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UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
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FIRST INTERNATIONAL SCHOOL ON COMPUTER NETWORK ANALYSIS AND MANAGEMENT

(3 - 14 December 1990)

FDDI
Fiber Distribution Data Interface

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FDDI

Fiber Distributed Data Interface

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Enterprise Integration Services
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Fiber Distributed Data Interface - FDDI

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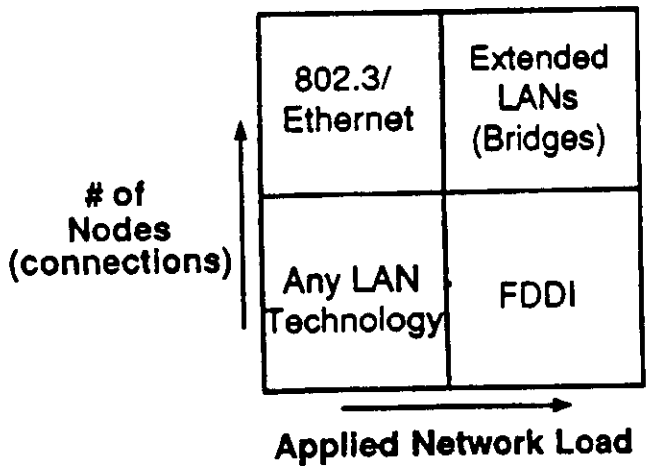
NEEDS FOR "NEXT GENERATION" LANS

High-speed networking needs are dictated by:

- **Increased number of users and applications**
- **Demand for greater geographic spans**
- **More powerful computers on current networks**
- **Network-wide intensive applications**
- **Increasing acceptance of the Client/Server Model**
- **Use of diskless workstations**
- **Backbone loading**
- **Integration of disparate networking technology**

FDDI vs. LAN TECHNOLOGIES

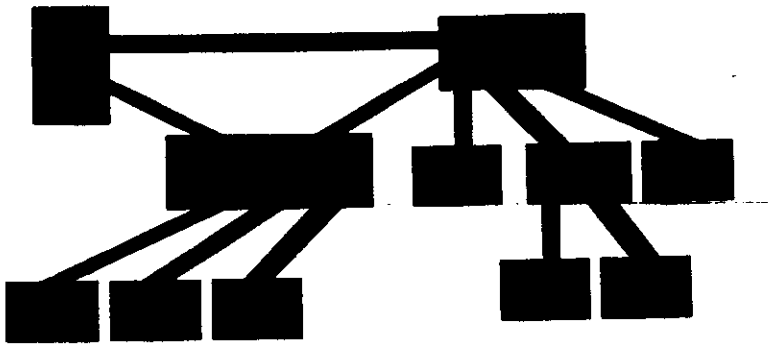
- **No single LAN technology alone meets customer demand for both Bandwidth and End-user support**
- **Although demand for high-speed networking is strong, organisations will continue to build and expand on existing LAN (ISO 8802) technology**
- **Combining FDDI and Ethernet/ISO 8802-3 provides investment protection and guarantees business growth**
- **FDDI represents a component part of LAN integration**



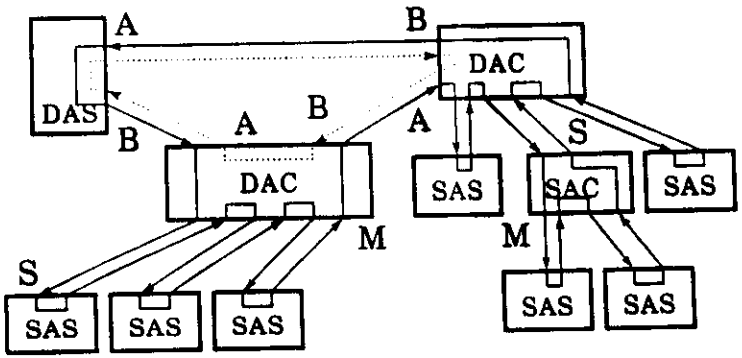
FDDI GENERAL CHARACTERISTICS

- **International standard ANSI X3T9.5 (since 1982)**
- **Specifies optical fiber as a medium (62.5/125 multimode, 1300 nm wavelength/second window)**
- **Allows for Dual/Single logical Rings via Timed Token Passing media access mechanism**
- **Data rates of 100 Mbps (200 Mbps on both rings)**
- **4B/5B NRZI (NonReturn to Zero Inverted) coding**
- **500 Stations (1000 attachments)**
- **200 Km of total fiber (100 Km of cable)**
- **2 Km between stations (60 Km SMF-PMD)**
- **Several priority levels**
- **Type of Traffic**
  - **Synchronous (Voice, Real Time)**
  - **Asynchronous (Data)**
  - **Restricted Asynchronous (Bulk Data)**
- **Fully Distributed - Fault Recovery, Clock, Elasticity, Initialisation, Topology Control**
- **Designed for overall bit error rate less than 10(-9)**
- **Maximum Frame size 4500 Bytes**

