are causing problems on the network, and to re-establish the ring after a break or an error has occurred. The Active Monitor performs Ring Polling every seven seconds and ring purges when there appears to be a problem. The ring polling allows all machines on the network to find out who is participating in the ring and to learn the address of their Nearest Active Upstream Neighbour (NAUN). Ring purges reset the ring after an interruption or loss of data is reported.

How token rings works?

Unlike Ethernet, Token Ring uses a ring topology whereby the data is sent from one machine to the next and so on around the ring until it ends up back where it started. It also uses a token passing protocol which means that a machine can only use the network when it has control of the Token, this ensures that there are no collisions because only one machine can use the network at any given time.

Basic working



At the start, a free Token is circulating on the ring, this is a data frame which to all intents and purposes is an empty vessel for transporting data. To use the network, a machine first has to capture the free Token and replace the data with its own message.

In the example above, machine 1 wants to send some data to machine 4, so it first has to capture the free Token. It then writes its data and the recipient's address onto the Token (represented by the yellow flashing screen).

The packet of data is then sent to machine 2 who reads the address, realizes it is not its own, so passes it on to machine 3. Machine 3 does the same and passes the Token on to machine 4.

This time it is the correct address and so number 4 reads the message (represented by the yellow flashing screen). It cannot, however, release a free Token on to the ring, it must first send the message back to number 1 with an acknowledgement to say that it has received the data (represented by the purple flashing screen).

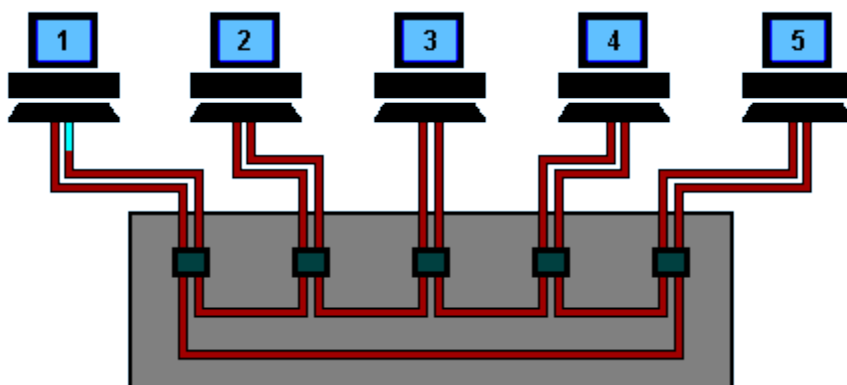
The receipt is then sent to machine 5 who checks the address, realizes that it is not its own and so forwards it on to the next machine in the ring, number 6.

Machine 6 does the same and forwards the data to number 1, who sent the original message.

Machine 1 recognizes the address, reads the acknowledgement from number 4 (represented by the purple flashing screen) and then releases the free Token back on to the ring ready for the next machine to use.

That's the basics of Token Ring and it shows how data is sent, received and acknowledged, but Token Ring also has a built in management and recovery system which makes it very fault tolerant. Below is a brief outline of Token Ring's self maintenance system

Token Ring Operation using a Hub

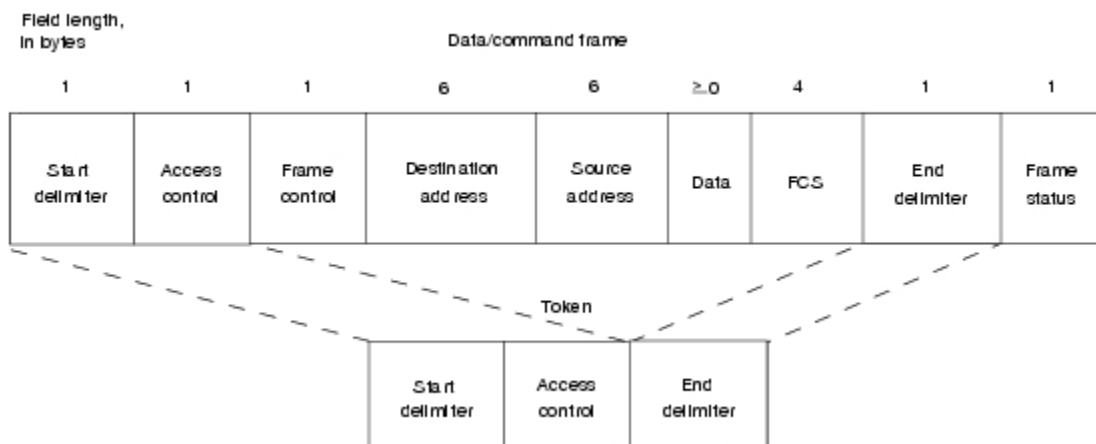


A Token Ring hub simply changes the topology from a physical ring to a star wired ring. The Token still circulates around the network and is still controlled in the same manner, however, using a hub or a switch greatly improves reliability because the hub can automatically bypass any ports that are disconnected or have a cabling fault.

