# Agilent Technologies
## Network Resources
White Paper

### Back to Basics: LAN Technologies

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Innovating the HP Way

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## Introduction

The internetworking world has witnessed a tremendous increase in new and varied technologies for interconnecting computer resources. Local-area networks (LANs) provide connectivity for a large number of mission-critical applications in organizations. Wide-area networks (WANs) and Asynchronous Transfer Mode (ATM) networks interconnect LANs to exchange remote information. The information superhighway is a reality, and modern companies who rely on the effective and secure exchange of information to be successful in business.

The volume of traffic in today's networks is increasing constantly, and the bandwidth offered by a typical 10 Mbps network is no longer sufficient to maintain the rate of growth of computer resources. This dilemma has provoked the emergence of high-speed technologies such as Fast Ethernet and Gigabit Ethernet.

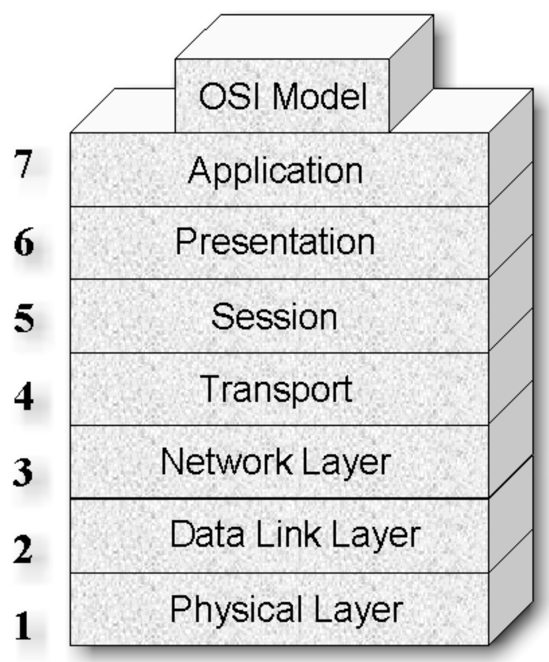
This paper explains those critical LAN technologies in use today and in the future. These technologies include Ethernet, Fast Ethernet, Gigabit Ethernet, Token-Ring and Fiber Distributed Data Interface (FDDI).

## Local Area Networks

One of the main objectives for the LAN is to share computer resources, such as file servers, printers, databases, and communication devices. A LAN connects devices so that they may be shared among a group of users within a workgroup, department, building or campus. Not sharing these resources is generally an expensive strategic mistake. The network is simply a medium used by the devices to make communications and resource sharing possible.

### The OSI Reference Model

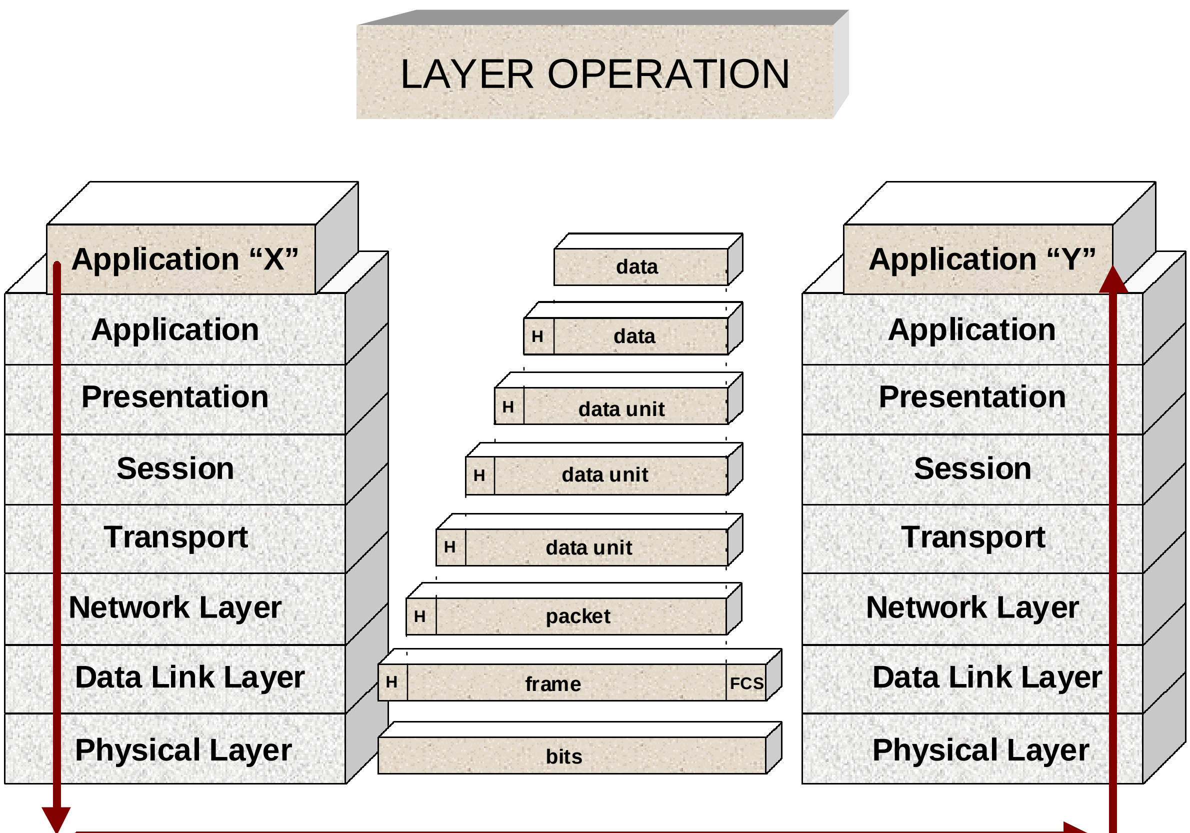
The International Standards Organization's (ISO) Open Systems Interconnection (OSI) reference model provides an architecture for networking protocols that facilitates multivendor communications in LAN (as well as WAN) environments. In a more generic sense, the OSI model breaks down the complex networking environment into more manageable "layers." Each layer performs a subset of the networking task. Implementation changes in any one layer will ideally not require a change in the other layers.



| Layer | Description |
|---|---|
| Application Layer (7) | Provides services to the end user or to a computer application. These services can range from file transfer to electronic mail exchange. |
| Presentation Layer (6) | Provides data transformations that are required for the particular application, such as encryption, or for the particular computer system, such as character translation (ASCII to EBCDIC or data type transformation (e.g. 16-bit integer fields to 32 bits) |
| Session Layer (5) | Provides for the setup, management and breakdown of connections (session) between communicating systems and applications |
| Transport Layer (4) | Provides for end-to-end transfer of data between end points. This layer ensures that no data is lost during transmission and that it arrives in the correct order. |
| Network Layer (3) | Provides the routing of a block of data, known as a packet, between the ultimate source and destination systems. The network layer also insulates higher layers from the methods and technologies of getting data from one point to another. |
| Data Link Layer (2) | Ensures that a block of data, known as a trame, is sent correctly from one node to another across a physical link. The communication between nodes at the data link layer is not necessarily between the ultimate source and destination of the data, but can be between intermediate stations. |
| Physical Layer (1) | Manages the transmission of a bit stream across a link. Mechanical, electrical and procedural parameters for transmission are also specified. |

