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Fiber Distributed Data Interface

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Fiber Distributed Data Interface [+]

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FIBER DISTRIBUTED DATA INTERFACE[*]

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Abstract

Fiber Distributed Data Interface is the 100Mbps LAN standard being developed by the ANSI's ASC X3T9 committee. This is the first attempt to provide a standard for fiber-optic LANs and is attracting a lot of attention due to its high bandwidth and reliability features. This report is a technical description of the FDDI and most of the information is based on the ANSI standards X3.139-1987 , X3.148-1988 and various other publications by the people working on development and implementation of FDDI.

The author is with Indian Institute of Technology, Bombay and this report is a part of a study on high speed Computer Networks and Protocols ,supported by UNDP at Purdue University.

Contents

1 Introduction

Fiber Distributed Data Interface (FDDI) is the emerging ANSI standard for high speed (100 Mbps) fiber-optic ring networks being developed by the ANSI X3T9 Committee[1]. The default values for FDDI are based on a configuration including 1000 nodes and a total fiber path of 200 kms. It is essentially a packet switched network standard but there is a companion standard called FDD1-II which will provide both circuit and packet switching capabilities.

The main LAN technologies in use are the CSMA/CD(802.3 or ethernet), token bus(IEEE 802.4) and token ring. CSMA/CD and token bus can not be used in fiber optic LANs because of difficulties in tapping the fiber. Token ring architecture is most suitable for the optical LANs[2]. IEEE 802.5 Token ring standard[3] is the starting basis for FDDI development with modifications and enhancements for supporting the higher speed[4] . For instance in 802.5 a token is issued after the transmitted frame comes back to the originating station whereas in FDDI it is issued immediately after the transmission.

FDDI has a lot of reliability features which allow it to monitor the ring and do self recovery in case of many faults[5]. At physical level it consists of dual,counter-rotating rings which are provided with bypass switches. The Station Management component of the protocol monitors the ring and in case of a station failure the bypass switches are used to connect the two rings into a single ring. If there are more than one failure, the rings can be divided into two independent rings(Fig. 1). This feature ensures that even in case of limited station failures/fiber breaks, some connectivity is still provided. This makes FDDI a better choice for remote sites like space stations. RIACS is evaluating FDDI for its suitability in space applications.

FDDI stations are of two types - Class A and Class B . Class A stations are directly connected to both the rings and Class B stations are in turn connected to the ring through a Class A station ,called a concentrator (Fig. 2). Class B stations do not have access to the main ring if the concentrator links fail.

The FDDI consists of:

i. A Physical layer, which is the fiber-optic medium, optical switches and interconnections. It also defines the encode /decode and clock requirements for the frames.

ii. A Data Link Layer, which consists of a Media Access Control(MAC) a Link Layer Control(LLC). The MAC provides the logical station to station connection and LLC interfaces to the upper network layer.

iii. A Station Management(SMT) which is distributed among various stations and does the monitoring , control and fault recovery.

The layers above MAC are not defined yet and may vary depending upon the requirements. Fig. 3 shows the layerwise organization of an FDDI station.

4
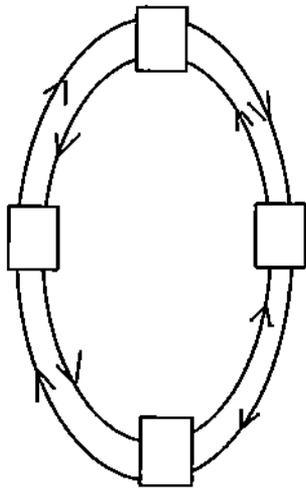
a. FDDI DUAL RING
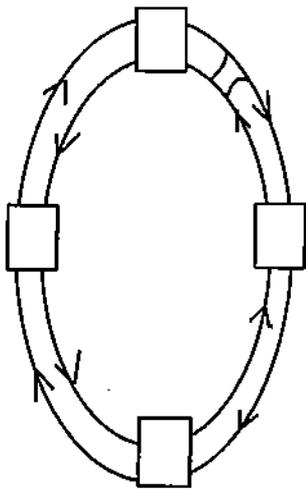
b. Ring with a break/station failure
(Single Ring)
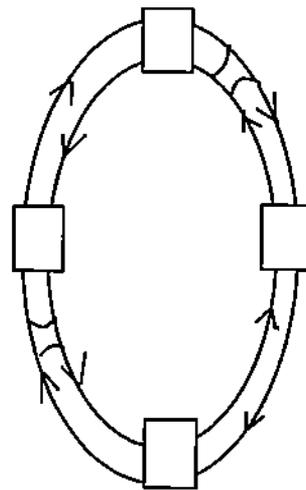
c. Ring with two breaks.
(Independent rings)

