L26 - Fibre Distributed Data Interface (FDDI)

FDDI

Fiber Distributed Data Interface
Principles, Framing and Procedures

Agenda

- FDDI Basics
- Fault Tolerance
- Topologies
- Protocol Layers: PMD, PHY, MAC, SMT

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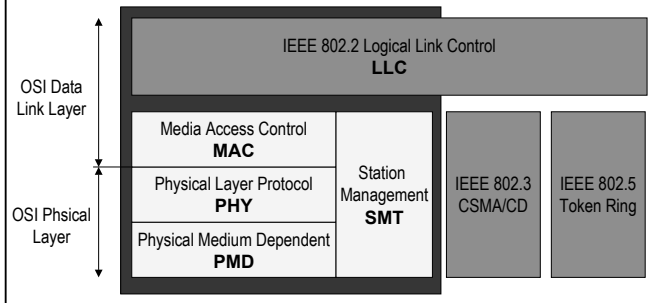
FDDI - Fiber Distributed Data Interface

- set of standards defining a shared media 100 Mbps LAN (MAN)
- main topology: *dual ring of trees*
- FDDI ring is commonly used as high-speed backbone
- using token passing scheme
- allows interconnection of up to 500 devices; maximal link length of 2 km; maximal ring length up to 200 km
- ANSI standard X3T9.5 (late 1980s)

Architectural Overview and Relationship to Other LAN Standards



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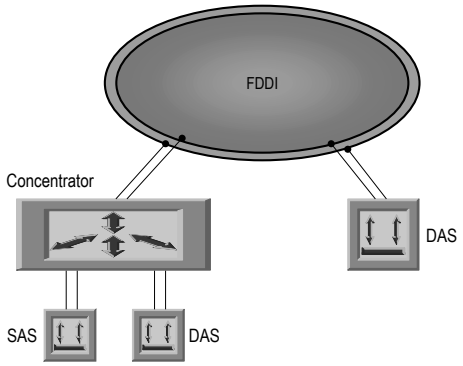
FDDI - Fiber Distributed Data Interface

- dual ring consists of
  - primary ring; used for normal operation
  - secondary ring; for reliability purposes only (not used while normal operations)
- rings are driven “counter-rotating”
- medium
  - single mode fiber
  - multimode fiber
  - twisted pair cabling (CDDI)
    - shielded and unshielded
    - only 100m link length

Basic Network Devices



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Types of Attachment Devices

- devices connect to FDDI either
  - directly
    - dual-attached stations
  - through concentrators
    - dual or single attached stations
    - devices can be powered down without disrupting the FDDI ring
- Dual Attachment Concentrators (DACs)
  - connected to Primary Ring and Secondary Ring (fault tolerant to ring failures)
- Single Attachment Concentrators (SACs)
  - used to connect SASs within a logical tree

Types of Attachment Devices

- Dual Attachment Stations (DASs)
  - DASs are connected to their neighbors by two links that transmit in opposite direction (*Primary Ring* and *Secondary Ring*)
  - in case of link failure, the devices on either side of the link reconfigure (isolates the fault and restores a continuous ring)
- Single Attachment Stations (SASs)
  - connect only to the primary ring
  - in case of ring failure a SAS may be disconnected from the network

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FDDI Fault Tolerance Issues

- FDDI achieves high reliability by implementing a number of fault tolerance features:
  - dual ring (and ring wrapping stations)
  - optical bypass switch
  - dual homed stations
- secundary ring is only used on primary ring failure
- optical bypass switch provides continuous dual-ring operation
  - disconnection or failure of a DAS enables intern mirrors to close the ring
- dual homed stations (DACs or DASs) are connected to two different concentrators (DACs)

