Token Ring/IEEE 802.5

IBM originally designed Token Ring in 1970s, but it was then standardized in the IEEE 802.5 document, and there are many manufacturers produced Token Ring hardware.

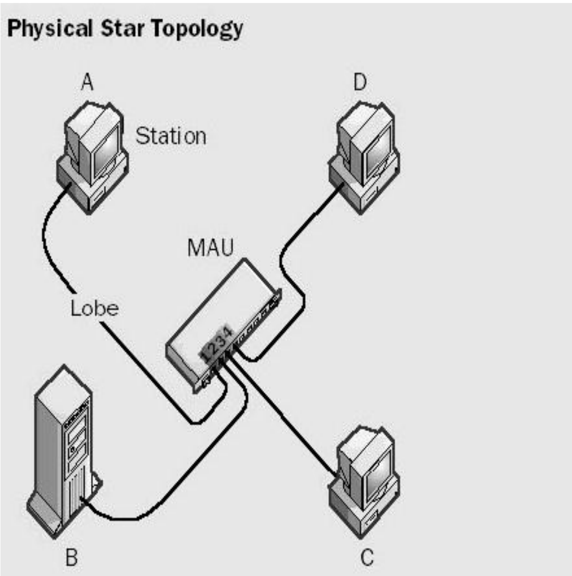
In Token Ring as in Ethernet, we will discuss the same elements: physical layer specifications, frame format, and MAC mechanism.

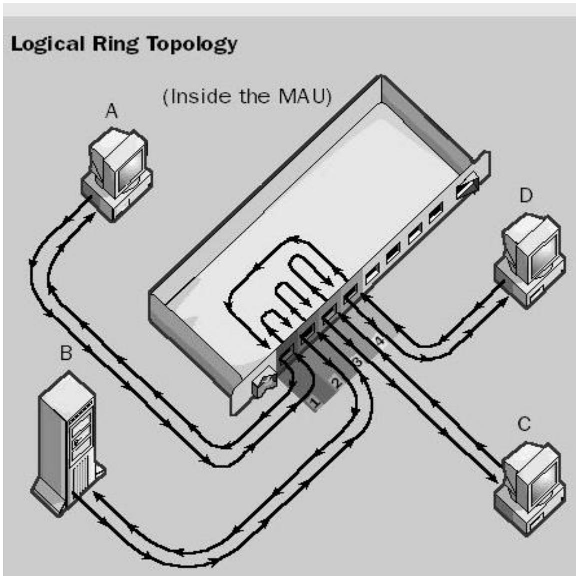
Physical Layer Specifications

Here we will mainly discuss the topology, the networking media and the bandwidths.

Topology

Token Ring networks use a ring topology, which is implemented logically inside the Multistation Access Unit (MAU), the Token Ring equivalent of a hub. The network cables take the form of a physical star topology, but the MAU forwards incoming data to the next port only, not to all of the ports at the same time, as in an Ethernet hub. This topology enables data packets to travel around the network from one workstation to the next until they arrive back at the system that originally generated them.





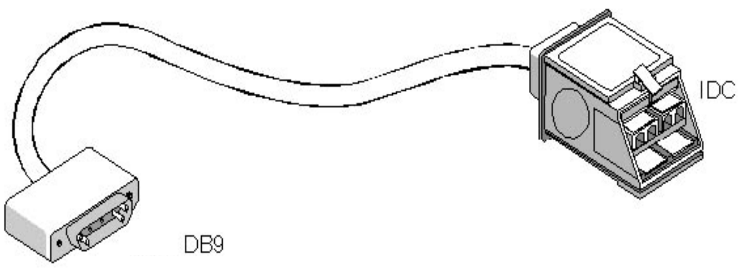
Token Ring networks use a shared medium, however, meaning that every packet is circulated to every computer on the network.