FDDI TOPOLOGY EXAMPLE

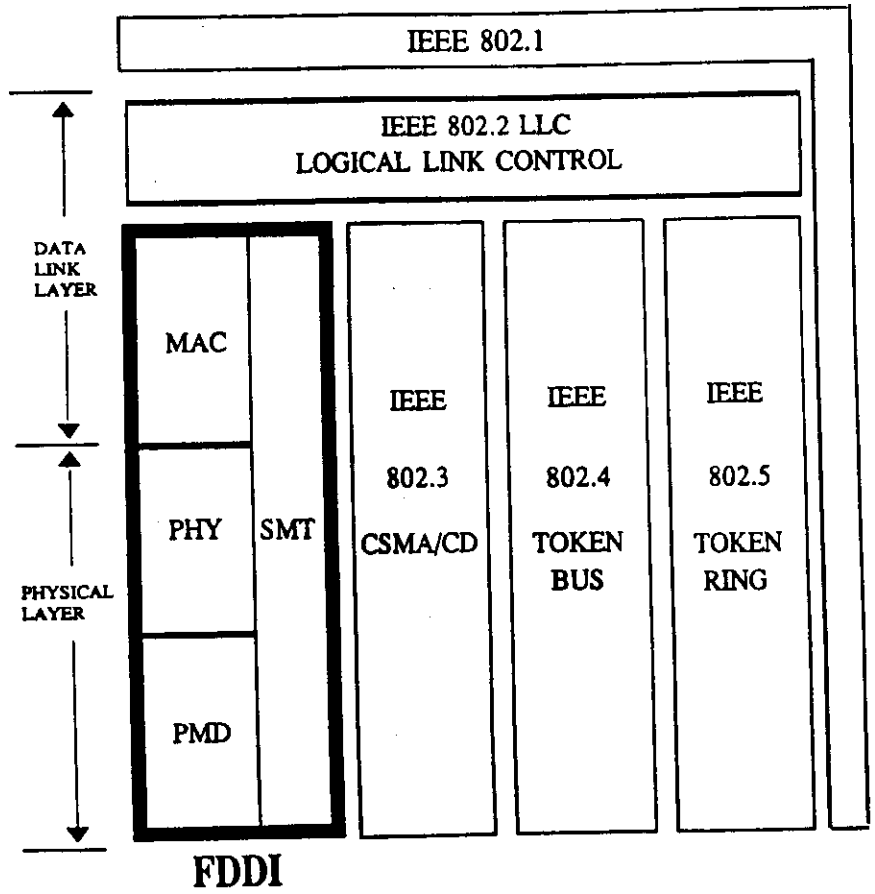


Dual Ring of Trees

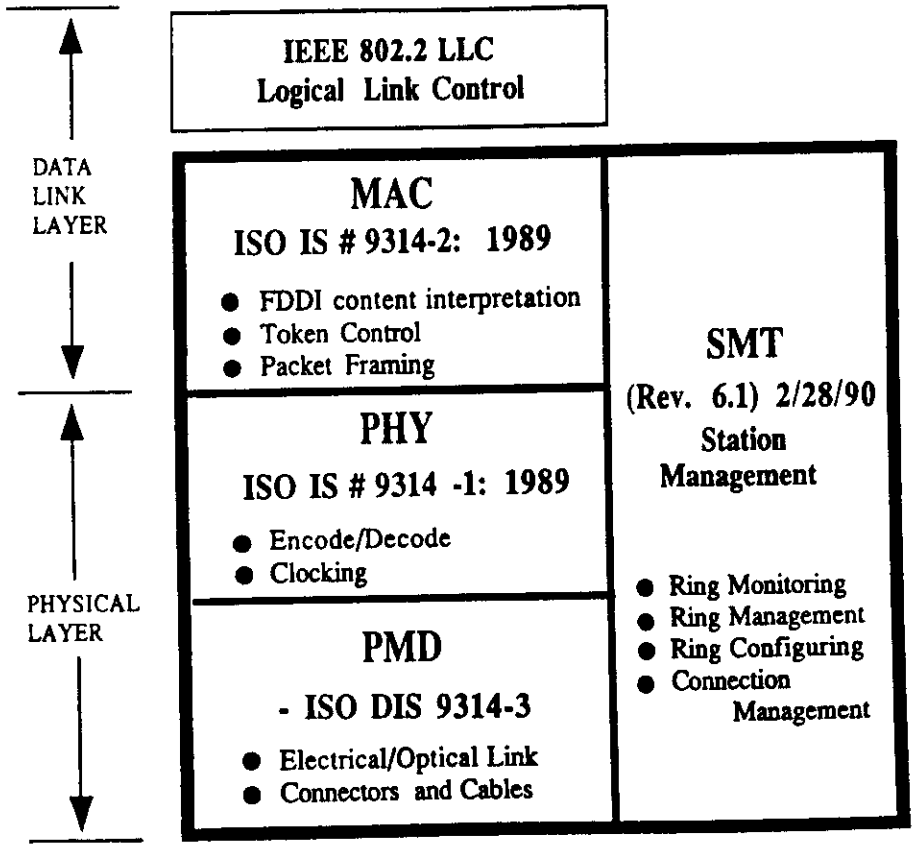


Types of PHY/PMDs:
A = Primary in, Secondary out
B = Secondary in, Primary out
M = Master (on concentrator spurs)
S = Slave (on single attachment stations)

FDDI vs. OTHER LAN STANDARDS



STATUS OF FDDI STANDARD



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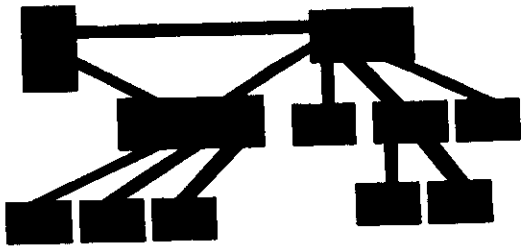
DIFFERENCES: FDDI, ISO 8802-3 AND ISO 8802-5

	FDDI	IEEE 802.3	IEEE 802.5
Media	Optical Fiber	Optical Fiber Twisted Pair Coaxial Cable Microwave	Optical Fiber Twisted Pair
Media Access	Timed Token Passing Dual Ring	CSMA/CD	Token Passing
Bandwidth	100 Megabits	10 Megabits	4 or 16 Megabits
Encoding Scheme	NRZI-4B/5B	Manchester	Manchester
Token Acquisition	By Absorption	CSMA/CD	By Resetting a Status Bit
Token Release	After Transmit	CSMA/CD	After Receive (4) After Transmit (16)
Maximum Frame Size	4500 Bytes	1500 Bytes	No Limit (4) 18,000 Bytes (16)
Maximum Nodes	1000	1024	260
Maximum Interstation Distance	2 km	Optial Fiber 2 km Twisted Pair 70 meters Coaxial Cable 1.5 km Microwave 4.5 miles	300 meters to MAU
Maximum Coverage	100 km	2.8 km	Varies with configuration
Encoding Efficiency	80%	50%	50%