FIG 1. STATION BYPASS IN CASE OF FAILURE

5

UPPER LAYERS(NETWORK/TRANSPORT)

LLC

DATA LINK
LAYER

MAC

S

PHYSICAL
LAYER

PHY

M

T

PMD

OR
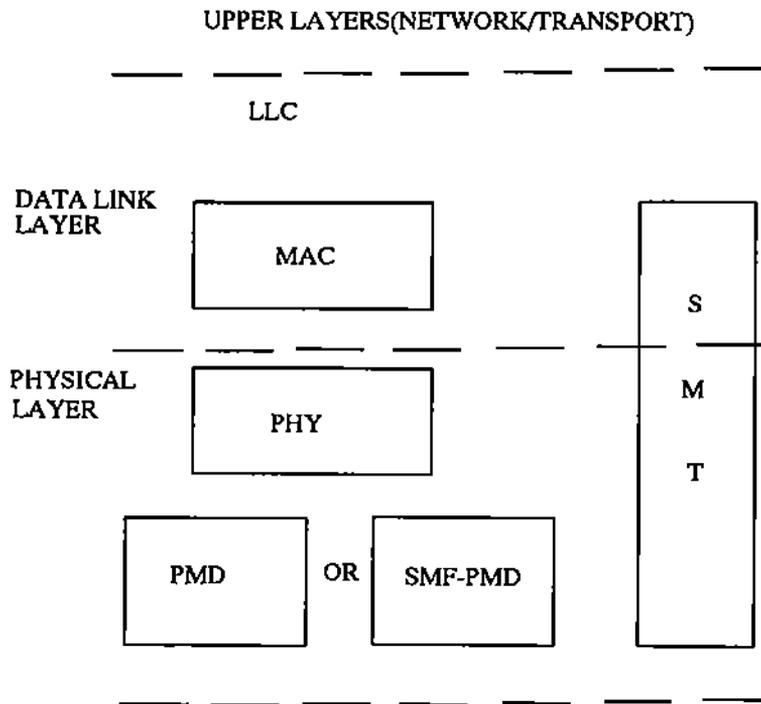
SMF-PMD

PMD = Physical Medium Dependent
SMF-PMD = Single Mode Fiber PMD
PHY = Physical Layer Protocol
MAC = Media Access Control
LLC = Link Layer Control
SMT = Station Management

Fig. 2 Organization of FDDI Layers.

6

CLASS B STATIONS.
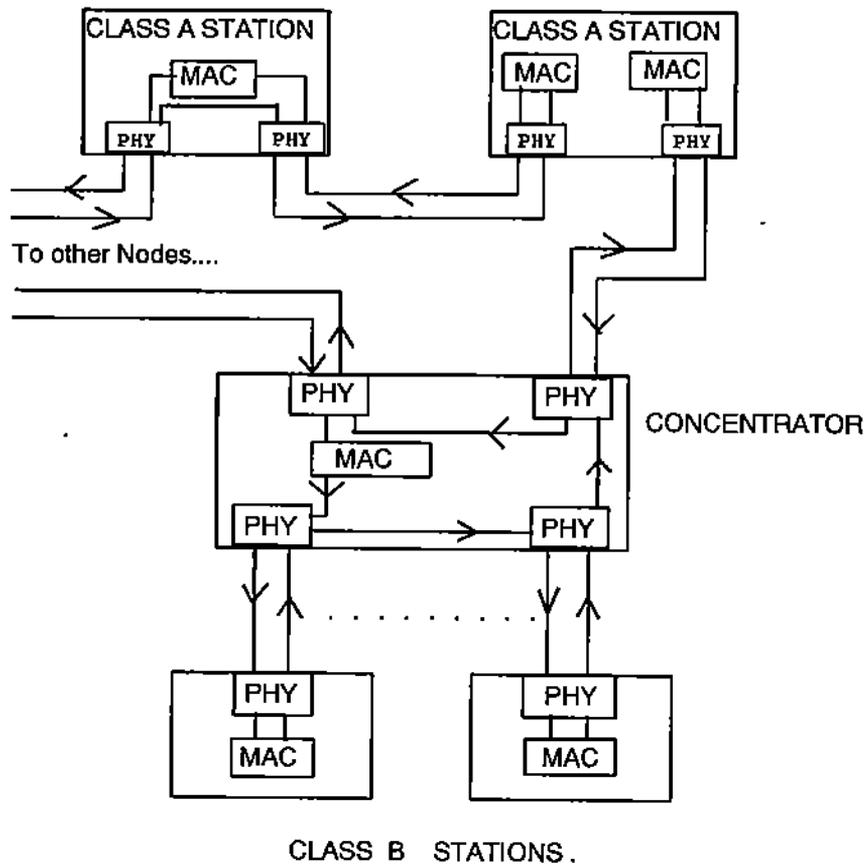
PHY = Physical Layer Protocol.   MAC = Media Access Control

FIG 3. TYPES OF STATIONS.