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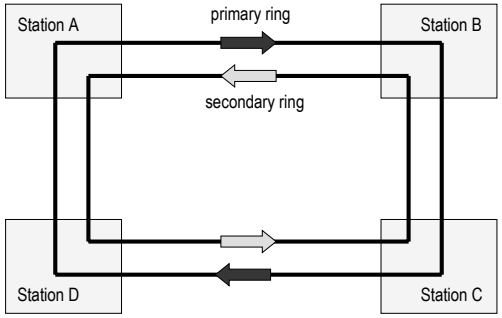
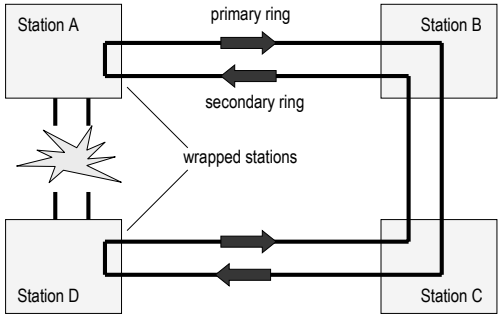
Fault Tolerance Of Dual Ring



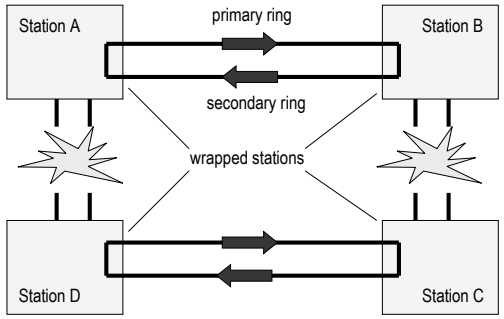
normal operation

Isolating Single Faults



to preserve reliability the maximal ring length is actually only 100 km !!

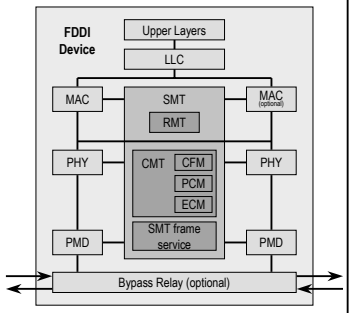
Isolating Multiple Faults



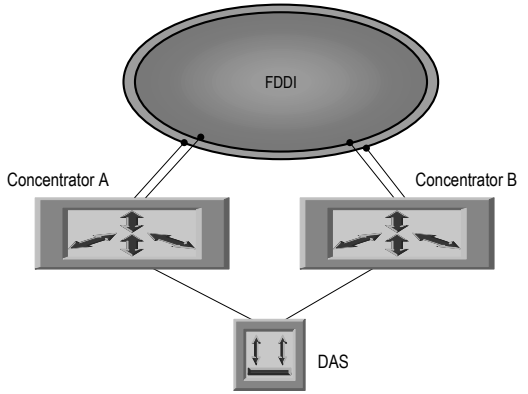
multiple faults split ring into smaller independent rings

Optional Bypass Relay

- installed optionally in Dual Attachment Device to improve reliability
- bypassing is activated
  - automatically by the device itself
  - a neighbor device
  - an administrator
- optional bypass switches introduce attenuation (impact on overall power budget)



Dual Homed Station



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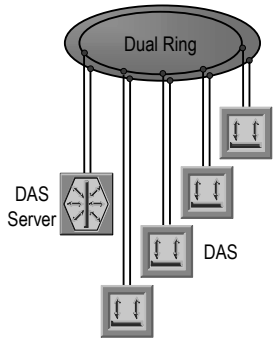
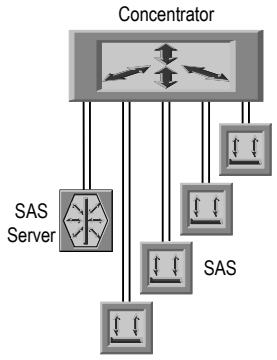
Dual Ring Topology



- set of Dual Attached Stations (DASs) connected to form a single dual ring
- typical for situations with a small number of users
- typical for interconnection of interdepartmental LANs
  - each FDDI device is a bridge
- inflexible configuration !!!
  - disconnecting a station means breaking up the ring