FDDI COMPONENTS

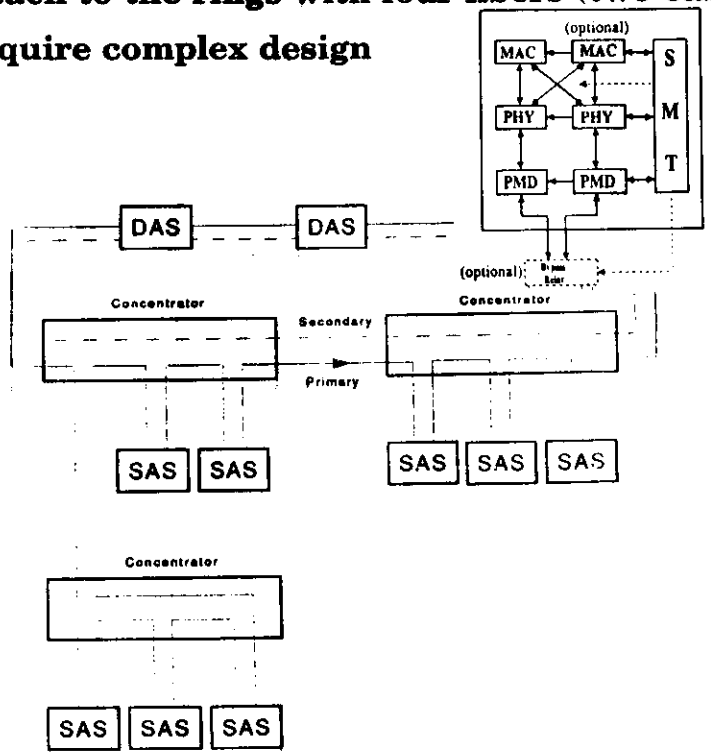
As with other LANs the ANSI/ISO standard defines

- **Media: Fiber Optic cable**
- **Devices: Stations and Concentrators**
  - **Dual Attachment Stations (DAS) - two PHY**
  - **Single Attachment Stations (SAS) - one PHY**
  - **Dual Attachment Concentrators (DAC)-n+2 PHY**
  - **Single Attachment Concentrators (SAC)-n+1 PHY**
- **Topology: "Dual Ring of Trees" configuration**



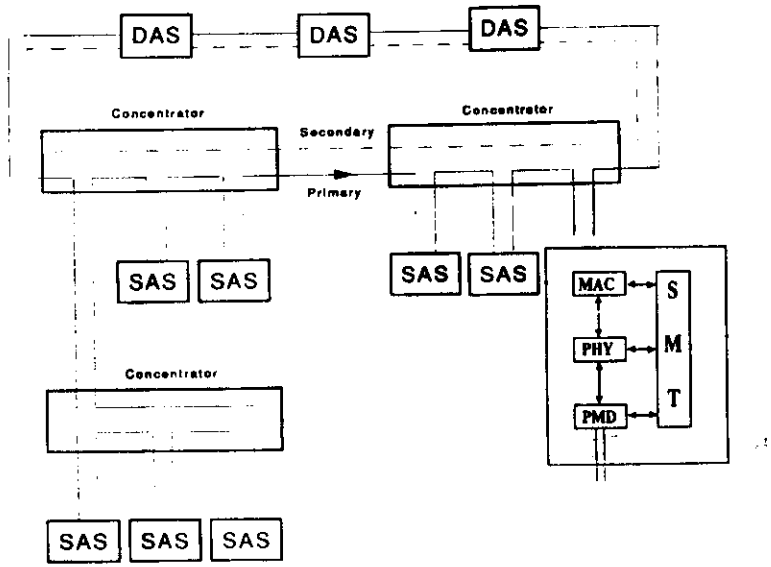
DUAL ATTACHMENT STATIONS (DAS)

- **DAS stations interconnect to form dual loops (primary and secondary rings)**
- **Attach to the rings with four fibers (two cables)**
- **Require complex design**



SINGLE ATTACHMENT STATIONS (SAS)

- **Connect via two fibers to a multiport DAS station (one ring)**
- **They lack fault recovery capabilities**
- **Allow for optimum plant design**



