Module
5

Broadcast Communication Networks

Lesson 5

High Speed LANs – Token Ring Based

Specific Instructional Objectives

On completion, the student will be able to:

- Explain different categories of High Speed LANs
- Distinguish FDDI from IEEE80 2.5 Token ring LAN
- Explain how FDDI provides higher reliability

5.5.1 Introduction

The IEEE 802.3 and 802.5 LANs, discussed in the previous sections, having data transfer rate in the range of 10 Mb/s to 16 Mb/s have served the purpose very well for many years. But with the availability of powerful computers at a low cost and emergence of new applications, particularly based on multimedia, there is a growing demand for higher network bandwidth. The combined effect of the growth in the number of users and increasing bandwidth requirement per user has led to the development of High Speed LANs with data transfer rate of 100 Mb/s or more.

The high speed LANs that have emerged can be broadly categorized into three types *based on token passing*, *successors of Ethernet* and *based on switching technology*. In the first category we have *FDDI* and its variations, and high-speed token ring. In the second category we have the *fast Ethernet* and *Gigabit Ethernet*. In the third category we have *ATM*, *fiber channel* and the *Ether switches*. In this lesson we shall discuss details of FDDI – the token ring based high speed LAN.

5.5.2 FDDI

Fiber Distributed Data Interface (FDDI), developed by American National Standards Institute (ANSI) is a token passing ring network that operates at 100 Mb/s on optical fiber-medium. Its medium access control approach has close similarity with the IEEE 802.5 standard, but certain features have been added to it for higher reliability and better performance. Key features of FDDI are outlined in this section.

The FDDI standard divides transmission functions into 4 protocols: physical medium dependent (PMD), Physical (PHY), media access control(MAC) and Logical link control(LLC) as shown in Fig. 5.5.1. These protocols correspond to the physical and data link layer of OSI reference model. Apart from these four protocols, one more protocol which span across both data link and physical layer (if considered of OSI), used for the station management.