Concentrator with Attached Devices



- single concentrator and Single Attached Stations (SASs)
- typical for connection of multiple high-end workstations in a workgroup
- typical for interconnecting multiple LANs (where each FDDI device is a bridge)

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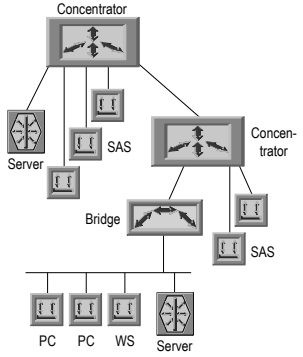
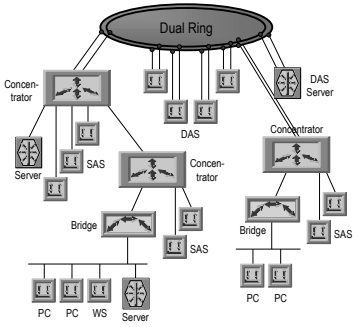
Tree of Concentrators



- concentrators are wired in a hierarchical star
- one concentrator serves as the root of the tree
- typical for interconnectin large groups of user devices
- facilitates adding and removing concentrators and devices without disrupting users

Dual Ring of Trees



- most sophisticated topology
- combination of the different attachment types
- allows flexible, local and distributed network design for large networks

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Bridging Different Protocols

- since FDDI is often used as backbone of LANs, bridges must provide methods to transport e.g. 802.3 frames or 802.5 frames etc.
- *encapsulating bridges* embed the entire foreign frame with an FDDI header and trailer
  - proprietary technique; bridges must be able to recognize the address fields
- *translating bridges* modifies the fields to make it compliant to FDDI frames and vice versa
  - nonproprietary; conforms to IEEE 802.1d standard
- FDDI allows frames up to 4500 bytes in length
  - *fragmentation* necessary before forwarding to 802.3 e.g.

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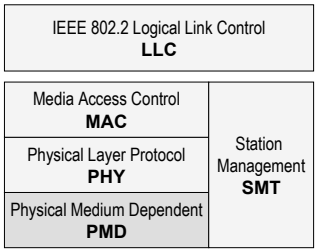
Physical Layer Medium Dependent



ANSI FDDI

Physical Layer Medium Dependent

- the ANSI FDDI PMD sublayer specifies
  - optical transmitters and receivers
  - cable types
  - media interface connector (MIC)
  - port types
  - optical bypass relais

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Supported Wiring

- MMF PMD - multimode fiber
- SMF PMD - singlemode fiber
- LCF PMD - low cost fiber
- TP PMD - twisted pair
  - SDDI - shielded twisted pair
  - CDDI - unshielded twisted pair
- SPM - SONET physical layer mapping
  - meant to allow for easy interconnection of FDDI networks to B-ISDN networks via SONET interface
  - slow progress in standardization bodies
  - not many technical details available at this time (?)

Single Mode Fiber PMD

- permits longer link lengths: up to 60 km
- this greatly exceeds the 2 km limit imposed by Multimode Fiber PMD
- greater distance is achieved by:
  - launching more power into the fiber
  - using fiber with less loss per km
  - employing a more sensitive receiver
- can easily result in large operational networks
- FDDI starts acting like a MAN

L26 - Fibre Distributed Data Interface (FDDI)

Low Cost Fiber PMD

- currently the optical interface is the most expensive component of FDDI nodes
- thus the standards committee started to design a low cost alternative: LCF-PMD
  - distance requirements limited to 500 m
  - wavelength kept at 1300 nm (different to 850 nm of CD lasers available for less than 1$ a piece!)
- LCF-PMD has the same interface to the other layers as original PMD
- LCF-PMD can be used interchangeably with original PMD
- fully compatible with FDDI II