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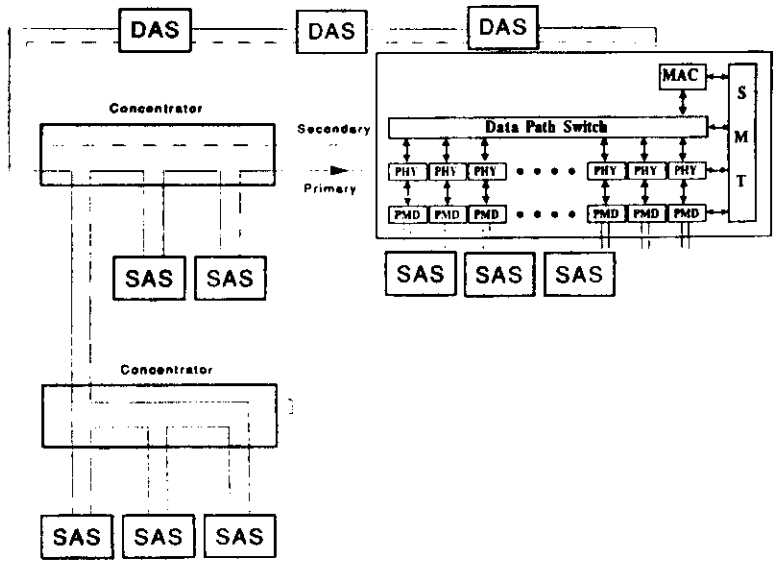
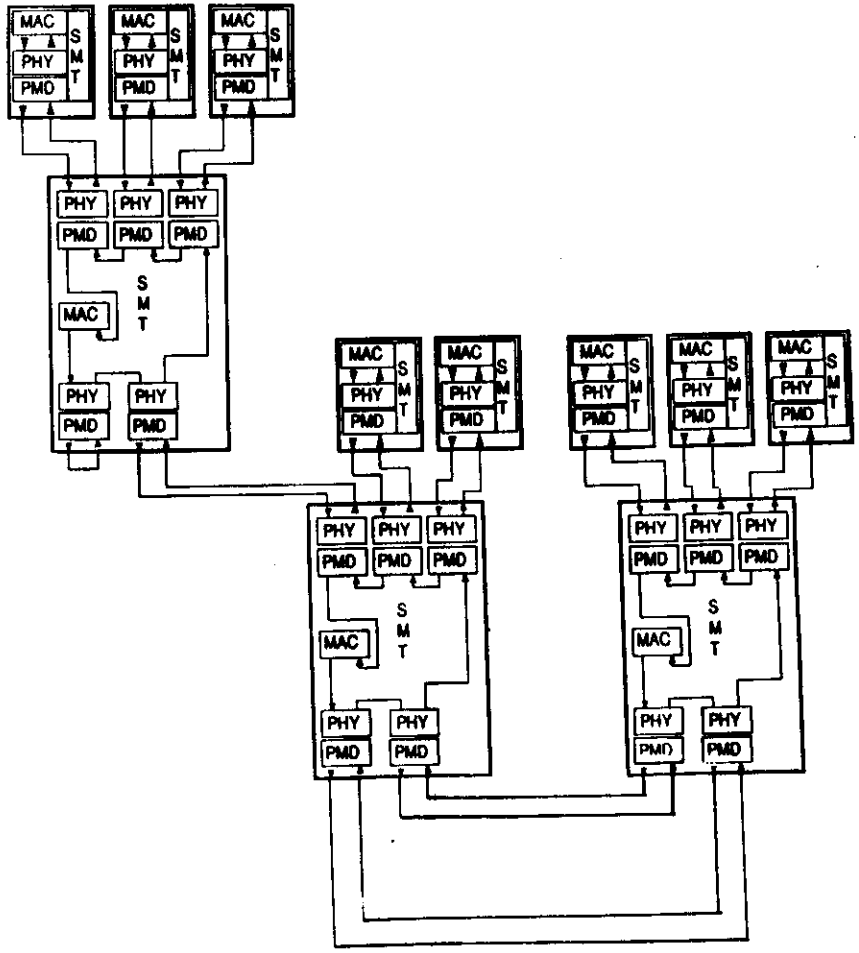
WIRING CONCENTRATOR (CON)

- **Attaches to the dual ring as a DAS and provides connections to SAS**
- **Dual Attachment Concentrator (DAC) - the "root" CON of a Tree, connects to other "root" CONs via the dual ring to form a "Dual Ring of Trees" topology**
- **Single Attachment Concentrator (SAC) - forms the branches within a tree (radial wiring to a DAC)**



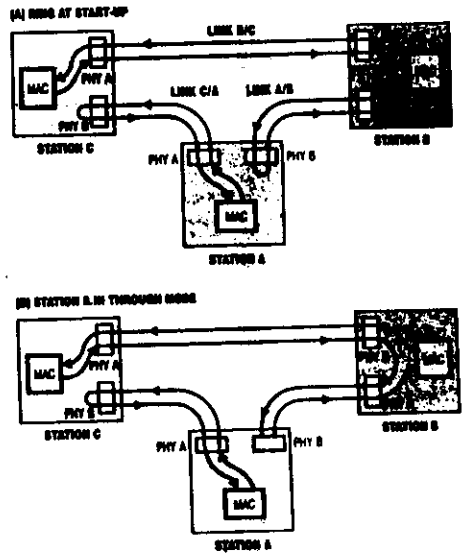
FDDI: ANOTHER VIEW



FDDI: INSIDE THE RING

RING FORMATION

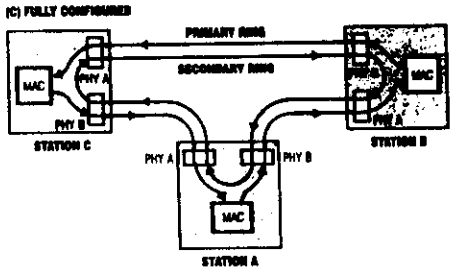
- **During Ring Startup, a series of minirings are formed (min: 2 PHYs and 1 MAC)**
- **Link integrity is guaranteed by PHY (Physical Connection Management)**
- **After HANDSHAKE both PHYs go into THROUGH_MODE**



FDDI: INSIDE THE RING

RING FORMATION

- **It is an asynchronous process (stations go into THROUGH_MODE at different times)**
- **Process completes when all stations are in THROUGH_MODE**



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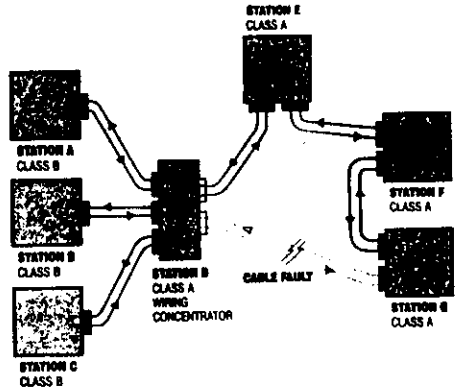
FDDI: INSIDE THE RING

RING RECOVERY

- **Both Physical Connection Management and Station Connection Management continue to operate after Ring Formation**
- **If a station goes down, the adjacent stations detect broken links, wrap-up and switch to secondary ring (outgoing)**
- **Other stations also channel data to the secondary ring**
- **Thus the faulty station (DAS) is isolated**
- **When Faulty DAS comes up the Ring Formation process initiates**