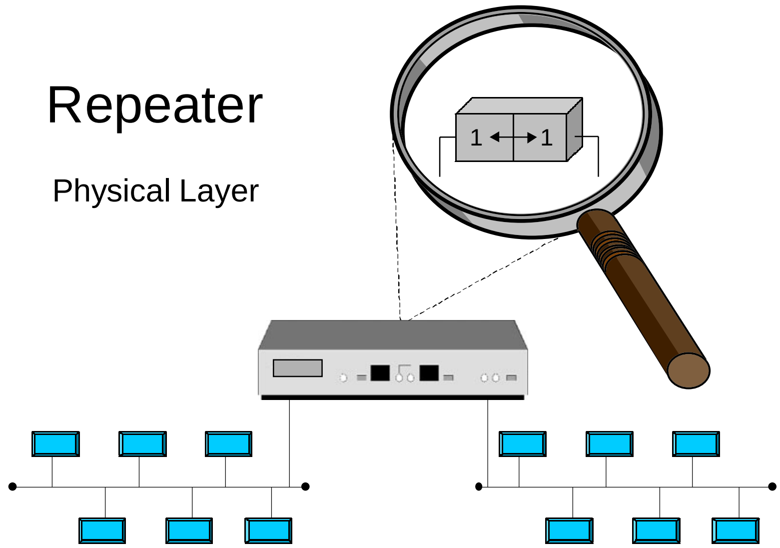
### Layer Operation

An important networking concept is how the user's data travels through the protocol stacks from one application to the next. Data is passed from the user application to the first protocol layer where layer overhead information is added in the form of a header. Each successive layer adds its own header to the "data unit" which is passed to the next layer. At the data link layer, a Frame Check Sequence (FCS) is also appended for the actual transmission of the new data unit across a physical link. The process is reversed so that the remote application gets only the data sent. An important part of the header information in each protocol layer is used to identify which process is to be given the data unit while traversing up the stack



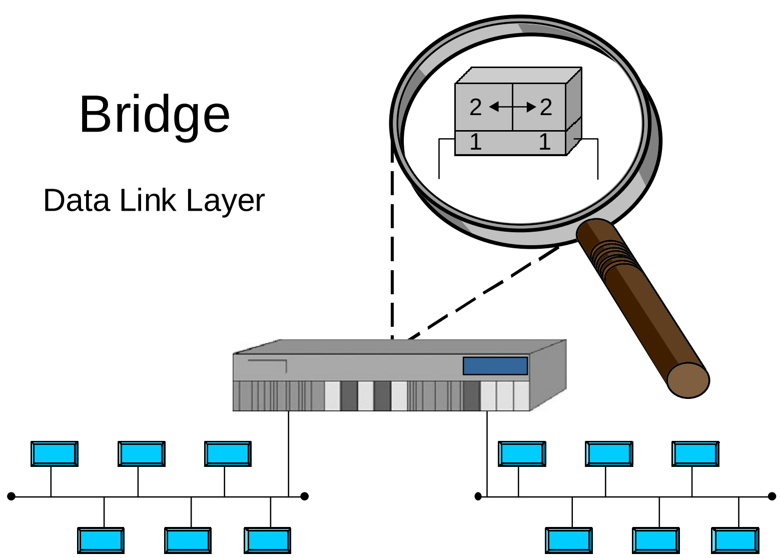
### Repeaters

A repeater is a network device that operates at the physical layer of the OSI model. It connects two or more LAN segments or rings, and its basic function is to retransmit each bit of a frame onto another network segment. Repeaters also pass on all collision signaling for Ethernet LANs.



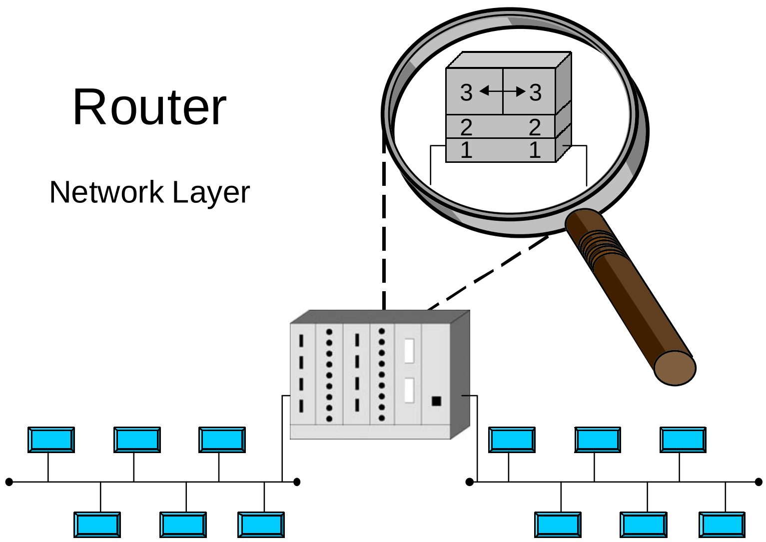

### Bridges

Bridges operate at the physical layer. Bridges forward frames based on the physical source and destination addresses in the frame. Bridges are very easy to install and need no configuration. They learn the addresses of the network and store them in internal configuration tables. Once a packet arrives at a bridge, it uses a reference table to decide whether the frame is filtered or forwarded. Bridges are protocol independent.



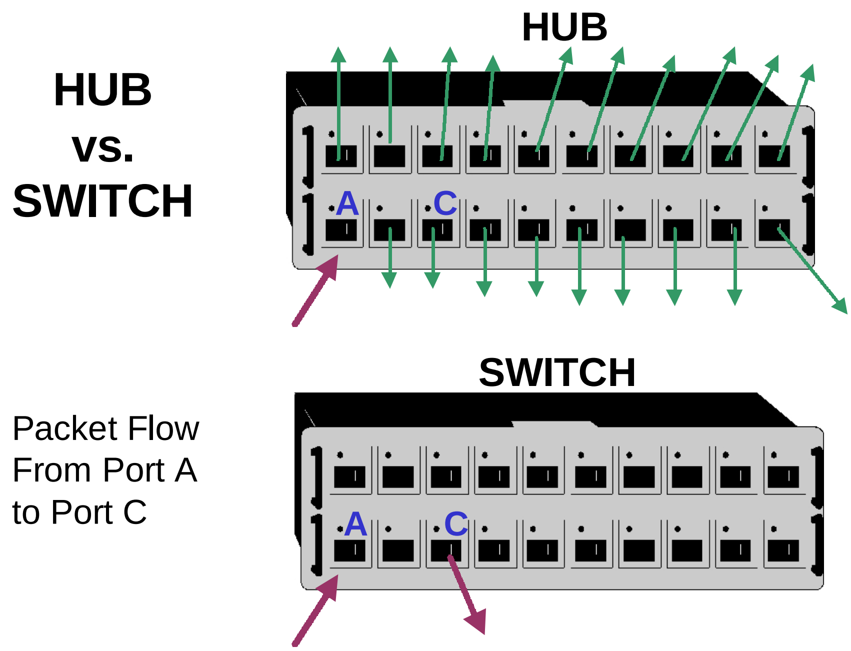
### Routers

A router is a device that routes packets between networks based on the network address located in the packet header (IP, IPX, etc.). Routers operate at the network layer and typically have routing tables that initially must be configured. Many routers have the ability to adjust their routing tables to the load and current configuration of the network through interactions with the network management systems or router-to-router communications. Routers are protocol dependent.