Copper Wire PMDs

- Twisted Pair PMD (TP-PMD) is the latest in the family of FDDI standards
- FDDI can be transmitted over Twisted Pair Cables according to EIA/TIA 568 via 100 m
  - STP 150 Ohm
  - UTP Cat 5 100 Ohm
  - giving acceptable error rates
  - meeting FCC Class B radiated emissions limits
  - sharing of other services and signals in the TP is not allowed, to keep crosstalk within acceptable values

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Twisted Pair PMD Requirements

- use of existing cable plants
  - voice-grade unshielded twisted pair (UTP Cat.3)
  - data-grade unshielded twisted pair (UTP Cat. 4 & 5)
- distance between wiring closets to the desktop is at least 100 m or more
- up to now 3 different TP-PMD alternatives have been proposed in the ANSI committee
  - ANSI STP (IBM Type 1)
  - ANSI FDDI PMD for UTP Cat. 4 & 5 and STP (includes IBM Type 1)
  - X3T9.5 UTP

FDDI Port Types

- to avoid illegal topologies, ANSI FDDI specifies connection rules corresponding to 4 port types:
- Port A - connects to incoming primary ring and outgoing secondary ring; part of DAS and DAC
- Port B - connects to outgoing primary ring and incoming secondary ring; part of DAS and DAC
- Port M (Master) - connects a concentrator to an SAS, DAS, or another concentrator (DAC or SAC); only implemented in concentrators
- Port S (Slave) - connects a SAS or a SAC to a concentrator; part of SAS and SAC

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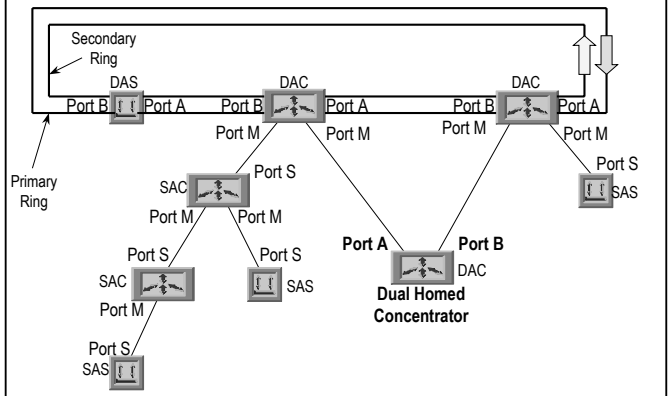
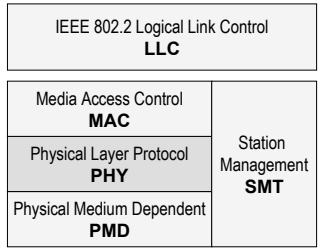
FDDI Dual Ring Architecture



Physical Layer Protocol



ANSI FDDI

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Physical Layer Protocol

- the ANSI FDDI PHY sublayer specifies
  - clock synchronization
  - encoding scheme
  - timing jitter management
  - data framing
- FDDI uses *distributed clocking*
- each station has an autonomous clock for transmitting or repeating frames
- receiving station synchronizes with incoming data for decoding and sends with local (=its own) clock

FDDI Encoding Scheme

- basic information unit used by MAC is the 4-bit *symbol*
- PHY sublayer transforms each symbol in a 5-bit code group (4B/5B coding) and performs a serial transmission
- the 16 additional code groups
  - improve clock synchronization
  - assists in error recovering
  - are used for signalization purposes
- finally a NRZ/NRZI encoding minimizes the required bandwidth

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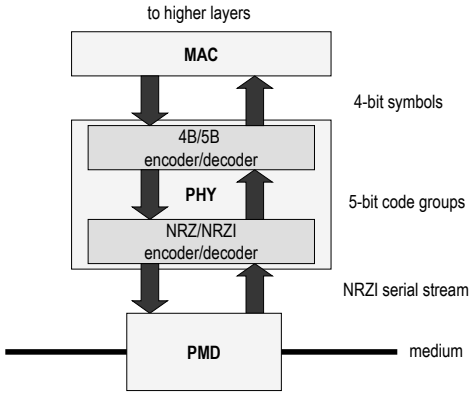
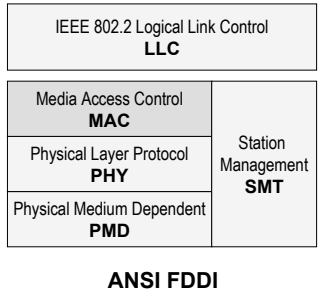
FDDI Encoding Scheme