2 Physical Layer

The Physical Layer consists of two sublayers - Physical Medium Dependent and the Physical Layer Protocol. A description follows.

2.1 Physical Medium Dependent(PMD)

The PMD includes the optical medium and the interface. It has three major components - Media interface connector (MIC), Station bypass switch, and an optical transceiver . An FDDI station is attached to the medium through MIC which is different for Dual and single attachment stations. The station bypass interface is usually an optical switch and the transceiver consists of an optical transmitter and a receiver.

2.1.1 Optical Fiber

The fiber is made of silica glass core with a cladding of slightly different refractive index to prevent losses. Outside the cladding is a protective plastic coating. Fibers are of two types - Singlemode(SMF) and Multimode(MMF). SMFs can support bandwidths of the order of 100 GHz-km. Multimode fibers have lower bandwidths but are inexpensive. Both types are supported by the FDDI although MMFs are adequate to meet the FDDI requirements. The major specifications for fibers are -

i. Core Diameter - It is different for MMF and SMFs. Core diameters used are 62.5 microns and 85 microns.

ii. Cladding Diameter - A uniform diameter of 125 microns is used by everyone to ensure compatible connectors and efficient coupling.

iii. Numerical Aperture - NA is the light collecting ability of the waveguide . It is defined as the sine of the angle of cone of light which couples itself to the fiber. For SMFs this is 0.275 and for MMFs 0.26.

iv. Bandwidth-distance product(at a specified wavelength)- For FDDI the required specification is 450 MHz-km . In fact the limitation is not due to the fiber but due to the slower electronic circuitry , optical transmitters and receivers .

v. Attenuation - Three local minimas in the attenuation vs wavelength curves for silica fiber are at 800, 1300 and 1500 nms. The LEDs are available for 800 and 1300nms but dispersion is lower at 1300 nm which is the wavelength specified for FDDI.

vi. Dispersion - Dispersion is the spreading of signal (pulse spreading) while traveling through the waveguide and tends to reduce the available bandwidth . The acceptable limits of dispersion slope(around a wavelength of 1300nm)are 0.5 and 0.11.

2.1.2 Optical Transmitter

Optical communication systems normally use LEDs or Lasers as the optical sources. Although lasers can provide more power, they are much more expensive and require complex driver circuitry. They can meet the FDDI specs but the PMD is designed to

support the LEDs. A transmitter consists of an LED and associated driver circuitry which provides the current to drive them. LEDs are made up of InGaAsP and should have the following specifications –

i. Center Wavelength - LEDs are not exactly monochromatic. Their central wavelength is constrained to lie between 1270 and 1380 nms. In this region the dispersion and attenuation in multimode fibers are at a minimum.

ii. Spectral width - Is defined as the width of wavelength over which the output power is within 3 dB of peak. This width for LEDs vary between 70 and 200 nm which is the acceptable limit for FDDI if center wavelength lies between 1270 and 1380 nm.

iii. Average optical power - This power should be between -14 to -20 dBm . A greater power can saturate the receiver and is not desirable.

iv. Optical Rise and Fall time - These are specified as the time between 10 and 90% levels and can restrict the system bandwidth. For FDDI these timings are specified between 0.6 and 3.5 ns .

2.1.3 Optical Receiver

An optical receiver consists of a photodetector, amplifier, filters and signal detection circuitry. PIN diodes are the photodetectors used in FDDI and are made of InGaAs/InP . The major specifications are-

i. Receiver Sensitivity - This is the minimum inputoptical power which gives a particular BER(bit error rate). For FDDI BER is $2.5 * 10E -10$ and Sensitivity is defined as -31dBm.

ii. Dynamic Range - It refers to the average input power range over which the BER can be maintained. The Dynamic range for FDDI is defined to be 17dBm (max. optical output minus receiver sensitivity).

iii. Optical Input Rise and Fall times - These are defined as between 0.6 and 5 ns to avoid interference between adjacent bits .

2.1.4 Optical Switches

These are optional in FDDI and provide extra reliability by bypassing a station in case of a failure. The optical switches are mostly of two types - moving mirror/ prism and moving fiber. As the name suggests, they have moving parts to couple the signal to different waveguides. The attenuation for these is defined as 2.5 dB maximum and the interchannel isolation is 40 dB minimum. The maximum switching time should be of the order of 25 milliseconds.