Media

The physical layer specifications for Token Ring networks are not as numerous as are those for Ethernet. Generally there are two options related to Token Ring physical layer specifications; these are called Type 1 and Type 3.

a- Type 1:

Originally, the medium for Token Ring networks was a cable known as IBM Type 1, also called the IBM Cabling System. Type 1 is a heavy, shielded twisted pair (STP) cable that is sold in various lengths, generally with connectors attached. The connector at the MAU end of the cable is a large, proprietary jack called an IBM Data Connector (IDC) or a Universal Data Connector (UDC). The NICs in the computers use standard DB-9 connectors. Cables with one IDC and one DB-9 connector, which are used to connect a computer to a MAU, are called lobe cables. Cables with IDC connectors at both ends, used for connecting MAUs together, are called patch cables. Type 1 cable is thick, relatively inflexible, and difficult to install in walls and ceilings because of its large, pre-attached connectors.



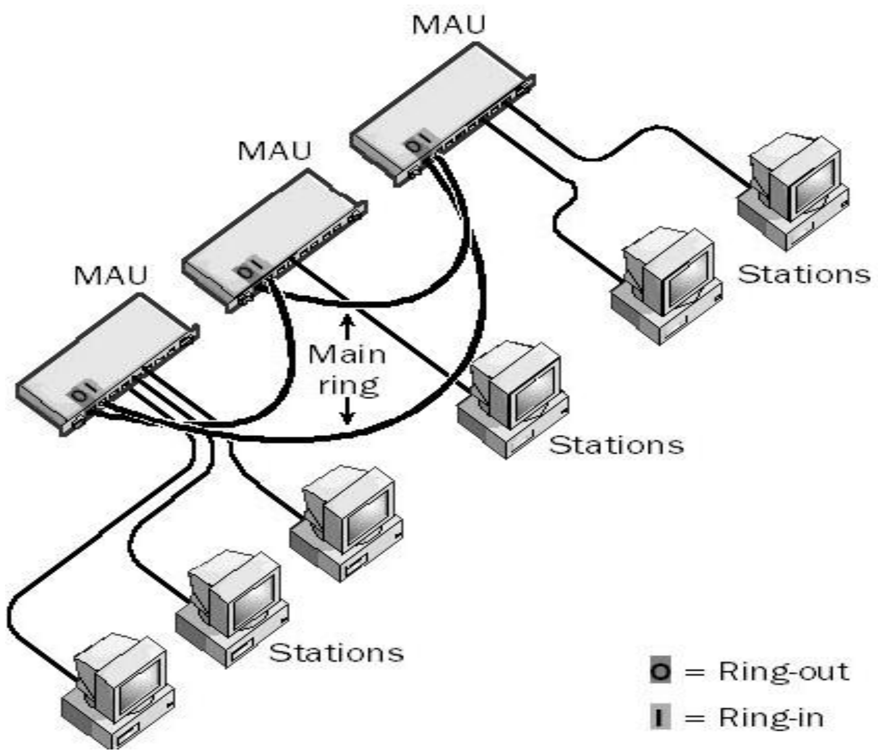
b- Type 3:

Most Token Ring networks use Category 5 UTP cable with standard RJ-45 connectors at both ends, known in the Token Ring world as Type 3 cabling. Type 3 networks use the same connectors for both computers and MAUs, In addition, it's possible to install the network inside walls and ceilings using bulk cable and attach the connectors afterward.

Some advantages Type 1 networks have over Type 3 networks are that they can span longer distances and connect more workstations. A Type 1 lobe cable can be up to 300 meters long, whereas Type 3 cables are limited to 150 meters. Type 1 networks can have up to 260 connected workstations, whereas Type 3 networks can have only 72.

Note

IBM Token Ring network stations can be wired together to form one large ring. Patch cables connect MAUs to other adjacent MAUs using "Ring IN" and "Ring OUT" ports



Bandwidth:

Token Ring networks were originally designed to run at 4 Mbps, but later implementations increased the speed to 16 Mbps. Most of the Token Ring NICs sold today support both speeds. 16 Mbps is faster than standard Ethernet, but nowhere near the 100-Mbps speed of Fast Ethernet.