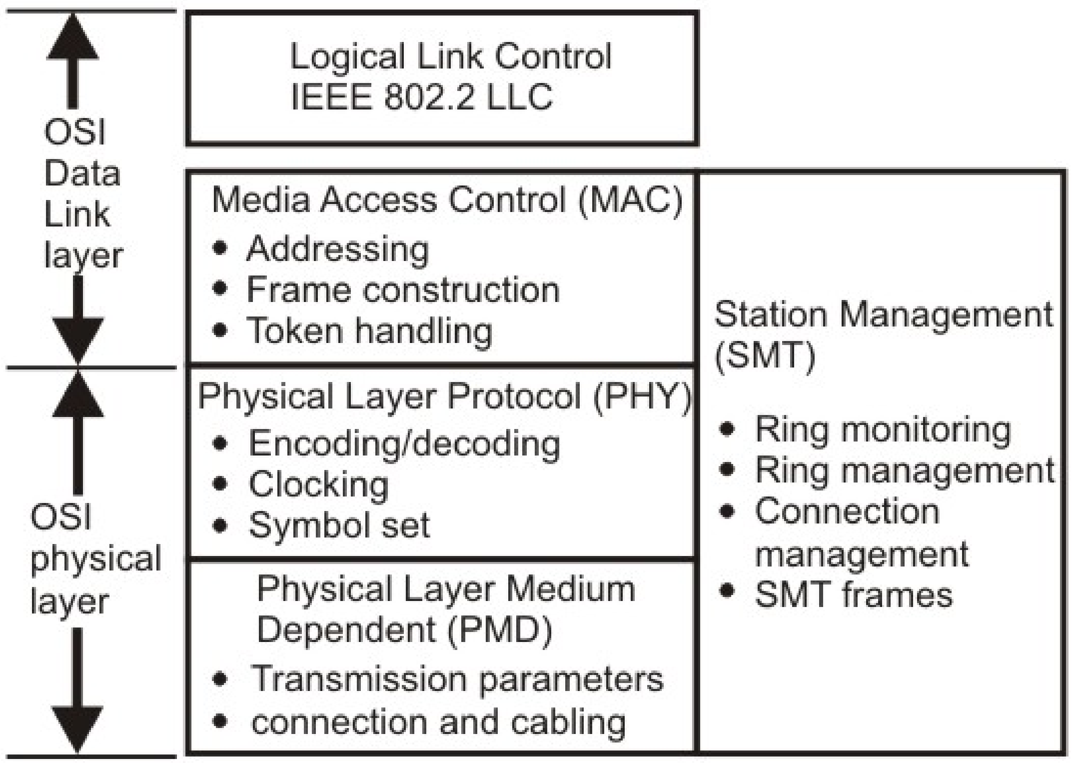


Figure 5.5.1 FDDI protocols

5.5.2.1 Medium

As shown in Table 5.5.1, the standard physical medium is multi-mode 62.5/125 micron optical fiber cable using light emitting diode (LED) transmitting at 1300 nanometers, as the light source. FDDI can support up to 500 stations with a maximum distance of 2 Km between stations and maximum ring circumference of 200 Km. Single-mode 8-10/125 micron optical fiber cable has also been included in the standard for connecting a pair of stations separated by a distance in excess of 20 km.

The standard has also been extended to include copper media - Shielded Twisted Pair (STP) and some categories of Unshielded Twisted Pair (UTP) with a maximum distance of 100 m between stations. FDDI over copper is referred to as *Copper-Distributed Data Interface (CDDI)*.

Optical fiber has several advantages over copper media. In particular, security, reliability, and performance are all enhanced with optical fiber media because fiber does not emit electrical signals. A physical medium that does emit electrical signals (copper) can be tapped and therefore vulnerable to unauthorized access to the data that is transmitted through the medium. In addition, fiber is immune to radio frequency interference (RFI) and electromagnetic interference (EMI). Fiber historically has supported much higher bandwidth (throughput potential) than copper, although recent technological advances have made copper capable of transmitting at 100 Mbps or more. Finally, FDDI allows 2 Km between stations using multimode fiber, and even longer distances using a single mode fiber.

Table 5.5.1 FDDI Physical layer specification

Trans. Medium	Optical Fiber 62.5/125 um	Twisted pair CAT5-UTP
Data Rate	**100 Mbps**	**100Mbps**
Signaling Technique	**4B/5B/NRZ-I 125 Mbaud**	**MTL-3**
Max. No. Repeaters	**100**	**100**
Max. distance	**2Km**	**100m**

FDDI uses 4B/5B code for block coding. The 5-bit code is selected such that it has no more than one leading zero and no more than two trailing zeros and more than three consecutive 0's do not occur. Table 5.5.2 shows the encoded sequence for all the 4-bit data sequences. The This is normally line coded with NRZ-I.

Table 5.5.2 4B/5B encoding

Data Sequence	Encoded Sequence	Data Sequence	Encoded Sequence
0000	11110	Q (Quiet)	00000
0001	01001	I (Idle)	11111
0010	10100	H (Halt)	00100
0011	10101	J (start delimiter)	11000
0100	01010	K (start delimiter)	10001
0101	01011	T (end delimiter)	01101
0110	01110	S (Set)	11001
0111	01111	R (Reset)	00111
1000	10010		
1001	10011		
1010	10110		
1011	10111		
1100	11010		
1101	11011		
1110	11100		
1111	11101		

4B/5B encoding

5.5.2.2 Topology

The basic topology for FDDI is *dual counter rotating rings:* one transmitting clockwise and the other transmitting counter clockwise as illustrated in the Fig. 5.5.2. One is known as *primary ring* and the other *secondary ring*. Although theoretically both the rings can be used to achieve a data transfer rate of 200 Mb/s, the standard recommends the use of the primary ring for data transmission and secondary ring as a backup.