FDDI: INSIDE THE RING

THE CLAIM PROCESS

The TIMED_TOKEN Ring establishes the following:

- **One station transmits at a time**
- **Bound on the the ring circulation time**

The claim process determines which station issues the TIMED_TOKEN

- **MACs detect need to initialise the Ring and enter in CLAIM_STATE**
- **They transmit a CLAIM_FRAME with requested TTRT (Target Token Rotation Time)**
- **Every MAC receives incoming CLAIM_FRAMES and compares bids (TTRT)**
  - **If bid is higher (slower TTRT) MAC continues to transmit its own bid**
  - **If bid is lower (faster TTRT) then it is transmitted**
- **The MAC that receives its own CLAIM_FRAME issues the TIMED_TOKEN**

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FDDI: INSIDE THE RING

BANDWIDTH ALLOCATION

To guarantee that each station actually transmits data, FDDI provides two services:

- **Asynchronous**
- **Synchronous**

- **Time for synchronous transmission (T_SYNC) is variable (per station) and bounded**
- **BANDWIDTH ALLOCATION asigns each station a fixed T_SYNC and the rest goes to T_ASYNC**
- **Sum of all T_SYNC and T_ASYNC does not exceed TTRT**

FDDI: INSIDE THE RING

UNRESTRICTED TIMED_TOKEN ACCESS

To control the access, FDDI uses the TTRT (negotiated) in conjuction with each station's

- **Token Rotation Time (TRT): time since token was last seen**
- **Token Holding Time (THT)**

- **Asynchronous data is transmited when TIMED_ TOKEN arrives earlier than expected**
- **Synchronous data is transmited when TIMED_ TOKEN arrives**
- **Station never exceeds target, THT = TTRT-TRT**
- **The mechanism is further refined via the introduction of priorities.**
  - **T_ASYNC are categorised in priority levels and are assigned values**
  - **The values are compared with remaining THT until the overall Threshhold is reached**
- **The TIMED_TOKEN is released immediately after transmission**

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FDDI: INSIDE THE RING

RESTRICTED TIMED_TOKEN ACCESS

Some stations may wish to utilise the entire allocated bandwidth.

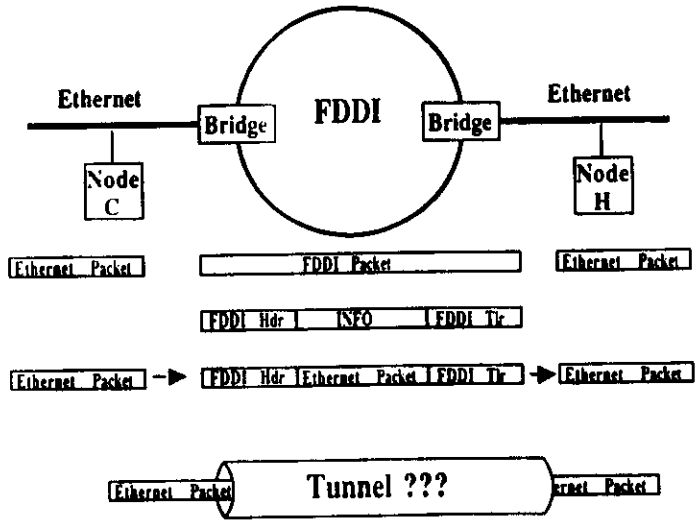
The use of RESTRICTED TIMED_TOKEN - that differs in format from the UNRESTRICTED one - is used exclusively for Asynchronous traffic

- **A station captures the UNRESTRICTED TIMED_ TOKEN (Initiator)**
- **The MAC isssues a RESTRICTED TIMED_TOKEN and informs the others that restricted dialogue is initiated**
- **Interested stations are enabled by their MACs for Asynchronous transmission**
- **Any station can capture the RESTRICTED TIMED_TOKEN after the final message is delivered and issue an UNRESTRICTED TIMED_ TOKEN (Terminator)**

FDDI CRITICAL CONSIDERATIONS

ENCAPSULATION BRIDGES

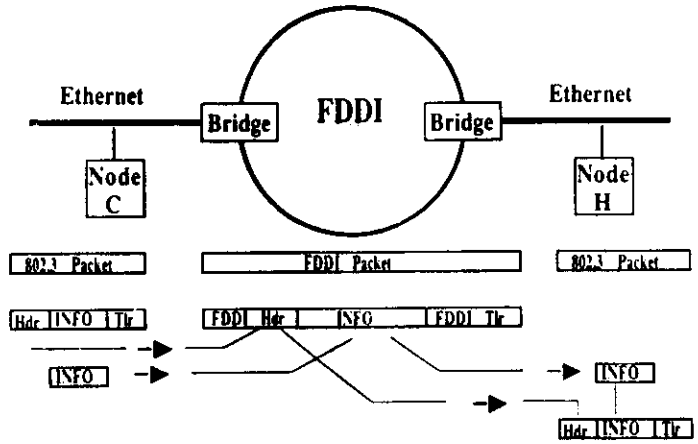
- **Encapsulation bridges are designed for quick market share**
- **Implement proprietary encapsulation protocols**
- **Do not facilitate interoperability between DAS, LAN and servers**
- **Can be poor performers (bottlenecks)**