Encoding:-

Token Ring networks use baseband differential Manchester encoding (a variation of Manchester encoding). While standard Ethernet uses baseband Manchester encoding.

Token Ring Frames

Unlike Ethernet, which uses one frame format for all communications, Token Ring uses four different frames:

- Data frame
- Token frame
- Command frame
- Abort delimiter frame.

1- Data frame

The largest and most complex of the Token Ring frames is the data frame. This is the frame that is most comparable to the Ethernet frame, because it encapsulates the data received from the network layer protocol using a header and a footer.

The other three frames are strictly for control functions, such as ring maintenance and error notification.

1-Byte	1-Byte	1-Byte	6-Bytes	6- Bytes	Up to 4500 Bytes	4-Bytes	1-Byte	1-Byte
Start Delimiter	Access Control	Frame Control	Destination Address	Source Address	Information (Data)	Frame Check Sequence	End Delimiter	Frame Status

The functions of the fields in the data frame are as follows:

- Start Delimiter (1 byte): This field contains a bit pattern that signals the beginning of the frame to the receiving system. The main usage for this frame is synchronization.
- Access Control (1 byte): This field contains bits that can be used to prioritize Token Ring transmissions, enabling certain systems to have

priority access to the token frame and the network. The access control byte contains the priority and reservation field, and a token and monitor bits.

3-bits	1-bit	1-bit	3-bits
priority	Token bit	Monitor bit	reservation

- Frame Control (1 byte): This field contains bits that specify whether the frame is a data or a command frame.
- Destination Address (6 bytes): This field contains the 6-byte address of the network interface adapter on the local network to which the packet will be transmitted.
- Source Address (6 bytes): This field contains the 6-byte address of the network interface adapter in the system generating the packet.
- Information (up to 4500 bytes): This field contains the data generated by the network layer protocol, including a standard LLC subheader.
- Frame Check Sequence (4 bytes): This field contains a 4-byte CRC-32 of the packet (excluding the Start Delimiter, End Delimiter, and Frame Status fields) that the receiving system uses to verify that the packet was transmitted without error.
- End Delimiter (1 byte): This field contains a bit pattern that signals the end of the frame, including a bit that specifies if there are further packets in the sequence yet to be transmitted and a bit that indicates that the packet has failed the error check.
- Frame Status (1 byte): This field contains bits that indicate whether the destination system has received the frame and copied it into its buffers.

2- Token frame

The token frame is 3 bytes long and contains only the Start Delimiter, Access Control, and End Delimiter fields. The Start Delimiter and End Delimiter fields use the same format as in the data frame, and the token bit in the Access Control field is set to a value of 1 to distinguish this frame from data frame. Monitor bit is used to distinguish a "busy" token from "free" token as will be discussed in "Token Passing" mechanism.

1-Byte	1-Byte	1-Byte
Start Delimiter	Access Control	End Delimiter

3- Command Frame

The command frame uses the same basic format as the data frame, differing only in the value of the Frame Control field and the contents of the Information field. The Information field, instead of containing network layer protocol data, contains a 2-byte called "major vector ID", which specifies the control function the packet is performing, followed by the actual control data itself, which can vary in length. The following major vector IDs values (in hexadecimal) indicate some of the most common control functions performed by these packets:

- 0010—Beacon: Beaconing is a process by which systems on a Token Ring network indicate that they are not receiving data from their Nearest Active Upstream Neighbor (NAUN), presumably because a network error has occurred. Beaconing enables a network administrator to more easily locate the malfunctioning computer on the network and also to reconfigure the network so that the malfunctioning station can be removed from the ring.
- 0100—Ring Purge: This vector ID is used by the active monitor system in the event of an error to clear the ring of unstripped data and to return all of the systems to repeat mode.