## Hubs and Switches

The function of a hub is to retransmit any packet that arrives at one port in the hub to the other ports in the hub. This means that all the nodes connected to a hub are  always able to listen to all the other nodes. Switches are a step ahead of hubs. Switches can "learn" the position of nodes in the network by mapping the physical addresses of the nodes localized in each segment of the network and then forwarding or filtering the packets depending on the destination address. When a packet reaches a switch, it compares the physical source and destination addresses of the conversation and isolates the conversation from the rest of the ports of the switch. Ethernet was the first technology addressed by switches, followed by Token Ring and FDDI.



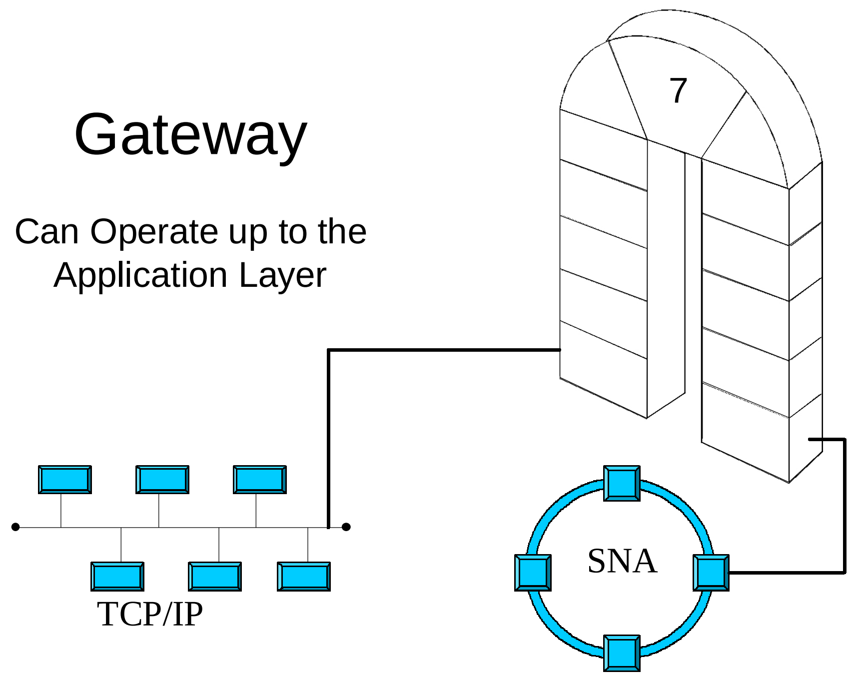

Switches are generally simple to install because they automatically learn the physical location of the nodes in the network. Some benefits of switches are that they can provide dedicated network bandwidth to each node in the network, and they separate collision domains, which reduces congestion and collisions in the network.

There are two kind of switches: cut-through and store-and-forward. The former is generally more efficient because it only waits only long enough to receive the destination address of the packet before forwarding the frame to the proper port. Although it is faster, a cut-through switch can forward erroneous packets because it does not wait for the entire packet to be deciphered. A store-and-forward switch stores the entire packet in a buffer and then decides where to forward it. While slower than a cut-through switch, the store-and-forward switch will not forward errors to the network.

A new generation of switches, now in development operates at layer 3 and 4 of the OSI model. This emerging technology identifies flows at the network and session layers and then sets up layer 2 to handle the forwarding and/or filtering to improve speed.

### Gateways

Gateways operate up to the application layer and convert from one protocol to another when two applications need to communicate and use different protocol stacks.




### Signaling Techniques

There are two major LAN signaling techniques.

Broadband is an analog transmission mechanism that requires modems. Several modulation techniques are used to transmit information onto actual carriers.

Baseband systems use bandwidth from DC (direct current) to a maximum frequency limit that is normally associated with the speed of a LAN (10Mbps, 16Mbps, etc.) One message at a time is carried on the cable, and there is no carrier frequency. Modems are not necessary, because all information is digital. Some of the more common encoding standards are Manchester, Return-to-Zero and Non-Return-to-Zero.

One difference between broadband and baseband is that the former uses separate frequencies for each channel, allowing transmission of different channels at the same time, whereas baseband allows only one channel of communication.

### Transmission Media

There are three main types of media used to carry the signals on a LAN: twisted pair, coax and fiber optic.

Twisted pair is used with baseband signaling. The advantages include low cost and installed base. Disadvantages are low noise immunity, limited distance, limited bandwidth and high maintenance.

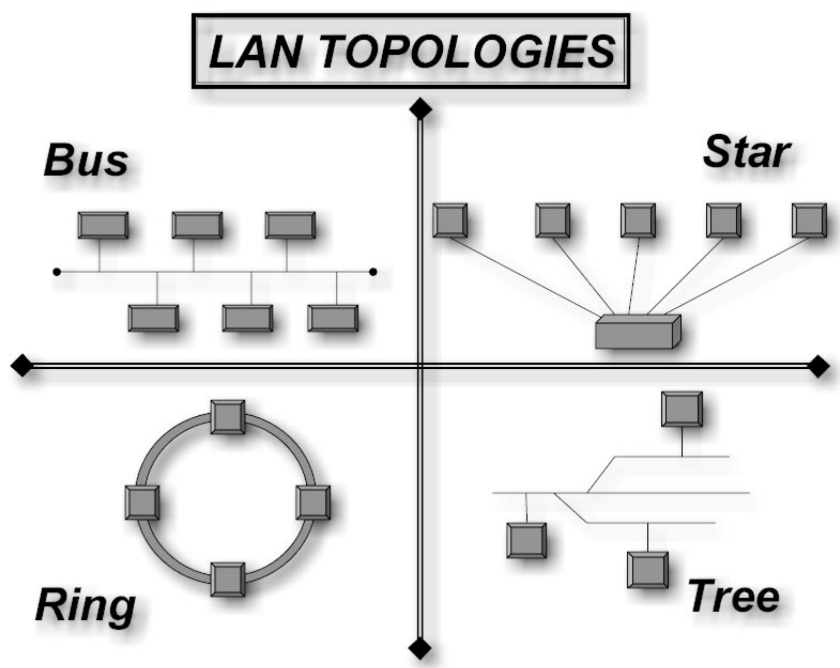
Coaxial cable is used with both baseband and broadband signaling, which are used on 50-ohm and 75-ohm cables respectively. The main advantages of coaxial cable are the ease with which the cable can be tapped, better noise immunity, and ruggedness than twisted pair; with the 75-ohm cable being the best.

Fiber optic has the advantages of being very secure, having extremely high noise immunity, very high bandwidth and being lightweight. Disadvantages of fiber are the cost, it is limited to point-to-point links and it is difficult to make a new connection.

## Topologies

Topology, in the context of a communication network, refers to the physical connection among network elements. It characterizes the data communication path between any two stations in a network. Topology is a major network design consideration as it affects cost, reliability, and more.

Four basic topologies exist: bus, ring, star and tree.



## Bus Topology

Bus topology was one of the first ones used for LAN networking. It is very simple and only requires one network interface card (NIC) for each node needing access to the medium. A bus network consists of a cable to which nodes are connected. In this topology, every device is directly tapped into the cable. Therefore, each device can listen to all traffic on the network, and an address filter allows each node to react only to information addressed to it. Examples of bus topology are Ethernet implementations using 10Base2 and 10Base5.

Advantages of bus topology are simplicity, low cost, reliability, availability, of several access methods and easy expandability and reconfiguration.

A major disadvantage is that if the bus breaks, the entire network is down. This is the main reason why this topology is not popular today. New networks are being implemented using star topology.

## Star Topology

Star is the most popular topology used today. Technologies using this topology include 10BaseT, 100BaseT and 1000BaseT.