2.1.5 Power Budget

A summary of various budget parameters is as follows:

Transmitter Output	-20.0 dBm (minimum)
Receiver Sensitivity	-31.0 dB (minimum)

9

Optical Fiber Attenuation	2.5 dB/km
Connector Loss	0.5 dB
Bypass switch	1.5 dB Inbound to Outbound
	2.5 dB Transmitter to Outbound
	2.5 dB Inbound to Receiver

According to these figures, a length of 2km fiber can be easily supported after allowing a system margin of 2.5 dBs .

2.2 Physical Layer Protocol (PHY)

The ANSI X3.148-1988 defines the Physical Layer protocol for FDDI[6]. The Physical Layer (PHY) provides the connection between the PMD and the Data Link Layer (MAC). It takes care of clock synchronization, conversion of bits into bytes, encoding of outgoing data and decoding of incoming data. It provides services to MAC and SMT and needs them from PMD. These services are -

2.2.1 Services

These Services are interfaces between layers and are used to exchange information between them. Defining these services allows users to have a constant interface between various layers and is independent of implementation variations. Each of the following services is a function with input and output variables uniquely defined . A detailed description is available in ANSI documents [7] [6].

PHY-to-MAC Services

i. PH_UNITDATA.request - This defines the transfer of data from MAC to PHY.

ii. PH_UNITDATA.indication - This defines the transfer of data from PHY to MAC.

iii. PH_UNITDATA_STATUS.indication - This primitive has local importance and signifies the acceptance of a symbol by PH_UNITDATA.request and willingness to accept another symbol.

iv. PH_INVALID.indication - Is generated by PHY and sent to MAC to indicate that the symbol was invalid.

PHY-to-PMD Services

i. PM_UNITDATA.request - This defines the transfer of data from PHY to PMD.

ii. PM_UNITDATA.indication - This defines the transfer of data from PMD to PHY.

iii. PM_SIGNAL.indication - Generated by PMD to PHY to indicate a change in status of the optical signal level being received by PMD.

PHY-to-SMT Services

These services allow the Local SMT to control the operation of PHY and have a higher priority. The services are -

i. SM_PH_LINE-STATE.request - Is generated by SMT to request PHY to send a stream of symbols to PMD. The action parameter can be TRANSMIT_HALT, TRANS-MIT_IDLE, TRANSMIT_MASTER (alternating Halt and Quiet symbols) or TRANS-MIT_PDR (symbols received from MAC).

ii. SM_PH-STATE.request - Is generated by PHY to inform SMT of line state activity and status changes.

2.2.2   Operation of PHY

Coding - In order to have a serial baseband operation, some kind of coding is required to combine clock and data transmission. Manchester code is perhaps the best code for clock recovery and is a balanced code. However it is only 50% efficient and FDDI, being a high speed system, can not afford to use this kind of redundancy. Therefore it uses a 4B/5B code which is 80% efficient and has a maximum dc variation of 10% from the normal center.

General Organization - According to functionality, PHY can be seen as consisting of the following functions :

a.   Encode Function - Responsible for encoding each 4 bit symbol into a 5 bit sequence. A local fixed frequency oscillator is used to clock the bits from MAC and the coded bits to the Transmit function.

b.   Transmit Function - It encodes the NRZ bit stream from encode function to NRZI for sending it to PMD.

c.   Receive Function - The receive function is responsible for decoding NRZI bits from PMD to NRZ. It also derives a 125 MHz clock from input bits using a PLL.

d.   Elasticity Buffer Function - The receiver recovery clock(RCRCLK) is used to recover timing information from the incoming bits. The output stream is clocked by a local oscillator . The difference between the two should not exceed .01% of the normal clock frequency. The Elasticity buffer is provided at each station to compensate for the difference in frequencies. MAC inserts at least sixteen IDLE symbols before every frame to allow for bits to be dropped when the outgoing frequency is less than the incoming frequency. This length of IDLE symbols may change at repeating stations due to elasticity buffer which acts like a FIFO (First In First Out). The input clock is RCRCLK and the output clock is the Local Clock. The minimum required elasticity is ±4.5 bits. This, at an accuracy of .01%, allows data frames upto 4500 octets (45000 transmitted bits).

e.   Decode Function - It accepts the serial NRZ coded bit stream, synchronized by the Local clock, from the elasticity buffer function.It establishes symbol boundaries, maintains synchronization to symbol clock and decodes the input NRZ stream.

f.   Smoothing Function - This function compensates for the variable preamble length due to the action of elasticity buffer function. It can insert additional preamble symbols an absorb surplus symbols from long preambles.

g.   Repeat Filter - Some station configurations require PHY to repeat the symbol stream from PH_UNITDATA.indication to a physical link in the form of PH_UNITDATA.request

stream. A repeat filter is used to do this. The repeat filter function prevents propagation of code violations and invalid line states. It is not required in all configurations.