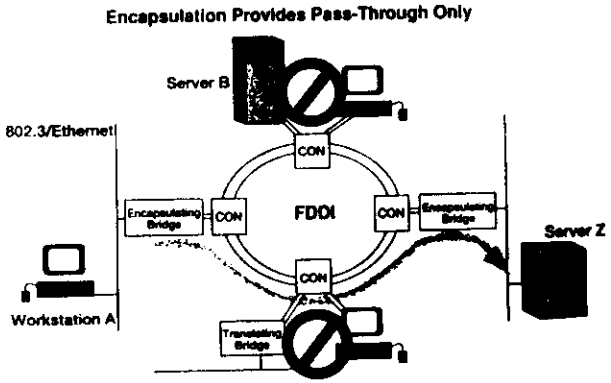
FDDI CRITICAL CONSIDERATIONS

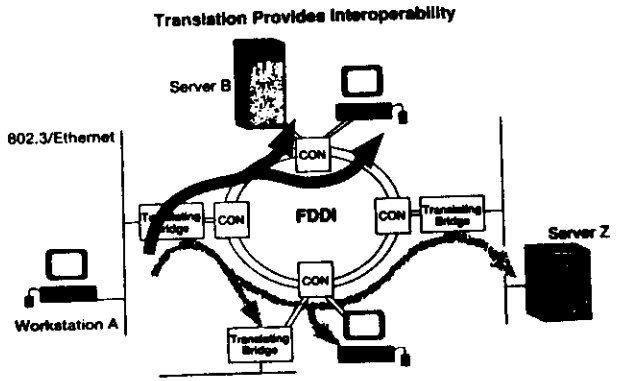
TRANSLATION BRIDGES

- **Translate data packets between Data Link protocols**
- **Provide full interoperability between LAN, DAS and servers**
- **Increased performance (FDDI:446,429 pps, ISO 8802-3:14880 pps)**



ENCAPSULATION vs. TRANSLATION





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FDDI CRITICAL CONSIDERATIONS

LARGE PACKET FRAGMENTATION

Connecting ISO 8802 LANs to FDDI requires the resolution of the differences in maximum packet sizes.

- **Applications' utilisation of large packets is a major concern (eg. file transfer, NFS/UDP)**
- **The IP RFC 971 (Request For Comment) specifies packet segmentation and reassembly**
- **Allows the use of maximum packet size on the respective networks**

FDDI CRITICAL CONSIDERATIONS

SAS vs. DAS

There is need for both schemes

- **DAS workstations are most appropriate for small groups**
  - **No structured cabling**
  - **High availability on Dual Ring**
- **DAS connection costs are high**
- **DAS may result in unstable backbone (reconfigure each time a DAS is turned off)**
- **In contrast, SAS connections via DAC provide**
  - **Manageable, flexible, stable configurations**
  - **Economies of scale**
  - **Facilitate the integration of FDDI and existing cabling systems**
  - **Isolate FDDI backbone resources (Bypass)**

FDDI CRITICAL CONSIDERATIONS

ROUTING AND BRIDGING

- **FDDI bridges should filter and forward packets at high speeds**
- **Perfomance depends on the ability to**
  - **perform table look-ups**
  - **translate between Data Link formats**
  - **fragment large FDDI packets (4500 Bytes)**
  - **execute the IEEE 802.1d Spanning Tree**
- **Worst case scenario at minimum 461,309 pps:**
  - **ISO 8802-3 64Byte packets : 14,880 pps**
  - **FDDI 20Byte+48bit address : 446,429 pps**
- **Router/bridge differences are blurring (Brouters)**
- **Multiprotocol Routers restrict interoperability**
- **IEEE 802.1d is the standard for LAN bridging**
- **Source routing is restricted to ISO 8802-5**
- **SRT specs are currently written for ISO 8802-3/ISO 8802-5 interconnection**

FDDI CRITICAL CONSIDERATIONS

FDDI NETWORK MANAGEMENT

A high level of confusion exists in the market about the role of SMT

- **SMT is a low-level, limited-function protocol addressing specific portions of the FDDI product set (PMD, PHY and MAC)**
- **Typically resides in firmware**
- **SMT is limited to a single FDDI ring**
- **Higher level protocols (CMIP/CMIS, SNMP) provide management across multiple rings on the enterprise network.**

DIGITAL'S FDDI VISION

- **FDDI complements the existing LAN technology**
- **Digital's FDDI product strategy is two-fold:**
  - **FDDI as a backbone for high-speed interconnect among LANs**
  - **FDDI as a dedicated high-speed network for specialised applications**

DIGITAL'S FDDI PRODUCTS

The following FDDI products feature Digital's FDDI Chipset, which is licensed to leading semiconductor suppliers (Motorola, AMD) for use in multivendor offerings

- **DECconcentrator 500, FDDI Hub**
- **DECbridge 500, LAN interconnect device**
- **DECelms, Extended LAN Management Software**
- **DEC FDDIcontroller 700**
- **A future communications controller from the DEC FDDIcontroller family will enable direct connection to the FDDI LAN by the XMI-based computers, such as the VAX6000 and VAX9000 class systems**

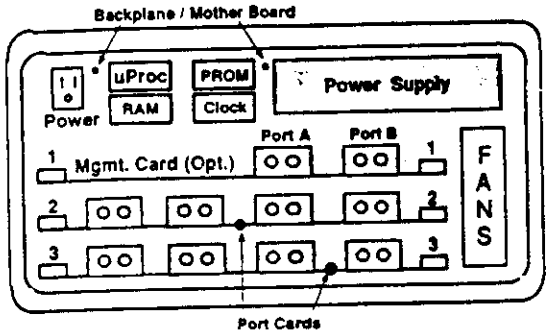
DECCONCENTRATOR 500

- **Standard compliant DAS (ANSI X3T9.5 Class A)**
- **In standalone used to create small, dedicated high-performance LANs**
- **As a backbone interconnect provides attachment to FDDI dual ring for workstations, computing systems and LANs**
- **Permits the design of " Dual Ring of Trees" by cascading several levels deep (SAC)**
- **Connects both DAS and SAS**
- **Optimises topologigal flexibility by inserting and/or removing stations (plug and play)**

Connection to FDDI dual ring and Network Management?	Number of FDDI device ports?	Number of DEFCN-Mx Modules Required	Number of DEFCN-Nx Modules Required
Yes	0	1	0
Yes	4	1	1
Yes	8	1	2
No	2	1	0
No	4	0	1
No	6	1	1
No	8	0	2
No	10	1	2
No	12	0	3