Star topology contains a central node to which all remote nodes are connected. Advantages of this topology are simplicity of control, monitoring, and point-to-point connections (which are good for fiber optics).

One disadvantage is its dependence on the central node's performance for network reliability. If the central node goes down, the entire network is down. Cost is another disadvantage, as an interface is required in the central node for every node in the network. In addition, expandability may be limited if the central node can only support a limited number of remote nodes.

Star topology represents a step forward in manageability from bus topology. When a cable breaks in a star topology, there is only one node of the network affected, not the entire segment.

## Ring Topology

Ring topology is relatively simple and involves connecting one node to another with a point-to-point link. Each node pulls information addressed to it off of the ring and passes along information not addressed to it.

The advantage of ring topology is its ability to use fiber optic media in its simple point-to-point links.

Disadvantages are high cost due to duplicated hardware, lack of reliability (one failed node can stop the entire network), and the lack of flexibility.

### Tree Topology

Tree topology is an advanced form of bus topology. A cable functions as a bus that has branches coming out of it. As with bus topology, when transmission occurs, information is transmitted to all the points of the network. This medium is referred to as multiunit or broadcast.

## Protocols

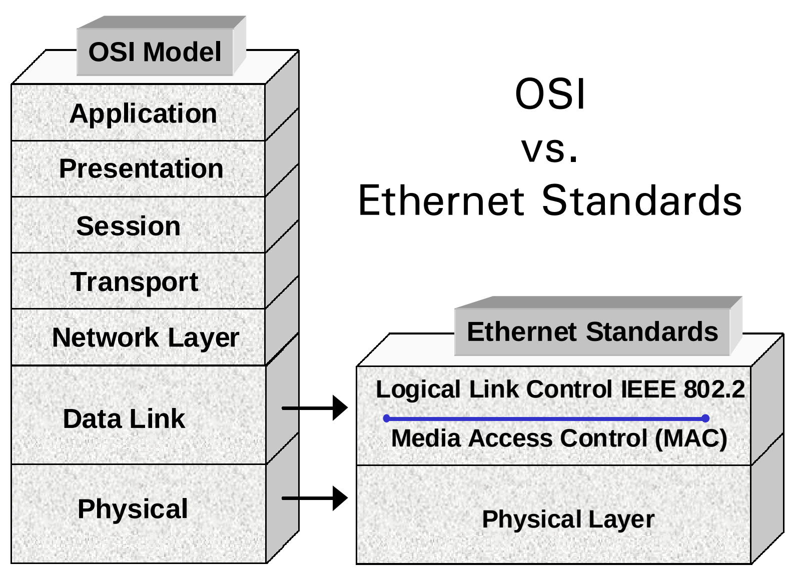
Protocols enable communication among devices in a network by defining how information will be handled during transmission and reception of data that is sent in packets across the network. Many different protocols are in use today, including TCP/IP, DECnet, IPX/SPX, AppleTalk, NetBIOS/NetBEUI, etc. It is very important to understand that each of these protocols acts as a logical network within the same physical cable or medium. For example, TCP/IP and IPX can coexist in the same ring of a Token Ring network.

## 10/100/1000 Mbps Ethernet

### Ethernet

The first implementation of Ethernet occurred in 1975. Xerox began development of this LAN technology and registered the name "Ethernet" as a trademark of Xerox Corporation. This technology was renamed as Ethernet I, and five years later was redefined as "Ethernet II." Digital, Intel and Xerox worked together on this new technology. It is often called Ethernet DIX in honor of these three companies.

Ethernet technology was very well received in the marketplace, and the IEEE proposed an International Standard for Ethernet. It formed the "802" committee to control LAN technologies such as Ethernet, Token Ring, FDDI, etc. In addition to the benefit of standardization, the IEEE proposed a method allowing communication between Ethernet, Token Ring and FDDI networks.

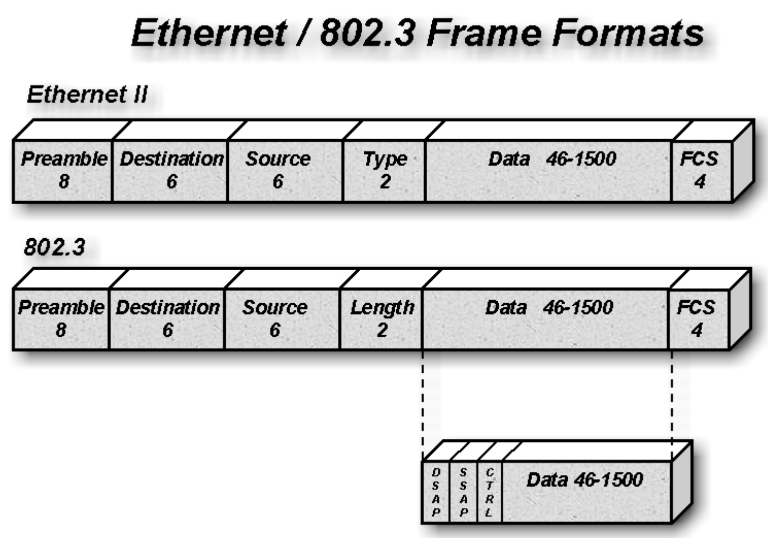


IEEE defines 802.3 as the standard for LAN Ethernet. It also created 802.2 as a format to communicate to any kind of LAN. 802.2, or Logical Link Control (LLC), on the Data Link layer of the OSI model. Internet Protocol, DECNET and some Novell protocols follow the regulations of the frame format of DXI. SNA and NetBEUI, as well as other protocols, follow the new 802 standards.

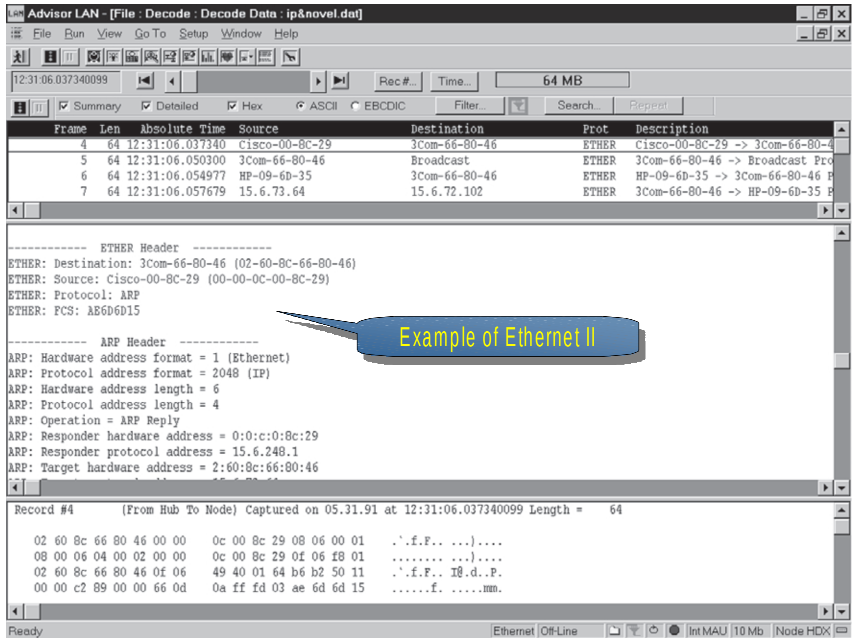
## Frame Format

Two kinds of Ethernet exist; thus, two types of frame formats must also exist. There is a third frame type called SNAP; however, it will not be discussed in this paper.