In case of failure of a node or a fiber link, the ring is restored by wrapping the primary ring to the secondary ring as shown in Fig. 5.5.3. The redundancy in the ring design provides a degree of fault tolerance, not found in other network standards. Further improvement in reliability and availability can be achieved by using *dual ring* of trees and *dual homing* mechanism.

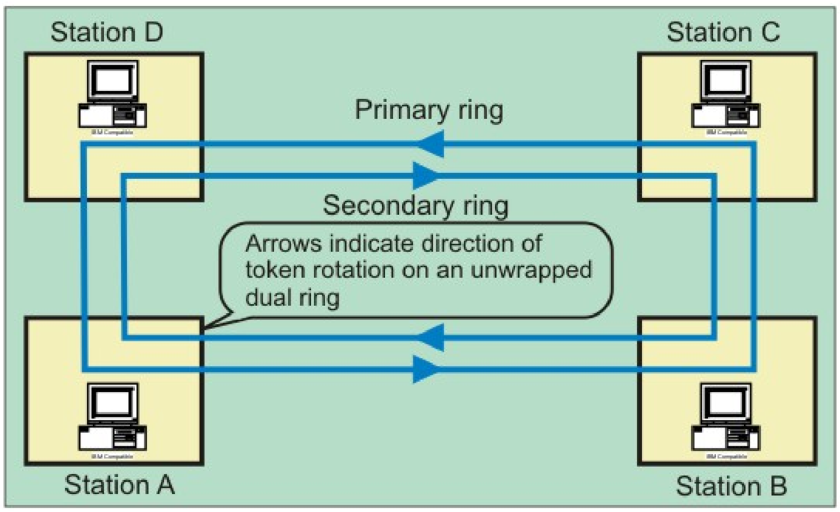


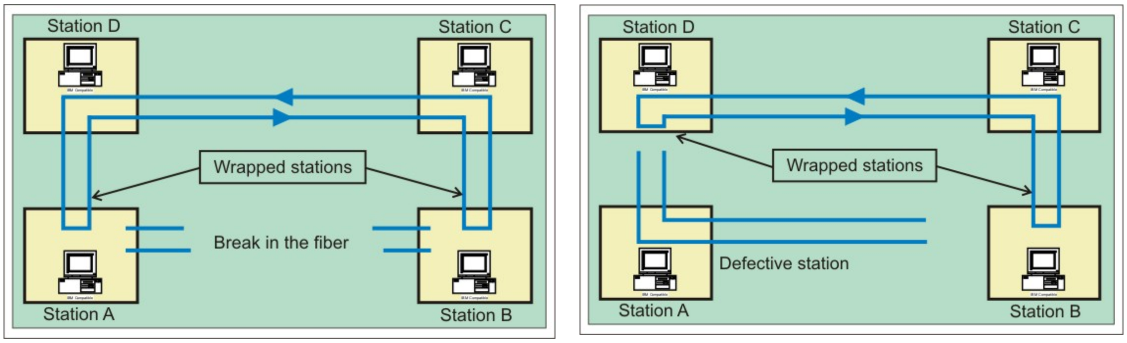
Figure 5.5.2 FDDI dual counter-rotating ring topology

5.5.2.3 Fault Tolerance

FDDI provides a number of fault-tolerant features. In particular, FDDI's dual-ring environment, the implementation of the optical bypass switch, and dual-homing support make FDDI a resilient media technology.

Dual Ring

FDDI's primary fault-tolerant feature is the *dual ring*. If a station on the dual ring fails or is powered down, or if the cable is damaged, the dual ring is automatically wrapped (doubled back onto itself) into a single ring. When the ring is wrapped, the dual-ring topology becomes a single-ring topology. Data continues to be transmitted on the FDDI ring without performance impact during the wrap condition. Figure 5.4.2(a) and Figure 5.4.2(b) illustrate the effect of a ring wrapping in FDDI.