3 Media Access Control(MAC) Layer

MAC, as defined in ANSI X3.139-1987[7], is a sublayer of Data Link Layer which is responsible for scheduling and routing data transmissions on the network. It provides fair and deterministic access to the medium, address recognition , and generation and verification of frame check sequences . It also encapsulates the data with the control characters required for a FDDI frame.

3.1 Functions

The main functions of MAC are -
   a. Frame transmission.
   b. Token transmission.
   c. Frame reception.
   d. Frame stripping.
   e. Ring scheduling.
   f. Ring monitoring.

MAC provides services to the LLC and MAC Layers and requires them from PHY. An overview of these services follows.

3.2 Services

These services allow upper (LLC), lower (PHY) and SMT layers to properly interface to MAC. They are as follows.

3.2.1 MAC to LLC Services

MA_UNITDATA.request - This primitive defines the transfer of Service Data Units (SDU) from local LLC entity to a single or multiple peer LLCs. After receiving this primitive, MAC appends all MAC specific fields and passes it on to the lower layers.

MA_UNITDATA.indication - This primitive defines the transfer of data from MAC to the local LLC. It is generated on arrival of a frame addressed to this station.

MA_UNITDATA_STATUS.indication - This primitive provides a response to MA_UNITDATA.request and signifies the success or failure of the request. The effect of its receipt is unspecified.

MA_TOKEN.request - This primitive is used by LLC to request the capture of the next token which can be restricted or unrestricted. The priority level has to be specified, if implemented.

3.2.2 MAC to SMT Services

These Services allow the local SMT to monitor and control the operation of MAC. They are as follows.

SM_MA_INITIALIZE_PROTOCOL.request - This primitive has local importance and is used by SMT to change the operating parameters of MAC . It is used by SMT whenever MAC has to be reconfigured.

SM_MA_INITIALIZE_PROTOCOL.confirm - This primitive is used by the MAC to confirm the completion of SM_MA_INITIALIZE.request to SMT.

SM_MA_CONTROL.request - This primitive has local significance and is used by the local SMT to control the operation of MAC and causes MAC to take appropriate action.

SM_MA_STATUS.request - This primitive is used by the MAC to inform the local SMT entity of errors and significant status changes.

SM_MA_UNITDATA.request - This primitive defines the transfer of one or more SMT SDUs from the local SMT to a peer SMT entity.

SM_MA_UNITDATA.indication - This primitive defines the transfer of data from MAC to the local SMT(s). It is used to report any SMT or MAC frame addressed to the station.

SM_MA_UNITDATA_STATUS.indication - This primitive is a response to the SM_MA_UNITDATA.request primitive generated by the SMT signifying the success or the failure of a request (SM_MA_ UNITDATA.request) from another SMT.

SM_MA_TOKEN.request - This primitive is used by the SMT to capture the next token. The priority level has to be specified if multiple levels are implemented.

3.3 Facilities

3.3.1 Symbols

Various MACs on the network communicate through a set of fixed length symbols. These are passed through various primitives defined earlier across the MAC-PHY interface. These include not only the data but also various control and violation symbols.

3.3.2 Protocol Data Units

Tokens and frames are the two type of PDUs which are used by the MAC . All the numeric fields are represented as unsigned magnitudes. Token is the means to get the right to transmitted on the network. It is passed from station to station and the one in possession can start transmitting. Other stations simply repeat the frames till they are removed from the ring by the originating station. The token consists of a preamble, starting delimiter(2 symbols), frame control (2 symbols), and an ending delimiter (2 symbols). The preamble has 16 or more idle symbols to ensure constant number of bits. Its length may be changed by the repeating stations.

A frame consists of 9 fields including a preamble, start delimiter, frame control, destination address, source address, information, frame check sequence, ending delimiter, and a frame status. The preamble is same as that in a token, consisting of 16 idle symbols. The delimiters mark the beginning and end of the information and related

14

checks etc. The frame control defines the type of frame and associated control functions and is followed by the addresses of the destination and source stations. These addresses can be either 16 or 48 bit type with all 1s indicating a broadcast address. The FCS field covers the FC, DA, SA, INFO and FCS. The frame status indicates whether it is a repeated frame or is meant for this station.

3.3.3 Timers

Several timers are provided at each station to control the ring operation and their values may vary from station to station. However there are limits on these values to ensure that ring timing restrictions are not violated. These timer values are a function of Physical layer parameters. The parameters used for timer calculations are -

D_Max - Maximum allowed ring latency (time required by a starting Delimiter to go around the ring). The default is 1.617 ms.