Ethernet defines a frame as a group of bytes transmitted sequentially over a physical medium. The first 12 bytes of  a frame contain the source and destination addresses of the data.



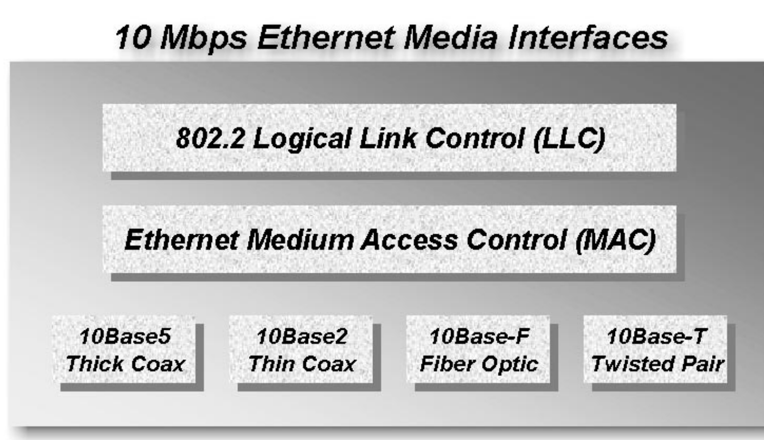

These addresses are called physical or factory addresses because the network adapter manufacturers hard code them. Source and destination addressees are six bytes long. The next two bytes vary between Ethernet DIX and Ethernet 802.3. The former uses them as a frame type and IEEE uses them as a length indicator. The length of an Ethernet frame is between 64 bytes and 1518 bytes; any frame size below 64 bytes is an error frame and is called runt. Jabber is a frame that is larger than 1518 bytes and is also an error frame.




## 10Mbps Ethernet Physical Media

10 Mbps Ethernet has four types of physical media: 10Base5, 10Base2, 10BaseT and 10BaseF. These names identify the basic characteristics of the system. The first 10 represents the speed of the network,which is 10Mbps for Ethernet. Base stands for Baseband, which is the signaling mechanism used. The last part gives an indication of the type of segment: 5 indicates 500 meters and uses thick coaxial cable; 2 indicates 200 meters (185 meters exactly) and uses thin coaxial cable. T stands for twisted-pair (100 meters) and F stands for fiber optic.

The initial Ethernet implementations used 10Base5 and 10Base2 because of the easy and economic characteristics of the bus topology. The problem was that when the bus cable was damaged in any point, the entire network went down. The star topology of 10BaseT improves the management issues of Ethernet. In 10BaseT if a link between a hub and a PC breaks, only this PC is out of service in the network. The problem here is the hub. If it goes down, the entire network follows it.



## CSMA/CD

In a broadcast network, every node can send information to the media. The restriction is that only one node is able to use the LAN at a time. CSMA/CD (Carrier Sense, Multiple Access with Collision Detection) is the protocol that Ethernet uses to access the physical media.

The Carrier Sense concept is that when a station needs to transmit a frame to the network, it has to make sure that the network is not being used by another station. The station will sense the network for voltage. Voltage represents a frame. The node will transmit after waiting 9.6ms from the last frame.

The Multiple Access concept is that the network is available for all stations. Every node is connected to the same physical media that forms a single data path.

Collision Detection recognizes the liklihood that two stations, both of which need to transmit information, can simultaneously detect that the LAN is idle. The two stations will each send a frame to the network and nanoseconds after doing so, the two frames collide. Collisions are normal events in Ethernet.When such a collision occurs, the two stations stop transmitting and will resend the frame, each doing so after a random delay. It is important that the delay is a random time, otherwise, the same collision will occur many more times.

## 100Mbps Fast Ethernet

When 10Mbps Ethernet was implemented in the late 1970s, it seemed that there was an infinite bandwidth for any kind of application. With the new services that followed the implementation of Ethernet like distributed servers, multimedia applications, etc., the speed of 10Mbps Ethernet is sometimes insufficient. This pushes the market to develop new and higher speeds.

10 Mbps Ethernet, with more than 70% of today's LAN market, is easy to maintain, inexpensive and reliable technology, so why not maintain the same knowledge of this technology and multiply the speed by 10? New purchases of Ethernet NIC cards are 10/100 Ethernet compatible, easing the transition to higher speed Ethernet.

IEEE defined Fast Ethernet in 1994 with the standard 802.3u. It uses CSMA/CD as the access media method. The topology used is star, identical to the star topology of 10Mbps Ethernet. In Fast Ethernet, the maximum theoretical frame rate is 10 times that of 10 Mbps Ethernet. As such, at a frame size of 64 bytes, for example, the maximum frame rate in Fast Ethernet is 148,800 frames/sec. At 1518 bytes, the maximum frame rate in Fast Ethernet is 8,110 frames/sec.

FDDI is a high-speed technology that allows transmission of 100Mbps. It is normally used in the backbone of corporation data networks. The problem with FDDI is that it is expensive. Another technology with 100Mbps is 100VG Any LAN. This is an excellent technology but somewhat complex.

Fast Ethernet at 100Mbps is the same as 10Mbps Ethernet but 10 times faster. This is the main reason why it has become so popular that it is replacing FDDI as a backbone and 10Mbps as a workstation and server access.

Fast Ethernet introduced two new concepts: Full Duplex and Auto-Negotiate.

### 10/100 Ethernet Full Duplex

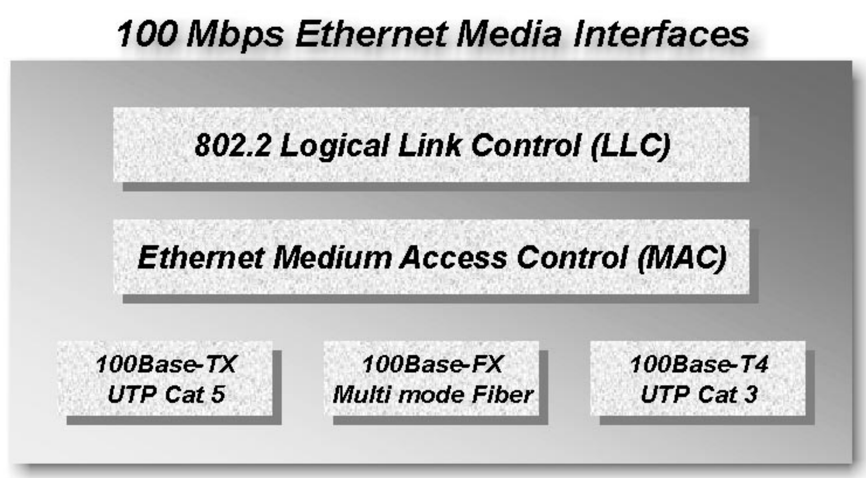
Full duplex allows simultaneous flow of data in both directions across a link. This is accomplished by disabling the collision scheme of the CSMA/CD access method. Full duplex can only be used with switching and only when both ends support, and are configured, for full duplex operation. Theoretically, full-duplex mode can double the bandwidth from 100 to 200 Mbps in the case of Fast Ethernet, and from 10 to 20 Mbps for Ethernet.

### Fast Ethernet Auto-Negotiation

Auto-negotiation (also known as auto-sense) provides support for determination of link options and optimal settings. With auto-negotiation enabled, a station can determine automatically - in conjunction with the other station - what physical signal capabilities to use: 10 or 100 Mbps.