(a) (b)

Figure 5.5.3 FDDI ring with a (a) broken link, (b) defective station

When a cable failure occurs, as shown in Fig. 5.5.3(a), devices on either side of the cable fault wrap. Network operation continues for all stations. When a single station fails, as shown in Fig. 5.5.3(b), devices on either side of the failed (or powered-down) station wrap, forming a single ring. Network operation continues for the remaining stations on the ring. It should be noted that FDDI truly provides fault tolerance against a single failure only. When two or more failures occur, the FDDI ring segments into two or more independent rings that are incapable of communicating with each other.

Optical Bypass Switch

An *optical bypass switch* provides continuous dual-ring operation if a device on the dual ring fails. This is used both to prevent ring segmentation and to eliminate failed stations from the ring. The optical bypass switch performs this function using optical mirrors that pass light from the ring directly to the DAS (dual-attachment station) device during normal operation. If a failure of the DAS device occurs, such as a power-off, the optical bypass switch will pass the light through itself by using internal mirrors and thereby will maintain the ring's integrity.

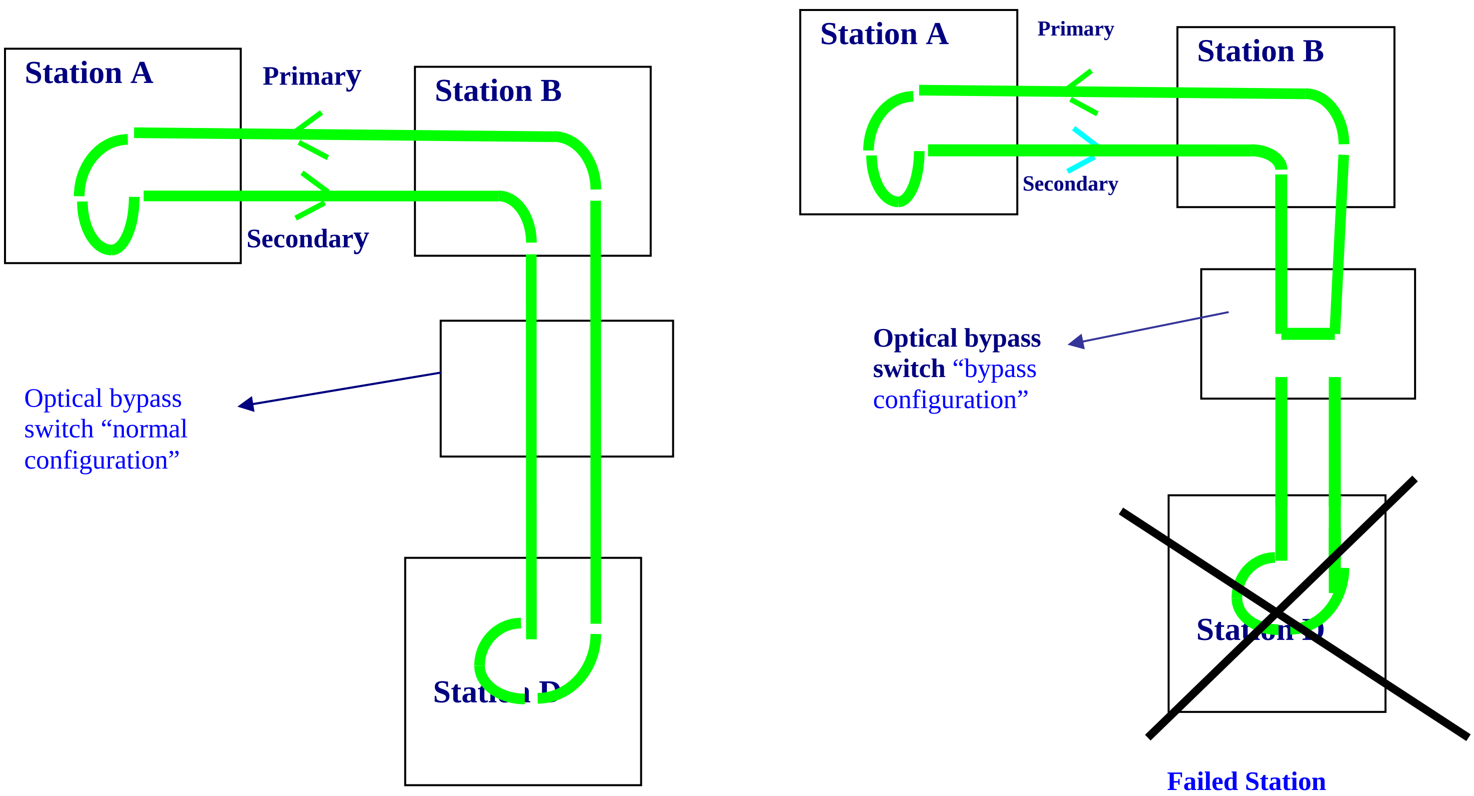


Figure 5.5.4 The Optical Bypass switch uses internal mirrors to maintain a network

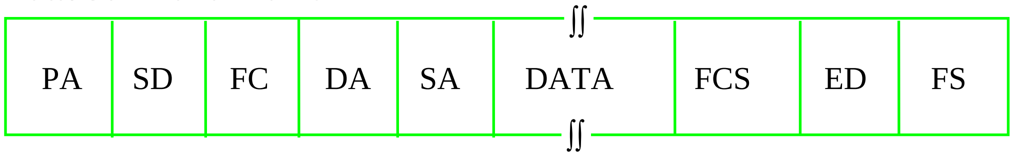
The benefit of this capability is that the ring will not enter a wrapped condition in case of a device failure. A somewhat similar technique has been discussed in Token ring section (Star Connected Ring- where relays are used to bypass the faulty node). Figure 5.5.4 shows the functionality of an optical bypass switch in an FDDI network. When using the OB, you will notice a tremendous digression of your network as the packets are sent through the OB unit.

Dual Homing: Critical devices, such as routers or mainframe hosts, can use a fault-tolerant technique called *dual homing* to provide additional redundancy and to help guarantee operation. In dual-homing situations, the critical device is attached to two concentrators.