DECCONCENTRATOR 500

- **Two-port for primary and secondary ring connections**
- **FDDI SMT in firmware, downline loadable for future upgrades**
- **Three slots available for any combination of**
  - **Network management module (DEFCN-Mx)**
  - **Port modules (DEFCN-Nx)**



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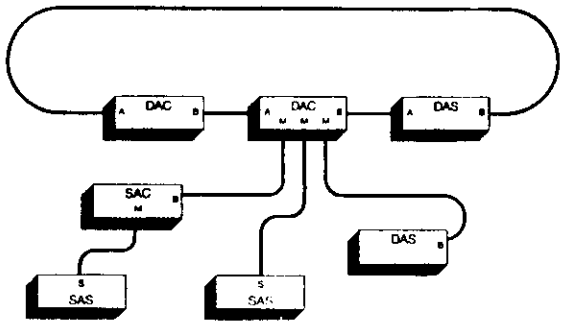
DECCONCENTRATOR 500

To properly configure the FDDI network one needs to be familiar with the following:

- **Port A - connects to incoming primary and outgoing secondary rings; implemented in DAC and DAS**
- **Port B - connects to outgoing primary and incoming secondary rings; implemented in DAC (DEFCN-Mx) and DAS; connects DAS to CON**
- **Port M - connects a CON to a DAS, SAS or another CON (DEFCN-Nx) CON only port**
- **Port S - connects SAS to CON**

But it is not enough... There are numerous configuration guidelines.



DECbridge 500

- Interconnects ISO 8802-3/Ethernet LANs to an FDDI backbone
- One FDDI port and one ISO 8802-3/Ethernet Thin/thickwire
- Connects to a DECconcentrator 500 as a SAS
- Standards compliant: ANSI X3T9.5 ISO 8802-2, ISO 8802-3, IEEE 802.1d
- Bridges traffic at maximum allowable speeds : 14,880 and 446,429
- Self-learning, bidirectional translation of Data Link formats
- Downline upgradeable firmware
- RFC 971 large data packet fragmentation
- Address and protocol filtering
- Protocol transparent
- Autoconfigures with LANbridge100 and IEEE802.1d

DECELMS - EXTENDED LAN MANAGEMENT S/W

- Allows for the management and control of bridges and concentrators from a remote location
- Supports DECconcentrator 500, DECbridge 500, LANbridge 200, LANbridge 150, LANbridge 100, Metrowave bridge
- Superset of RBMS V2.0, replacement in DECmcc EMS/SMS
- Network operation and topology management
- Provides ANSI SMT management functions
- Polls devices for faults, errors and changed information
- Enables password protection, address and protocol filtering
- Runs on VAX/VMS host systems
- Remotely invokes device self-test procedures

DEC FDDIcontroller 700

- **Enables RISC workstations (DECstation 5000/200) to connect to FDDI as SAS**
- **Compact (single slot, VLSI), TURBOchannel bus interface**
- **Supports network-based high bandwidth graphics applications**
- **Can install up to three**
- **Entry level IP router between OSI 8802-3 and FDDI resources**

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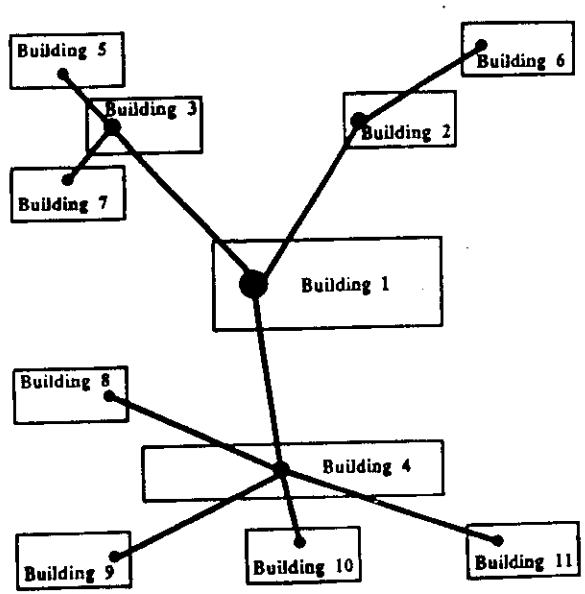
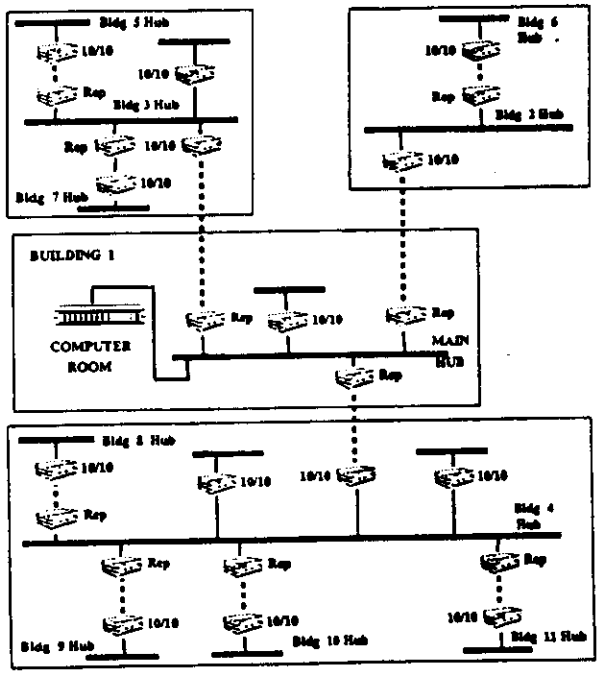
BACKBONE TRANSITION TO FDDI