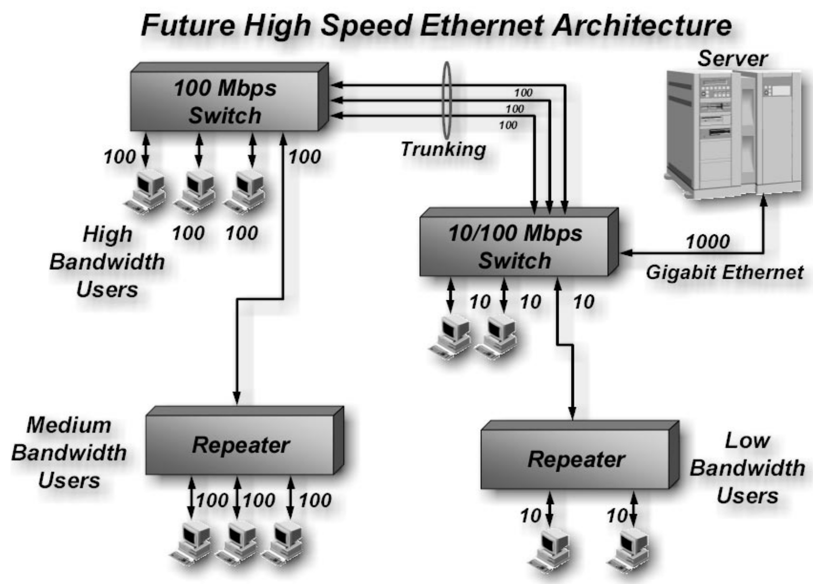
### 100Mbps Fast Ethernet Physical Media

Fast Ethernet defines a new mechanism to detect the speed of the media. This is called Auto-Negotiation. It allows Ethernet to work at 10Mbps or 100Mbps with the same media. However, there are minimum media specifications for Fast Ethernet: 100Base-TX uses twisted-pair cable UTP CAT 5, 100Base-FX uses Multimode fiber and 100Base-T4 uses twisted-pair cable UTP CAT 3. The most popular specification is 100Base-TX because it uses the same network configuration as 10BaseT.



## 1000Mbps Gigabit Ethernet

After having upgraded 10Mbps Ethernet to Fast Ethernet, it is a natural approach to upgrade Fast Ethernet to Gigabit Ethernet — 10 times faster than Fast Ethernet and 100 times faster than Ethernet. Multimedia, and more powerful servers and distributed computing are applications that could consume the entire bandwidth of a Fast Ethernet network. In 1998, the IEEE formalized the 802.3z Gigabit Ethernet task force. Gigabit Ethernet also uses CSMA/CD, same frame configuration and size as the other Ethernet technologies. The intention of Gigabit Ethernet is to work at the backbone of corporations and, in some cases, connect supercomputers to the network.

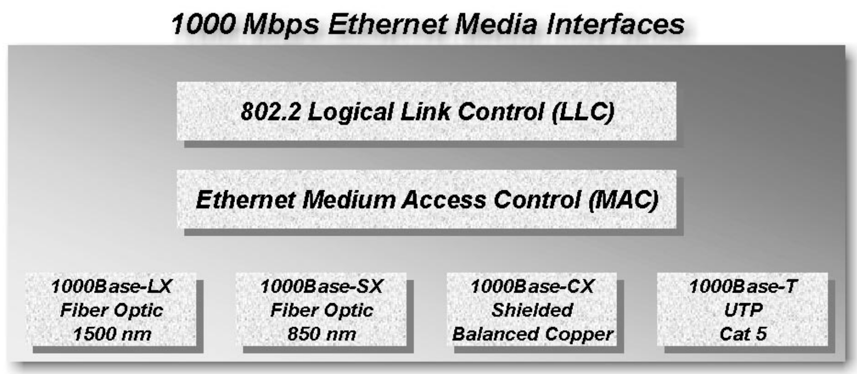



Gigabit Ethernet allows two types of connections: Full duplex and half duplex. As described in the Fast Ethernet section, full duplex can transmit and receive at the same time. This makes a Gigabit Ethernet connection of 2000 Mbps! When it operates at half-duplex mode, it incorporates the concept of CSMA/CD. Due to the high speed of transmission, Gigabit Ethernet may not detect collision of short frames. A station could send a short frame and finish sending it and after some time, a collision could occur. This makes 25 meters the longest collision diameter at Gigabit Speeds. To maintain the Ethernet standard of 200-meter collision diameter, the minimum packet size in the network becomes 512 bytes. This still allows sending 64-byte frames, but they are padded to form 512-byte frames. Frames longer than 512 bytes are not extended. Short frames sent in a full-duplex environment are not extended either. They keep their original size.

## 1000Mbps Fast Ethernet Physical Media

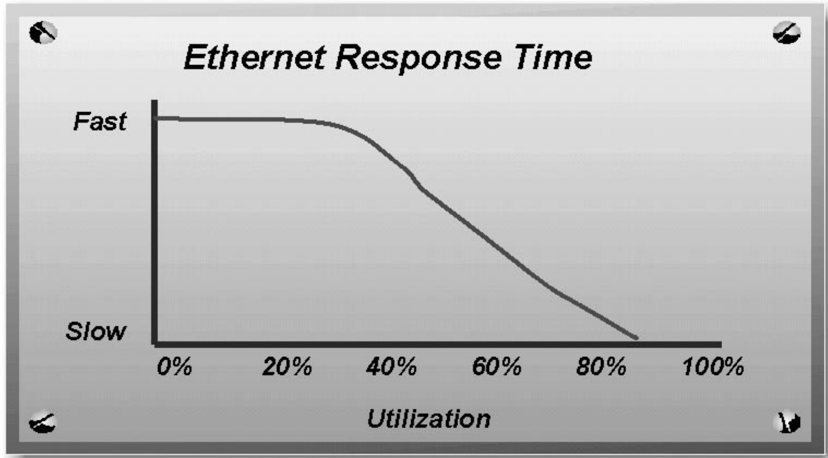
The first implementations of Gigabit Ethernet used Fibre Channel, 850-nm wavelength with multi mode fiber optics. There is also single mode fiber up to 3 km with 1300-nm wavelength. The specifications of the physical media of Gigabit Ethernet are:

| | | |
|---|---|---|
| 1000BASE-LX | Single Mode Fiber Optic | up to 3 km. |
| 1000BASE-SX | Multi Mode Fiber Optic | up to 550 m. |
| 1000BASE-CX | Shielded Balanced Copper | up to 25 m. |
| 1000BASE-T | UTP Category 5 | up to 100 m. |




## Ethernet Comparison

| | Ethernet | Fast Ethernet | Gigabit Ethernet |
|---|---|---|---|
| Data Rate | 10 Mbps | 100 Mbps | 1000 Mbps |
| Applications | File and Printer Sharing | Workgroup Imaging, Computing; Client/Server; Database Access | Multimedia Data Warehousing and Data Mining |
| CAT 5 UTP | 100 m. | 100 m. | 25-100 m. |
| STP | 500 m. | 100 m. | 25-100 m. |
| Multi Mode Fiber | 2 Km. | 2 Km.<br>412 Km. (HDX) | 500 m. |
| Single Mode Fiber | 25 Km. | 20 Km. (FDX) | 2 Km. |




## A typical characterization of a LAN Ethernet should contain:

| Parameter | Recommendation |
|---|---|
| % Utilization: | < 35% sustained |
| Collision rate | < 5% of packet rate |
| Error rates | < 5% of packet rate |
| Stations | Less than 200 active stations per segment |
| Broadcast and multicast traffic levels | < 20 pps (protocol dependent) |
| Frame size distribution by protocol | > 200 bytes average (protocol dependent) |
| Protocol distribution | In accordance with programmed protocol |
| Top talkers | Normally routers and servers |
| Response time | < 10% variation over time |

## Short Frames in Gigabit Ethernet

- When Gigabit Ethernet operates in half-duplex mode, it enables CSMA/CD. As explained before, frames shorter that 512 bytes are a problem, because stations could not realize that the frame that they sent collided with another one. Gigabit fixes it by padding any frame shorter than 512 bytes into a 512 byte-frame. The implications of this are serious. For example, a network that uses 64 byte frames will add an overhead of 488 bytes per packet! One of the first parameters that a Network Administrator needs to verify before a migration to Gigabit Ethernet is the average frame size of the network.