M_MAx - Maximum number of MAC entities. The default is 1000.

L_Max - Maximum station physical insertion time. The default is 25.0 ms.

A_Max - Maximum signal acquisition time. It is the sum of maximum allowed clock and DC balance signal acquisition time contributed by the physical layers. The default is 1.0 ms.

Token time - Time required to transmit a token and its preamble. It is 0.00088 ms.

L_Max - Maximum set-up time permitted for a station to begun transmission of the first and subsequent frames after the capture of a token(0.0035 ms).

F_Max - Time required to transmit a maximum length frame(9000 symbols) and its preamble (16 symbols).

Claim_FR - Time required to transmit a minimum length claim frame using 48 bit addresses(0.00256 ms).

S_Min - Minimum safety timing allowance (0.3645 ms)

The timers are the Token-Holding Timer(THT), Valid-Transmission Timer (TVX), and the Token Rotation Timer(TRT). THT controls the time for which a station can transmit asynchronous frames. A station can transmit if THT has not expired. THT is assigned the current value of the TRT at the time of token capture.

TVX is required to recover from temporary errors and its value is calculated as follows -

$$TVX > DMax * + Token\_Time + F\_Max + S\_Min$$
$$> 2.35ms.$$

(* F_Max, if greater than D_Max)

TRT is used to control the ring scheduling during normal operation and to detect and recover from serious ring error situations. TRT is initialized with different values during different phases . At its expiration it is reinitialized to the current value of T_Opr. T_Opr is the operative timeout value of TRT and is negotiated between the stations. There is a counter called Late_Ct which is cleared whenever there is a valid token arrival and is incremented on each expiration of TRT.

15

3.3.4 Frame Counts

MAC maintains diagnostics which include Frame_Ct (total number of frames received), Error_Ct (number of error frames detected by this station and no previous station) and Lost_Ct (Frames with errors and replaced by idle symbols).

3.4 Operation

MAC consists of two asynchronous processes, the MAC Receiver and the MAC Transmitter, within each station. These two are defined as cooperating state machines.

The receiver process receives frames, passes on the valid ones to upper layers and detects ring errors and failures. The transmitter process repeats information from other stations, inserts the local frames into the ring and cooperates with other stations in order coordinate the priorities for using the ring.

There are two classes of service provided by the fddi, synchronous and asynchronous. The synchronous service has a higher priority and provides guaranteed bandwidth. It is used for applications which require predictable bandwidth, like real time applications. The sum of all stations' allocations should not exceed the maximum usable synchronous bandwidth of the ring. The Timed Token Rotation protocol (TTR) used by MAC ensure this. Each stations keeps the time elapsed since the token was received. At the time of initialization, the lowest bid by any of the stations is the TTRT (Target Token Rotation Time). Whenever a token is received and the time expired since the last token was received (TRT) has not exceeded the TTRT, a station is allowed to transmit asynchronous frames provided the token is not late(Late_Ct is not 0). If it has exceeded TTRT, the token should be passed to the next station. Expiration of TRT when token is already late means a ring problem and recovery is initiated. The asynchronous service is used for less critical applications and is provided the unused bandwidth.

In order to transmit a frame, the station must wait for the token and should follow the TTRT protocol restrictions. After the transmission is over, the station should immediately issue a new token. The transmitting station is also responsible for removing the frames from the ring after a rotation by stripping it of all fields except PA, SD, FC, DA and SA. These are appended with idle symbols and are removed when they encounter a transmitting station.

In case of a unrecoverable error, ring reinitialization is started. The first step is to claim the token. All stations issue claim tokens with TTRT bids. If a bid higher than self is encountered, it is ignored and they must yield to smaller bids. The process is complete when a station receives its own frames and it starts the initialization by setting TTRT as its bid and by issuing a nonrestricted token to allow other stations to set their TTRT values. The first rotation doesn't involve any transmissions by the stations.

If the claim process fails, it indicates a station failure or break in medium. A beacon process is started to diagnose this. SMT can also request the start of a beacon process.

16

The station starts transmitting beacon frames containing its own address. Stations receiving a beacon frame upstream neighbors repeat it rather than sending their own frames. If there is a break, beacon of the first station downstream from break are the only frames on the ring and the SMTs may use this information to bypass the faulty station.

4 Station Management (SMT)

The Station Management performs various control and management functions within a station including initialization , monitoring, maintenance and error control. It interacts with other SMTs on the network in order to control the network. It provides vital information about the network including statistic and diagnostic information. SMT consists of many functions of which most important is the Connection Management.