5.5.2.4 Frame Format

Each Frame is preceded by a preamble (16 idle symbols-1111), for a total of 64 bits, to initialize clock synchronization with the receiver. There are 8 fields in the FDDI frame as shown in Fig. 5.5.5.

Data/Command Frame



Token

PA :	Preamble
SD :	Starting Delimiter
FC :	Frame Control
DA :	Destination Address
SA :	Source Address
FCS:	Frame Check Sequence
ED :	Ending Delimiter
FS :	Frame Status

Figure 5.5.5 Frame format for the FDDI

Let us have a look at the various fields:
SD: The first byte, after the preamble, of the field is the frame's starting flag. As in Token ring these bits are replaced in physical layer by the control codes.

FC: it identifies the frame type i.e. token or a data frame.
Address: the next 2 fields are destination and source addresses. Each address consists of 2-6 bytes.

Data: Each data frame carries up to 4500 bytes.

FCS: FDDI uses the standard IEEE four-byte cyclic redundancy check.
ED: this field consists of half a byte in data frame or a full byte in token frame. This represents end of the Token.

FS: FDDI FS field is similar to that of Token Ring. It is included only in data/Command frame and consists of one and a half bytes.

5.5.2.5 Media Access Control

The FDDI media access control protocol is responsible for the following services.

(i) Fair and equal access to the ring by using a *timed token protocol*. To transmit on the ring, a station must first acquire the token. A station holds the token until it has transmitted all of its frames or until the transmission time for the appropriate service is over. Synchronous traffic is given a guaranteed bandwidth by ensuring that token rotation time does not exceed a preset value. FDDI implements these using three timers, *Token holding Timer* (THT), which determines how long a station may continue once it has captured a token. *Token Rotation Timer* (TRT) is reset every time a token is seen. When timer expires, it indicates that the token is lost and recovery is started. The *Valid*

Transmission Timer (VTT) is used to time out and recover from some transmit ring errors.