# Token Ring

## IEEE 802.5 Token-Ring

Token-Ring is a Local Area Network (LAN) architecture that provides communication capability to computers and other peripherals. There are two speeds for Token-Ring (IEEE 802.5): 16Mbps and 4Mbps. A good definition of "Token-Ring" is in an article entitled "Lore of the Token Ring" by Roy C. Dixon of IBM, printed in *IEEE Network Magazine* in January 1987. It is an old definition, but it is still valid. "A Token-Ring consists of a set of stations serially connected by a transmission medium. Information is transferred sequentially, bit by bit, from one active station to the next. Each station generally regenerates and repeats each bit and serves as a means for interfacing one or more devices (terminals, workstations) to the ring for the purpose of communicating with other devices on the network."

## Basic Token-Ring Configuration

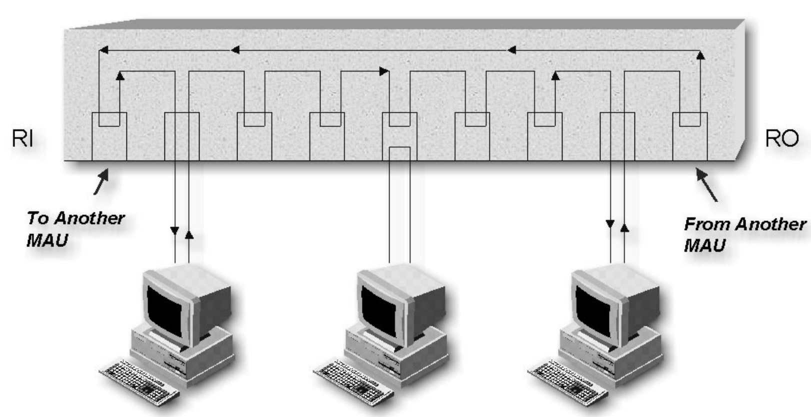
Token Ring is a group of stations connected back to back forming a circle. This configuration creates a point-to-point link between two stations. The link has a very simple operation: the data can flow in only one direction.

A special type of packet, called token, flows around the ring. Only a station in possession of the token has permission to transmit information. When any station transmits, it sends the information to its "downstream" neighbor. This neighbor retransmits the data to its "downstream" neighbor and so on, until the packet gets to its destination node. Each station also has an "upstream" neighbor. A disadvantage of this kind of operation is that if any link is broken, or a station is powered off, the entire network is down. However, most ring technologies provide good ring error recovery procedures.

## MAU

The Multistation Access Unit (MAU) is a network device that acts as the central node in a Token-Ring network. This converts a ring topology into a logical star topology. Physically the topology is still a ring, but it looks like stations connected to a central node similar to a hub. The MAU simplifies the wiring of the network. It has a switching capability that keeps the ring intact when the stations are powered off and on or a link to a station breaks. As the stations are entering the ring, the length of the ring changes. The same occurs when a station is turned off. This is normal operation in a Token-Ring network.

**MAU Block Diagram**



## Token-Ring Cabling Types

Several types of cables are available in the industry for use in Token-Ring networks. IBM usually recommends Type 1 cable.

Type 1: shielded data grade (available in outdoor and plenum)
Type 2: shielded data grade and unshielded voice grade
Type 3: unshielded data or voice grade (requires filters on connectors)
Type 5: fiber optic
Type 6: shielded data grade (patch cable)
Type 8: shielded data grade (under carpet)
Type 9: shielded data grade (plenum, a low cost version of Type 1)

## Token Passing

The token passing technique is based on a small frame or token that goes from station to station in the network. When a station is ready to transmit data, it takes the token and transforms it into a frame. The frame circulates around the ring until it reaches the source station. The station then releases the frame and transmits the token back to the network.

## Token-Ring Media Access Control (MAC) Functions

MAC frames control the operation of the Token-Ring network. The main functions of these frames are:
•Medium Control: Recovering errors in the network.
•Station Initialization: Control the access and exit of stations into the ring.
•Error Monitoring: Reporting of errors to a Ring Monitor.
•Network Management: Configuration of station.

A special station in the ring that controls some basic functions of the network. This node is called the Active Monitor. The Active Monitor is usually the first station recognized when the LAN is first starting to operate. Some functions of the Active Monitor are to control token issuance, transmission priority, to compensate for frequency jitter and basically to ensure that the network is running efficiently and without errors.

## Token Ring Hard Error Types

- Hard errors are generally related to physical layer problems
- The active monitor generates purge frames to clear the ring when a claim token process is completed or if a token error occurs.
- A station sends beacon frames when it detects a problem with its upstream neighbor. Usually indicates a problem with cabling or adapter faults.
- Any station that detects the absence of the active monitor sends claim token frames to initiate an active monitor election process.

## Token Ring Soft Error Types

- Soft errors are intermittent errors which can interfere with the normal flow of data on the ring
- Soft errors, when not accompanied proportionally by hard errors, are generally the result of a marginal token-ring adapter or interference coming across the cabling.

## Token Ring Source Route Distribution

- Routing Profiles provide information on traffic flow between local and remote rings. This information helps when designing or tuning the network topology.
- Unless this is a backbone ring, traffic just passing through should be minimal.

# FDDI

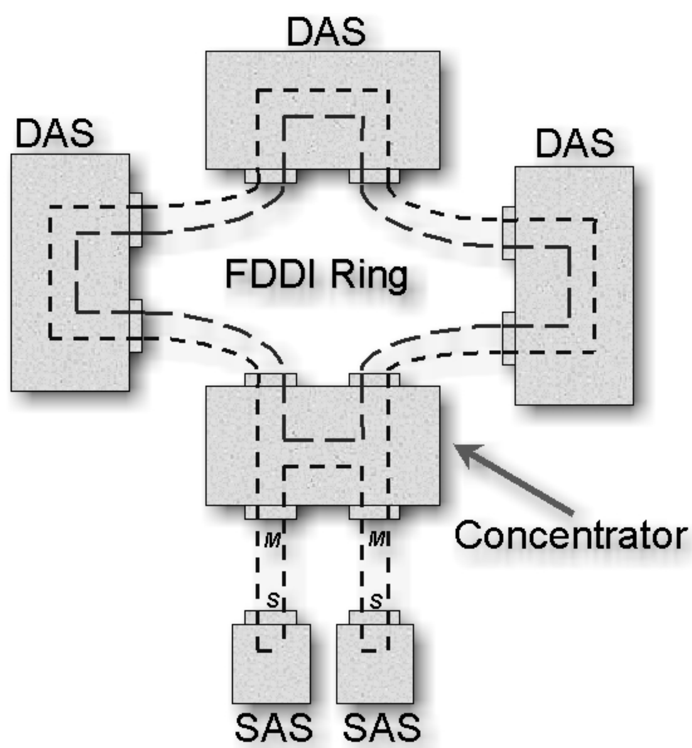
## Fiber Distributed Data Interface

Fiber Distributed Data Interface or FDDI is a mature LAN technology. It has been used in the backbone of corporate networks. It is a reliable network and supports extended distances between nodes. The speed of the network is 100 Mbps and is based on Fiber Optic connections or copper cable connections (CDDI). Much of FDDI is based on the standard for Token Ring, IEEE 802.5.