4.1 Connection Management(CMT)

CMT performs functions involving physical as well as logical interconnection between various entities on the network. Some of these are -

a. Physical attachment of a station to the network - This is done by deactivating the optical switch , thereby removing the station from the ring.

b. Physical detachment of a station from the network - This is done by activating the optical switch , thereby connecting the station to the ring.

c. Logical attachment - This can be done within the station at various levels including the PHY to MAC connection. Station becomes a member of the ring and the data path is available to the applications.

d. Logical detachment - After logical detachment a station is removed from the ring without affecting the ring configuration and the data path is not available to the applications .

e. Establishing the ring configuration - This is done by talking to the upstream and downstream neighbors.

f. Establishing and maintaining the ring integrity - This is achieved by constantly monitoring the connections , both upstream and downstream.

All these functions together provide a distributed network management network management as opposed to a centralized management in case of a 802.5 Token ring on which fddi is based.

Depending upon the kind of physical interconnection, there are two classes of stations defined – class A and class B.

A class A station has two PHY entities and is connected to both counterrotating rings. It may have one or two MACs and in case of two, they may be on the same or different rings. It may also have optical bypass switches to remove it from the rings. All these provide extra reliability.

A class B station has only one PHY and one MAC and is connected to the ring through a concentrator. Nodes not requiring the extra reliability can be of this type.

A concentrator connects class B stations to the ring through a class A station. Concentrators normally have two PHYs but may or may not have a MAC. It can bypass any failing class B station thereby removing it from the ring. It can also be used to connect a class A station to the ring.

18

5 Applications

High speed, reliability features , fiber optic medium and guaranteed bandwidth are some of the features which make FDDI desirable in special applications. Standalone data networks which do not have any bandwidth intensive requirements may not be able to make optimum use of FDDI capabilities, at least at the present stage. Some of the applications of FDDI are listed below.

1. Bandwidth Intensive Applications.

   a. Backbone Networks - A backbone network connecting various mainframes, gateways, bridges, and hubs to various LANs has to cope with concentrated traffic most of the time. This is where FDDI can be of use .

   b. High speed applications - Now the emphasis is on an integrated work environment which provides data, images and document exchange between the stations. Conferencing system on the LANs is one application which requires high bandwidths. Image processing is another which can make use of high capacity networks.

2. Networks in Remote and sensitive sites - FDDI is being considered for applications where its reliability features and self correcting provisions are particularly useful. Space stations are one such example . Since human intervention is undesirable or impossible here, the network employed should have self monitoring capabilities.

3. In hazardous environments, nuclear power stations for instance, such features are of great use as they allow minimum risk to humans. In other sensitive areas, where confidentiality of information is useful, optical medium has the advantage that it can't be easily tapped.

4. FDDI finds application in real-time processes which need a guaranteed bandwidth. It has message priorities which can be allocated to different processes. There are timers which keep watch over these conditions and ensure that lower priority message get the bandwidth only if there is spare capacity.

6   VLSI Implementation of FDDI Layers

The lower FDDI layers - Physical and MAC, are available in VLSI form. This is more efficient and cost-affective as fddi data rate is at the threshold of normal TTL range. Many vendors,including AMD[8] and National Semiconductor[9][10] have already announced chipsets which implement these layers. Evaluation boards for PC/ATs are also provided by them. A description of the functionality of these devices follows.

Advanced Micro Devices' SUPERNET chipset for FDDI -

1. Am79C81A RAM Buffer Controller (RBC) :
   a. Generates buffer addresses for receive/transmit frames.
   b. Does arbitration between the host , node processor and the DPC.
   c. Takes care of FIFO management .
   d. Provides interrupts to the node processor .

2. Am79C82A Data Path Converter (DPC) :
   a. Converts frames between 8 bit and 32-bit formats.
   b. Performs parity checks and generates station status.
   c. Provides interface for NP access to buffer.

3. Am79C83A Fiber Optic Media Access Controller (FORMAC) :
   a. Implements MAC functions including -
   Network access and Token handling .
   Stripping of headers from received frames.
   Generation and checking of frame CRC.
   Generation of station status and frame conditions.
   b. Provides optional full-duplex data capability.

4. Am79C84A Encoder/Decoder (ENDEC) :
   a. Does 4B/5B encoding/decoding.
   b. Provides buffer elasticity.
   c. Converts data from byte-parallel to bit-serial.
   d. generates byte clock.

5. Am79C85A Data Separator (EDS) :
   a. Extracts receive clock from serial bit stream .

   The SUPERNET chipset provides three major functions - Station Initialization, Frame Transmission and Frame Reception.