Note: Data and command frames vary in size depending on the size of the information field.

4- Abort Delimiter Frame:-

The abort delimiter frame consists of only 2 bytes, the same Start Delimiter and End Delimiter fields, and uses the same values for those fields as the data and command frames. When a problem occurs, such as an incomplete packet transmission, the active monitor system generates an abort delimiter frame to flush all existing data from the ring.

Priority System

Token Ring networks use an optional sophisticated priority system that permits certain user-designated, high priority stations to use the network more frequently. Token Ring frames have two fields that control priority, the priority field and the reservation field.

Only stations with a priority equal to, or higher than, the priority value contained in a token can seize that token. Once the token has been seized and changed to a data frame, only stations with a priority value higher than that of the transmitting station can reserve the token for the next network pass. The next token generated includes the higher priority of the reserving station. Stations that raise the priority level of a token must reinstate the previous priority when their transmission has been completed.

Active Monitor System:-

Token Ring networks use several mechanisms for detecting and compensating for network faults. Token Ring network select one station or the MAU to be the active monitor system. This system acts as a centralized source of timing information for other ring stations and performs a variety of ring maintenance functions.

1- **Errant Frame:** One of this functions of the station is to remove continuously circulating frames from the ring called "Errant" or "Orphan" frames. When a sending device fails, its frame may continue to circle the ring and prevent other stations from transmitting their own frames. This can lock up the network. The active monitor can detect these frames, remove them from the ring, and generate a new token. To avoid this the monitor system changes the value of the "monitor" bit in the Access control" field form "0" to "one" in a frame which circulates the ring for the first time. When this frame circulates the ring for the second time, the value of the monitor bit is checked again, if it

is "1" this means that this frame is an errant frame and it is drained from the ring.

2- **No Frame or NoToken:** this case occurs when the receiving station crashes after receiving a frame or a token, and thus there is nothing circulating in the ring. This problem can be solved by the by setting a timer when the frame or the token passing through the monitor station. When this timer expires and there is nothing pass through the active monitor system. It is now the responsibility of the active monitor to generate a new token.

Note: Another functions are mentioned in previous sections in this lecture such of active monitor system such as removing the a faulty NAUN, ring purge, and generating abort delimiter frame.

Token Passing

The MAC mechanism of a Token Ring LAN, called "Token Passing". Token passing is a controlled access method. In controlled access methods the station cannot send unless it is authorized by other stations. Token passing works by circulating a special packet called a token around the network. The token is only 3 bytes long and contains no useful data. Its only purpose is to designate which system on the network is allowed to transmit its data.

Repeat Mode

In their idle state, computers on a Token Ring network are in what is known as repeat mode. While in this state, the computer systems receive packets from the network and immediately forward them back to the MAU for transmission to the next port.

If a system doesn't return the packet, the ring is effectively broken and network communication ceases.

Transmit mode

After a designated system (called the active monitor) generates it, the token circulates around the ring from system to system. When a computer has data to

transmit, it must wait for a free token to arrive before it can send its data. No system can transmit without being in possession of the token, and because there is only one token, only one system on the network can transmit at any one time. This means that there can be no collisions on a Token Ring network.

When a computer takes possession of the token, it changes the value of the monitor bit to "one" and forwards the packet back to the MAU for transmission to the next computer on the ring. At this point, the computer enters transmit mode. The new value of the monitor bit informs the other computers that the network is in use and that they can't take possession of the token themselves. Immediately after the computer transmits the "network busy" token, it transmits its data packet.