Even though FDDI is a mature technology, it has proved to be an excellent option for backbone solutions; However, it is losing market share against Fast Ethernet, a technology that is easier to install and maintain and is cheaper. Another technology that is being implemented today as a backbone is ATM (Asynchronous Transfer Mode).

FDDI is a ring topology with two parallel rings. The dual-ring topology provides reliability. The secondary ring provides a back up path. This allows a tolerance to faults in cabling. The downside is that a FDDI ring supports only one fault in the cabling. With two faults, the ring becomes two isolated rings.

The basic components of FDDI are concentrators, stations, optical fiber and optical connectors. There are two kinds of stations: Dual Attachment Station (DAS) and Single Attachment Station (SAS). DAS devices attach directly to the dual ring or to a concentrator. They have two terminals or ports called port A and port B. SAS devices attach directly to concentrators and have a port called M.



## FDDI Standards

The first two layers of the OSI model are physical and data link. FDDI subdivides each layer in two. The physical layer is subdivided into the Physical Layer Medium Dependent (PMD) and the Physical Layer Protocol (PHY). The PMD specifies connector types and the media used. The PHY specifies transmission details.

The data link layer is subdivided into the Media Access Control (MAC) and Logical Link Control (LLC). The MAC specifies frame formats, addressing conventions, and the FDDI timed-token protocol. LLC specifies data exchanging conventions between LLC users, and is defined by IEEE 802.2.

FDDI Station Management (SMT) defines relationships between PMD, PHY, and MAC. SMT secures that each station is operating properly.

## Media

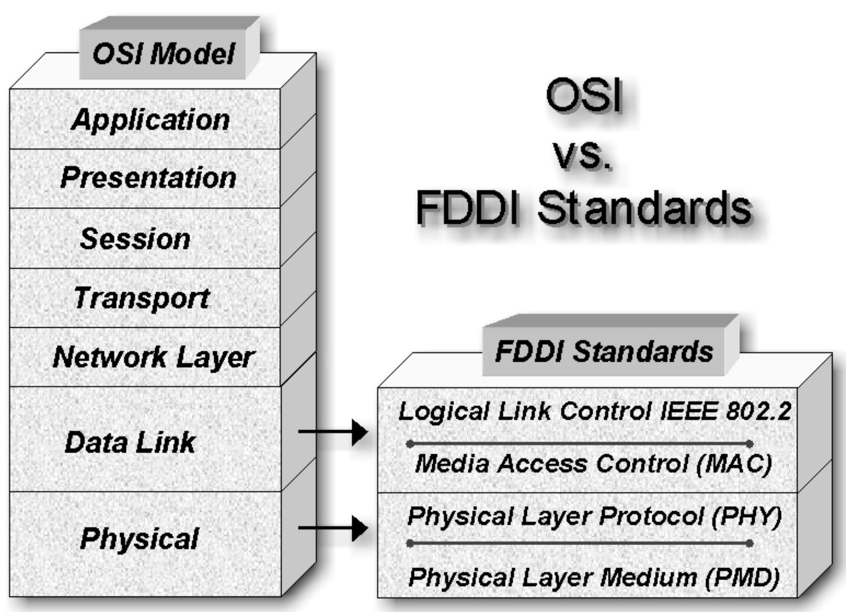
PMD specifies how stations physically attach to the FDDI ring and the media type that physically interconnects stations. Four PMD standards correspond to various physical media.

The two approved media types for FDDI are multi-mode fiber (PMD) and single-mode fiber (SMF-PMD). Other media include twisted pair (TP-PMD) and low-cost fiber (LCF-PMD). Twisted pair includes Shielded Twisted Pair (STP) and some categories of Unshielded Twisted Pair (UTP).

## Physical Layer (PHY) Functionality

Physical layer functionality consists of data encoding/decoding, clock synchronization, elasticity buffer, preamble smoothing, repeat filter, and scrubbing orphan frames.

In FDDI, the basic unit of information is the symbol. Interestingly, this technology is in reality a 125 Mbps network. A four-bit symbol is represented by a five-bit symbol. The three types of symbols that have been defined include data symbols, line state symbols, and control symbols. The remaining symbols are either not allowed or are used in signaling.



## FDDI Soft Error Types

- Soft errors are generally caused by faulty adapter cards or cabling.
- E-Flag set or bad FCS indicates a checksum error – a bit error in transmission. Bad FCS indicates a problem with your upstream neighbor. E-Flag set is a bad FCS value in frame sent from a station further upstream.
- Violation is an invalid symbol on the ring.
- Long frames are frames greater than 4500 bytes or 9000 symbols in length.

## FDDI Hard Error Types

- Hard errors are generally more related to FDDI cabling issues and faulty components than soft errors.
- Claim frames are sent when a station inserts or de-inserts in the ring, has not received a frame or token within 2.5 ms, or has a high bit error rate.
- Beacon frames are sent when a fault occurs in the network and stations are attempting to locate the fault domain.
- Claims and beacons cause the ring to re-set.

## FDDI Ring State

- The ring operation counter indicates the number of times the ring has switched from operational to non-operational per second.
- SMT frames, usually NIFs, are seen on the network at 30-second intervals. Unusually high levels of SMT frames can indicate problems.
- SRF frames report errors.
- Link error monitor (LEM) counts indicate that a physical layer problem exists.

## Conclusion

The need for higher speeds in LANs is a constant. New applications require higher bandwidth every time. An example is the incredible growth of the Internet, which is growing more than 200% a year. Legacy technologies such as 10BaseT are now insufficient and companies are starting to implement new types of LANs in order to keep up. Some of these technologies are Fast Ethernet and Gigabit Ethernet.

The OSI model is an important reference source to understand the operation of networks. Every kind of network and protocol follows this model or a similar one. In order to interconnect different networks, a number of network elements exist, such as repeaters, bridges, routers, hubs, switches, gateways, etc. Each performs a unique task in the network and has advantages and disadvantages. The main LAN topologies are bus, star, ring and tree. Ethernet can use either bus or star topology. The main LAN technologies are Ethernet, with speeds of 10, 100 or 1000 Mbps, Token Ring, and FDDI, the most popular being Ethernet at 10Mbps. Fast Ethernet, which is ten times faster than regular Ethernet has an important place in the market today. Gigabit Ethernet is another ten times faster than Fast Ethernet and companies are very serious about putting it into their expansion plans.

The data communications world is more than simple LAN technologies connecting network resources in a local environment. It is a complex relationship among LANs, WANs and protocols.

The future of LAN's is bright, and the development of new technologies is faster than ever. It is just a matter of time before we see the world enter the next millennium and fascinate us with new inventions in data communications.

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## What is the main problem you need to solve on your network?

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## Notes

## Notes

## Notes

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## About The Author

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Luis Hernández is a member of the Business Development Team for network test products with Hewlett-Packard Company and now with Agilent Technologies. He has several years of experience in the evolution of data communication networks. Luis has an engineering degree in Electronic Systems from the Instituto Tecnológico y de Estudios Superiores de Monterrey, in Mexico City.


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