Media Access Control



ANSI FDDI

Media Access Control

- the ANSI FDDI MAC layer
  - is responsible of LLC frame delivering (sending, receiving, removing frame)
  - employs a Timed Token Protocol TTP providing a fair ring access
  - executes ring initialization and claim process
  - implements error detection mechanisms; beaconing
- each downstream neighbor repeats the incoming frame immediately
  - if the destination address is equal to the station's address the frame is copied and forwarded to its higher layers

Frame Fragments

- to minimize delay, every station reads and repeats the frame immediately as it receives the frame
- when the sending station receives the frame
  - and recognizes its own source address it removes the remainder of the frame from the ring; the first part of the frame has already been repeated !!!
- the next transmitting station must remove these frame fragments before sending
- also "stray"-frames from deattached stations must be removed
  - MAC generates a series of idle symbols and at the same time removes all frames and tokens (scrubbing)

Timed Token Protocol

- if station acquires the token it may insert own frame(s) on the ring
- immediately after data transmission the station releases the token !
  - several simultaneous transmissions possible !!!
- the timed token protocol (TTP) guarantees that a token appears at every station within twice the *target token rotation time* (TTRT)
  - every station must observe the TTRT
- responsibility for monitoring proper token operation
  - is distributed among all FDDI devices which are directly connected to the ring

Proper Token Operation

- each device has knowledge of
  - Target Token Rotation Time (TTRT)
  - Token Rotation Timer (TRT); different values depending on actual ring conditions; if TRT exceeds 2 * TTRT the token is considered lost
  - Token Holding Timer (THT); device can begin asynchronous transmission as long as THT has not expired
  - Valid Transmission Timer (TVX); period between valid transmissions on the ring; to detect excessive ring noise, token loss, a.s.o.

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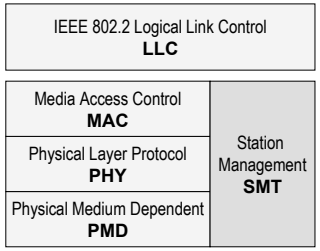
FDDI Transmission Modes

- Asynchronous Ring Transmission
  - sending whenever the token rules allow transmission
  - useful for not delay-sensitive applications
  - asynchronous traffic is subdivided into eight levels of priority
- Synchronous Ring Transmission
  - guarantees each station a minimum portion of the total ring bandwidth

Station Management



ANSI FDDI

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Station Management

- FDDI Station Management (SMT) includes standards for
  - ring management (RMT)
  - connection management (CMT)
  - SMT frame service
- connection management includes
  - insertion and removal of stations
  - connecting PHYs inside particular nodes (e.g. concentrators)
  - trace functions for detection and isolation of faulty components

Station Management

- ring management includes
  - detecting stuck-beacon stations (i.e. stations that are locked in sending beacon frames continuously)
  - recognizing MAC availability for transmission
  - detection of duplicate addresses
- SMT frame services
  - provide the means to control and observe the FDDI network
  - neighborhood information frames (NIF) to announce their addresses to downstream neighbors (triggered by each station every 30 seconds)
  - station information frames (SIF) to exchange detailed configuration information

L26 - Fibre Distributed Data Interface (FDDI)

Summary

- high speed LAN standard for large number of stations (500) and large geographical expansion (200 km)
- still typically used as a backbone-architecture, although as well suited for the desktop
- originally specified for fiberoptic media only
- newer Twisted Pair standards and implementations available today
- 100 MBit user bandwith, 125 MBit transmission speed