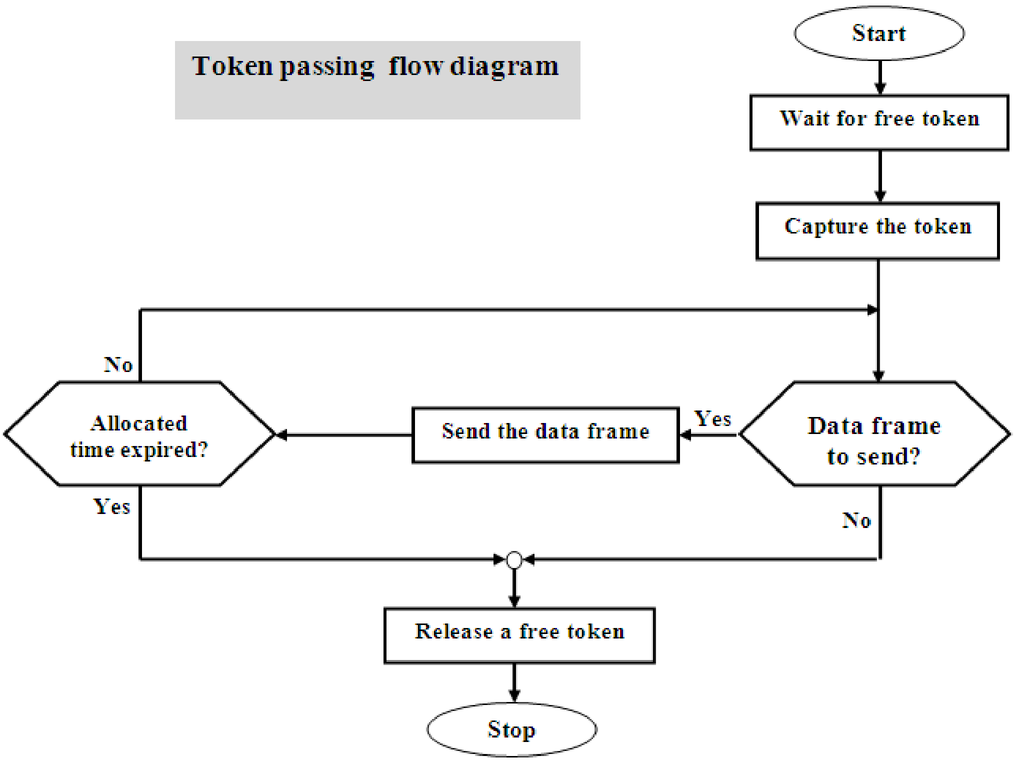
Strip mode

As with the token frame transmitted immediately before it, the MAU forwards the data packet to each computer on the ring in turn. The information frame circulates around the ring until it reaches the intended destination station, which copies the information for processing. The information frame continues around the ring until it reaches the sending station. At the same time that the sending computer goes into transmit mode, its receive wire pair goes into stripping mode. When the data packet traverses the entire ring and returns to its source, it is the responsibility of the sending computer that generated the packet to strip it from the network. This prevents the packet from circulating endlessly around the ring. The sending station can verify whether the frame was received and copied by the destination.

Token release

The original Token Ring network design calls for the system transmitting its data packet to wait for the last bit of data to arrive back at its source before it generates a new token by modifying the monitor bit in the token frame back to its original value and transmitting it.

The following diagram illustrates the four modes of Media Access Control mechanism used by IEEE 802.5 networks



Early Token release

Most 16-Mbps Token Ring networks have a feature called early token release, which enables workstations to transmit a free token immediately after their data packets. This way, another system on the network can receive a data packet, take possession of the token, and begin transmitting its own data frame before all of the data from the first packet has returned to its source. There are parts of two data frames on the network at the same time, but there is never more than one free token.

Token passing vs. CSMA/CD:

Token passing is an inherently more efficient MAC mechanism than CSMA/CD because it provides each system on the network with an equal opportunity to transmit its data without generating any collisions and without diminished performance at high traffic levels.

Unlike CSMA/CD networks, such as Ethernet, token passing networks are deterministic. This means that you can calculate the maximum time that will pass before any end station will be able to transmit.

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