(ii) Construction of frames and tokens are done as per the format shown in Figure 5.5.5. The frame status (FS) byte is set by the destination and checked by the source station, which removes its frame from the ring and generates another token.

(iii) Transmitting, receiving, repeating and stripping frames and tokens from the ring, unlike IEEE 802.5, is possible for several frames on the ring simultaneously. Thus a station will transmit a token immediately after completion of its frame transmission. A station further down the ring is allowed to insert its own frame. This improves the potential throughput of the system. When the frame returns to the sending station, that station removes the frame from the ring by a process called *stripping*.

(iv) It also does *ring initialization*, *fault isolation* and error detection as we have discussed for IEEE 802.5.

5.5.2.6 FDDI and the OSI model

The relationship between the OSI model and the FDDI layered architecture is shown in Fig. 5.5.1. The physical layer is divided into two sub layers: PMD and PHY. The lower sub layer is defined by *Physical Layer Medium Dependent* (PMD) standards, which specify requirements such as media and connection types. The upper sub layer is defined in the physical layer protocol (PHY) standard, which is medium-independent. It defines symbols, line status, encoding/decoding techniques, clocking requirements and data framing requirements.

The Data Link Layer is divided into two sub layers, MAC and LLC. The lower sub layer, the FDDI Media Access Control (MAC) standard defines *addressing conventions*, *frame formats* and the *timed token protocol*. The upper sub layer is defined in the IEEE 802.2 LLC standard, which provides a means for exchanging data between LLC users.

The Station Management (SMT) standard provides services that monitor and control a FDDI station. SMT include facilities for connection management, node configuration, recovery from error condition, and encoding of SMT frames.

The FDDI has been successfully used as a backbone LAN in an enterprise network or in a campus network.

5.5.2.7 Comparison

Important features of the FDDI with the two popular IEEE 802 LAN standards are given in the Table 5.5.3

Table 5.5.3 Comparison of the standards

COMPARISON AMONG STANDARDS			
Parameters	FDDI	IEEE 802.3	IEEE 802.5
• BANDWIDTH	100Mb/s	10Mb/s	4 or 16Mb/s
• NUMBER OF STATIONS	500	1024	250
• MAX. DISTANCE BETWEEN STATIONS	2Km (MMF) 20Km (SMF)	2.8Km	300m (4Mb/s) 100m (RECO.)
• MAX. NETWORK EXTENT	100Km	2.8Km	VARIED WITH CONFIGURATION
• LOGICAL TOPOLOGY	DUAL RING, DUAL RING OF TREES	BUS	SINGLE RING
• PHYSICAL TOPOLOGY	RING, STAR HIERARCHICAL STAR	BUS, STAR	RING BUS HIERARCHICAL STAR
• MEDIA	OPTICAL FIBER	OPTICAL FIBRE, TWISTED-WIRE, COAXIAL CABLE	TWISTED-WIRE OPTICAL FIBER
• ACCESS METHOD	TIMED-TOKEN PASSING	CSMA/CD	TOKEN PASSING
• TOKEN ACQUISITION	CAPTURES THE TOKEN	-	BY SETTING A STATUS BIT
• TOKEN RELEASE	AFTER TRANSMIT	-	AFTER STRIPPING OR AFTER TRANSMIT (16)
• FRAMES ON LAN	MULTIPLE	SINGLE	SINGLE
• FRAMES TRANSMITTED PER ACCESS	MULTIPLE	SINGLE	SINGLE
• MAX. FRAME SIZE	4500 BYTES	1518 BYTES	4500 BYTES (4) 17,800 BYTES (16)

Fill In The Blanks:

1. The high speed LANs that have emerged can be broadly categorized into three types_______________, successors of Ethernet and ____________.
2. *ATM, fiber channel* and the Etherswitches comes under high speed LANs based on _________________.
3. _______________________ is abbreviated as FDDI.
4. FDDI over copper is referred to as ____________________________.
5. The basic topology for FDDI is ______________________.
6. An _____________ provides continuous dual-ring operation if a device on the dual ring fails
7. Each data frame in FDDI carries up to _____________ bytes.