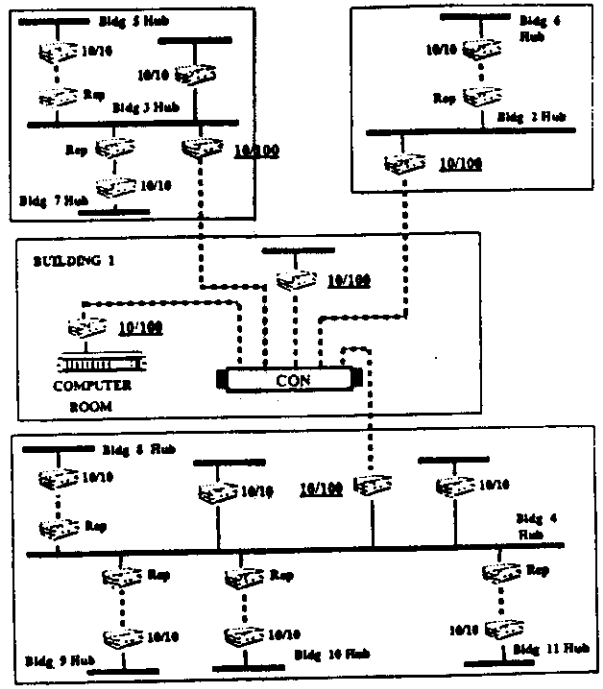


BACKBONE TRANSITION TO FDDI

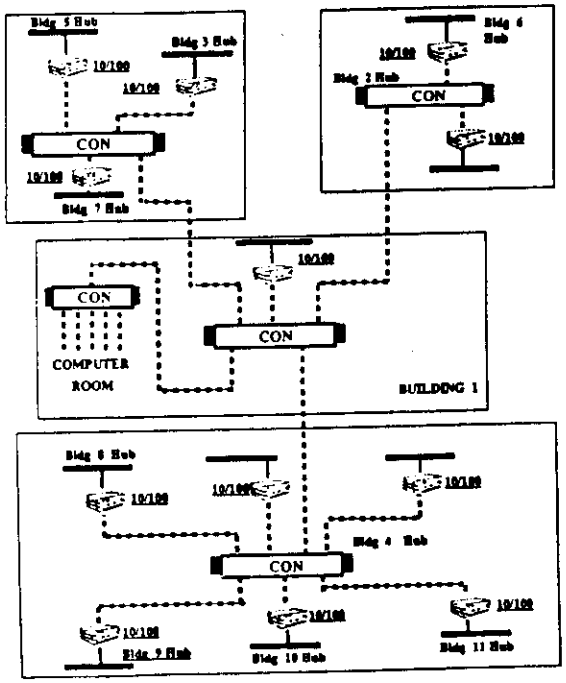


Fiber Distributed Data Interface - FDDI

BACKBONE TRANSITION TO FDDI



BACKBONE TRANSITION TO FDDI



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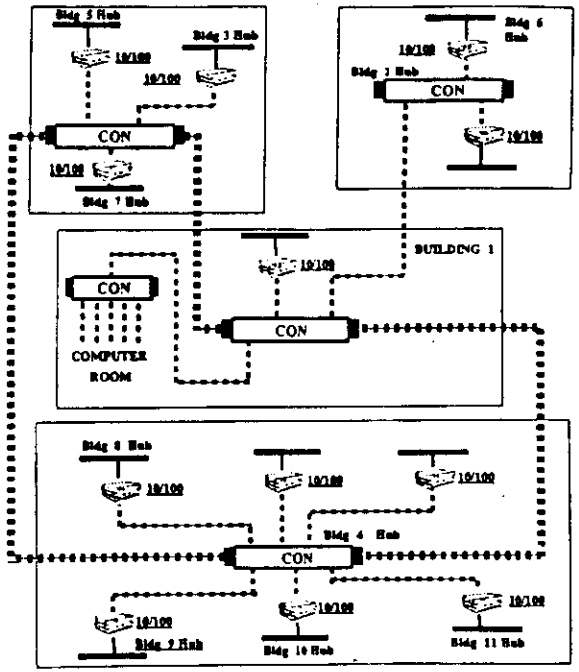
BACKBONE TRANSITION TO FDDI



FDDI FUTURE DIRECTIONS

Digital is currently investigating:

- **XMI FDDI controler**
- **Single mode fiber**
- **Copper alternatives (UTP)**
- **Combined Bridging and Routing**
- **FDDI to FDDI connections**
- **CI and NI VAXcluster to FDDI interconnect**

FDDI MARKET

- **Technology**
  - **Considerable misinformation**
  - **Proprietary or "FDDI-like" products**
  - **Uncertainty about product availability, associated costs, actual FDDI peformance, FDDI utilisation**
- **Market potential**
  - **Predictions vary dramatically**
  - **Greatest growth from 1991-1994**

FDDI MARKET

- **More than 25 vendors with differing perspectives/interests**
  - **Full systems (IBM, DEC, AT&T, UNISYS, HP/Apollo...)**
  - **LAN (Ungermann-Bass, 3COM, BICC, NOVELL ...)**
  - **Internetworking (Proteon, Artel, Cisco, Wellfleet, Vitalink, NSC...)**
  - **Workstations (SUN, Apollo, Apple ...)**
  - **Fiber Optics (Fibronics, Chipcom, Fibercom, IN-NET...)**
  - **Cabling (Focom, Codenoll, Synoptics, Cabletron...)**
  - **Silicon suppliers (Sumitomo, AMD, Motorola, National...)**
  - **T1/mux (Timeplex, Racal...)**

FDDI PROGRAM SUMMARY

- **FDDI is the next generation network interconnect**
- **FDDI complements Ethernet/OSI 8802-3 technology for building large networks**
- **FDDI is an evolving international standard**
- **Large, high-availability LANs can be built with standard FDDI products**
- **Design methodoly is critical to the creation of a unified "FDDI system"**
- **Transition from Etherner/OSI 8802-3 to FDDI is simple**