   The Physical layer protocols are implemented by ENDEC and EDS as defined by the ANSI X3T9 committee. EDS extracts the bit clock from received data and ENDEC takes care of the encoding/decoding and conversion of bits to bytes etc . ENDEC operates in four different modes - Thorough, Loopback, Short Loopback and Repeat. Thorough mode is the normal mode during the fddi operation. The two loopback modes are mostly used for testing etc and the data transmitted is looped back as the data received (at two different stages). PMD is implemented using fiber-optic components.

   FORMAC implements the Media Access Control Protocol for fddi and provides the interface between the station and the physical layer using RBC and DPC to pass the

20

data. The FORMAC is full-duplex but for a full-duplex system two RBCs, DPCs and buffer memories are required, one each for transmission and reception . DPC transfers data from media to buffer memory and vice versa . It also generates and checks parity during buffer operations . The RBC generates the addresses for buffer memory such that FIFOs are formed within the memory for orderly data transfers .

National Semiconductor's DP83200 Chip Set.

1. DP83231 FDDI Clock Recovery Device (CRD).

Extracts a 125MHz clock from the incoming bit stream . It uses a crystal or an external TTL reference and has a 100k ECL input/ output. CDD also provides PHY loopback test .

2. DP83241 FDDI Clock Distribution Device (CDD).

Synthesizes various clocks(125, 25 and 12.5MHz) required by PLAYER and BMAC using a 12.5 MHz reference.

3. DP83251/DP83255 FDDI Physical Layer Controller (PLAYER).

Implements the Physical Layer protocol and has the following features -

    . 4B/5B encoder/decoder.
    . Framing Logic.
    . Elasticity buffer, Repeat filter and smoother.
    . Line state detector/generator.
    . Link error detector.
    . Configuration switch.
    . Separate management port used for configuration and control.
    . Additional PHY_Data.request and PHY_Data.indicate ports for concentrators and dual attachment stations.

4. DP83261 FDDI Basic Media Access Controller (BMAC).

Implements the Timed Token Media Access Control protocol.

5. FDDI BMAC System Interface.

Provides interface between BMAC and the system/node processor. Not yet available.

A single CDD can serve more than one set of PLAYER and BMACS but for a dual attachment station two CRDs and PLAYERs are required. PLAYER can operate in four different modes - RUN, STOP, LOOPBACK, and CASCADE. RUN is the normal mode and STOP mode is used while the device is being initialized or configured . LOOPBACK mode is useful for troubleshooting and testing and in CAS-CADE(parallel) mode, multiple devices are connected together to provide a higher data rate. This is a non-fddi mode though the normal fddi rules for framing etc are used.

7 Remarks

FDDI protocol is still in an early stage and is not yet in widespread use. Any protocol has to be put to commercial use before any shortcomings or gaps can be discovered and further revisions come out. FDDI also has to go through few more changes and modification cycles before it fully stabilizes. At this stage many vendors are providing protocol engines for FDDI and there are few who are offering complete FDDI solutions including hardware, drivers , network software and applications. Appendix A lists some of these vendors .

The upper layers of an FDDI LAN is usually a conventional TCP/IP or ISO Network/Transport layer . These are not a very good solution because they have their limitations . All these protocols were designed for speeds than 100MHz and around this limit they are stretched to the maximum. Another interesting work is the XTP/PE (Xpress transport protocols/protocol engine) project at Protocol Engines Inc. The aim of the project is to develop high performance protocols for the network and transport layers and to develop VLSI protocol engines based on these[11]. They satisfy some of the requirements of distributed and real time systems including latency and delay control. They also provide reliable multicasting mechanisms and message priority/ scheduling for real-time systems.

The FDDI has still a long way to go but it is an excellent effort to provide a common standard for fiber-optic LANs .

List of Vendors.

Components -
    a. National Semiconductor
P.O.B. 58090, Mail Stop D3615
2900 Semiconductor Drive
Santa Clara , CA 95052-8090
408-721-3094.

    b. Advanced Micronic Devices.
901 Thompson Place
P.O.B. 3453, Sunnyvale
CA 94088-3453. 1-800-538-8450

Network Adaptors and drivers.
    a. Network Peripheral Inc.
2890 Zanker Road, Suite 209
San Jose, CA 95134
408-954-8030.
(EISA bus compatible)

    b. Summit Microsystems Corp.
949 Hillsboro Ave., Sunnyvale, CA 94087
408-730-4996

    c. Codenoll Tech. Corp.
1086 N. Broadway, Yonkers
NY 10701. 914-965-6300.

    d. Interphase Corp.
13800 Senlac
Dallas, Texas 75234
214-919-9200
(Unix Systems/VME bus/Workstations)

Test Instruments and Packages.
    a. Digital Technology Inc.
2300 Edwin C. Moses Blvd.
Dayton , Ohio 45408.
513-443-0412.

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24

Acknowledgements