8. FDDI gives fair and equal access to the ring by using a _________ *protocol.*
9. FDDI implements MAC using three timers namely: ________________, *Token Rotation Timer* (TRT) and ___________________
10. *Token holding Timer* (THT), which determines ___________________________.
11. The frame status (FS) byte is set by the ____________ and checked by the _______________ station which removes its frame from the ring and generates another token.
12. When the frame returns to the sending station, that station removes the frame from the ring by a process called ___________.
13. The physical layer is divided into two sub layers - _______ and ______

Solutions...

1. based on token passing, based on switching technology.
2. based on switching technology.
3. Fiber Distributed Data Interface
4. *Copper-Distributed Data Interface (CDDI).*
5. *dual counter rotating rings*
6. *optical bypass switch*
7. 4500
8. *timed token*
9. *Token holding Timer* (THT), *Valid Transmission Timer* (VTT)
10. how long a station may continue once it has captured a token
11. destination, source
12. *stripping*
13. *PMD, PHY*

Short Questions:

Q-1. In what way the MAC protocol of FDDI differs from that of token ring?

Ans: In the frame format of FDDI protocol, preamble is eight bytes instead of one byte in token ring. Also token has one additional byte.

FDDI can have multiple frames simultaneously, which cannot be present in token ring. Here, the access method is timed token passing. Multiple frames can be transmitted after capturing a token.

First, the entire token is captured and then the data frames are introduced, whereas token ring follows token passing protocol and beginning of token is converted to the header of a frame.

In case of token ring token is released after receiving the acknowledgement (as the data frame returns after circulating the ring). On the other hand, in case of FDDI, token is released immediately after sending data frame, which is known as early token release.

Q-2. How FDDI offers higher reliability than token ring protocol?

Ans: Token ring protocol is applicable in a single ring. Disadvantage of this protocol is that, if one segment of wires fails or a node fails, the protocol cannot work. To increase reliability, ***dual counter ring topology*** used in FDDI protocol, where there are two rings, called primary ring and secondary ring. In case of failure of a node or a fiber link, the ring is restored the by wrapping up the primary ring to the secondary ring. Further improvement in reliability can achieve by using ***dual ring of trees*** and ***dual homing*** mechanism. It will provide multiple paths and if one path fails, another path will be available for passing token or data.

Q-3 What are the functionalities of a Optical Bypass Switch?

Ans: An *optical bypass switch* provides continuous dual-ring operation if a device on the dual ring fails. This is used both to prevent ring segmentation and to eliminate failed stations from the ring. The optical bypass switch performs this function using optical mirrors that pass light from the ring directly to the DAS (dual-attachment station) device during normal operation. If a failure of the DAS device occurs, such as a power-off, the optical bypass switch will pass the light through itself by using internal mirrors and thereby will maintain the ring's integrity. When using the OB, you will notice a tremendous digression of your network as the packets are sent through the OB unit.

Q-4 What are the functionalities provided by SMT standard?

Ans: The Station Management (SMT) standard provides services that monitor and control a FDDI station. SMT include facilities for connection management, node configuration, recovery from error condition, and encoding of SMT frames.

Q-5 Describe various fields in frame format of FDDI?

Ans: Let us have a look at the various fields:
SD: The first byte, after the preamble, of the field is the frame's starting flag. As in Token ring these bits are replaced in physical layer by the control codes.
FC: it identifies the frame type i.e. token or a data frame.
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