Token Ring frame format

A data token ring frame is an expanded version of the token frame that is used by stations to transmit media access control (MAC) management frames or data frames from upper layer protocols and applications.

Token Ring and IEEE 802.5 support two basic frame types: tokens and data/command frames. Tokens are 3 bytes in length and consist of a start delimiter, an access control byte, and an end delimiter. Data/command frames vary in size, depending on the size of the Information field. Data frames carry information for upper-layer protocols, while command frames contain control information and have no data for upper-layer protocols. Token ring can be connected to physical rings via equipment such as 100Base-TX equipment and CAT5e UTP cable.



Token Frame Fields

The three token frame fields illustrated in Figure 9-3 are summarized in the descriptions that follow:

- **Start delimiter**—Alerts each station of the arrival of a token (or data/command frame). This field includes signals that distinguish the byte from the rest of the frame by violating the encoding scheme used

elsewhere in the frame.

- Access-control byte—Contains the Priority field (the most significant 3 bits) and the Reservation field (the least significant 3 bits), 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).
- End delimiter—Signals the end of the token or data/command frame. This field also contains bits to indicate a damaged frame and identify the frame that is the last in a logical sequence.

Data/Command Frame Fields

Data/command frames have the same three fields as Token Frames, plus several others.

The Data/command frame fields illustrated in Figure 9-3 are described in the following summaries:

- Start delimiter—Alerts each station of the arrival of a token (or data/command frame). This field includes signals that distinguish the byte from the rest of the frame by violating the encoding scheme used elsewhere in the frame.
- Access-control byte—Contains the Priority field (the most significant 3 bits) and the Reservation field (the least significant 3 bits), 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).
- Frame-control bytes—Indicates whether the frame contains data or control information. In control frames, this byte specifies the type of control information.
- Destination and source addresses—Consists of two 6-byte address fields that identify the destination and source station addresses.
- Data—Indicates that the length of field is limited by the ring token holding time, which defines the maximum time a station can hold the token.
- Frame-check sequence (FCS)—Is filed by the source station with a

calculated value dependent on the frame contents. The destination station recalculates the value to determine whether the frame was damaged in transit. If so, the frame is discarded.

- **End Delimiter**—Signals the end of the token or data/command frame. The end delimiter also contains bits to indicate a damaged frame and identify the frame that is the last in a logical sequence.
- **Frame Status**—Is a 1-byte field terminating a command/data frame. The Frame Status field includes the address-recognized indicator and frame-copied indicator.

Abort Frame

Used to abort transmission by the sending station

Token ring insertion process

Token ring stations must go through a 5-phase ring insertion process before being allowed to participate in the ring network. If any of these phases fail, the token ring station will not insert into the ring and the token ring driver may report an error.

- **Phase 0 (Lobe Check)** — A station first performs a lobe media check. A station is wrapped at the MSAU and is able to send 2000 test frames down its transmit pair which will loop back to its receive pair. The station checks to ensure it can receive these frames without error.
- **Phase 1 (Physical Insertion)** — A station then sends a 5 volt signal to the MSAU to open the relay.
- **Phase 2 (Address Verification)** — A station then transmits MAC frames with its own MAC address in the destination address field of a token ring frame. When the frame returns and if the address copied, the station must participate in the periodic (every 7 seconds) ring poll process. This is where stations identify themselves on the network as part of the MAC management functions.
- **Phase 3 (Participation in ring poll)** — A station learns the address of its Nearest Active Upstream Neighbour (NAUN) and makes its address known to its nearest downstream neighbour, leading to the creation of the ring

map. Station waits until it receives an AMP or SMP frame with the ARI and FCI bits set to 0. When it does, the station flips both bits (ARI and FCI) to 1, if enough resources are available, and queues an SMP frame for transmission. If no such frames are received within 18 seconds, then the station reports a failure to open and de-inserts from the ring. If the station successfully participates in a ring poll, it proceeds into the final phase of insertion, request initialization.

- Phase 4 (Request Initialization) — Finally a station sends out a special request to a parameter server to obtain configuration information. This frame is sent to a special functional address, typically a token ring bridge, which may hold timer and ring number information with which to tell the new station about.

References & Resources

- http://en.wikipedia.org/wiki/Token_ring
- <http://www.cisco.com/en/US/docs/internetworking/technology/handbook/Token-Ring.html>
- <http://www.datacottage.com/nch/troperation.htm>
- <http://www.ieee802.org/5/www8025org/>