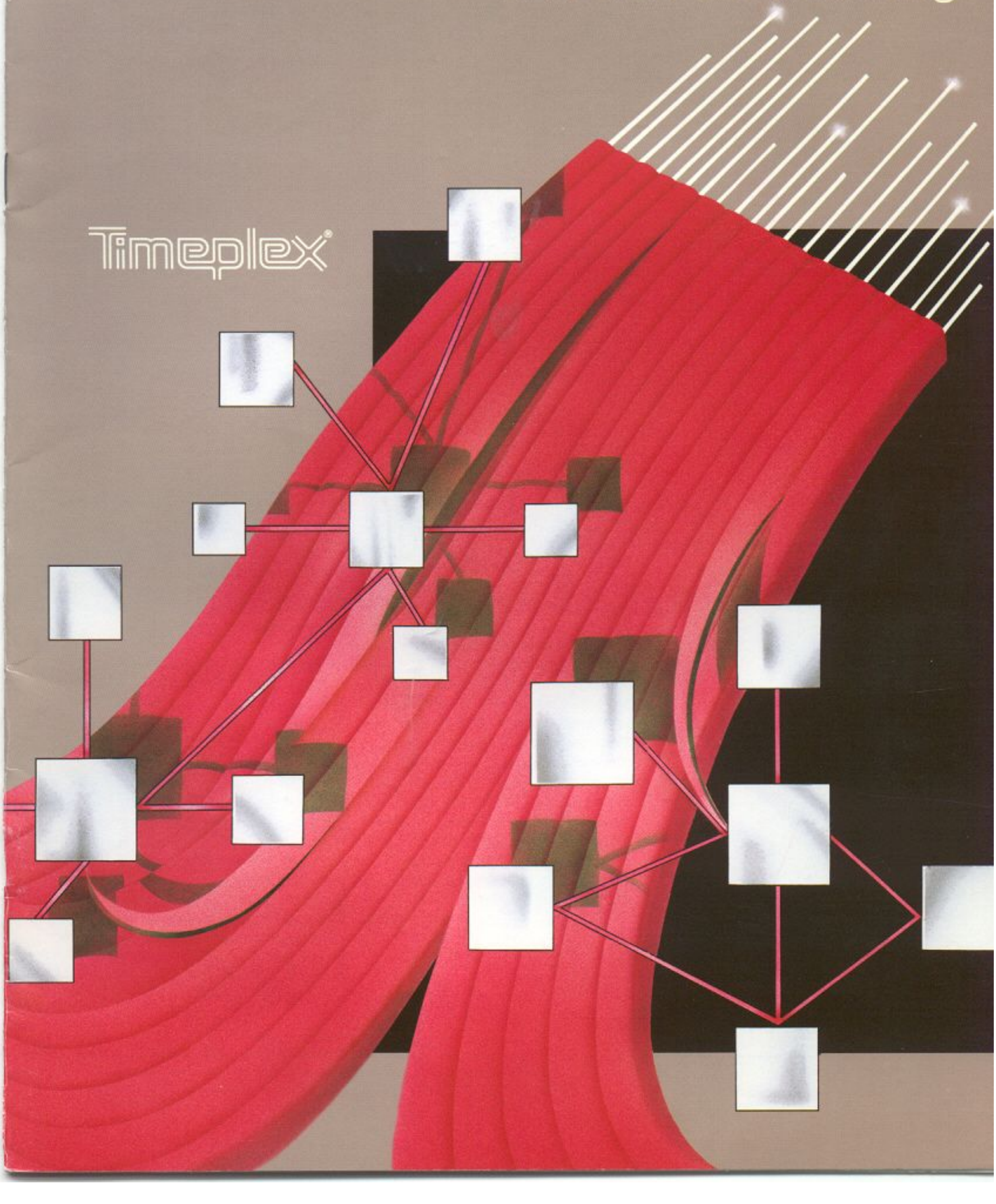
Technical Backgrounder: LAN/WAN Internetworking

Timeplex®



Technical Backgrounder: LAN/WAN and LAN/LAN connectivity

The growth in local area networks has created a demand for a new type of connectivity: LAN/WAN internetworking and LAN/LAN connectivity.

In the corporate environment today, both local area network (LAN) and wide area network (WAN) data and image communications are the network high-growth areas. Recent studies show that data communications is increasing at 35 percent annually versus only a 5 percent growth rate for voice.

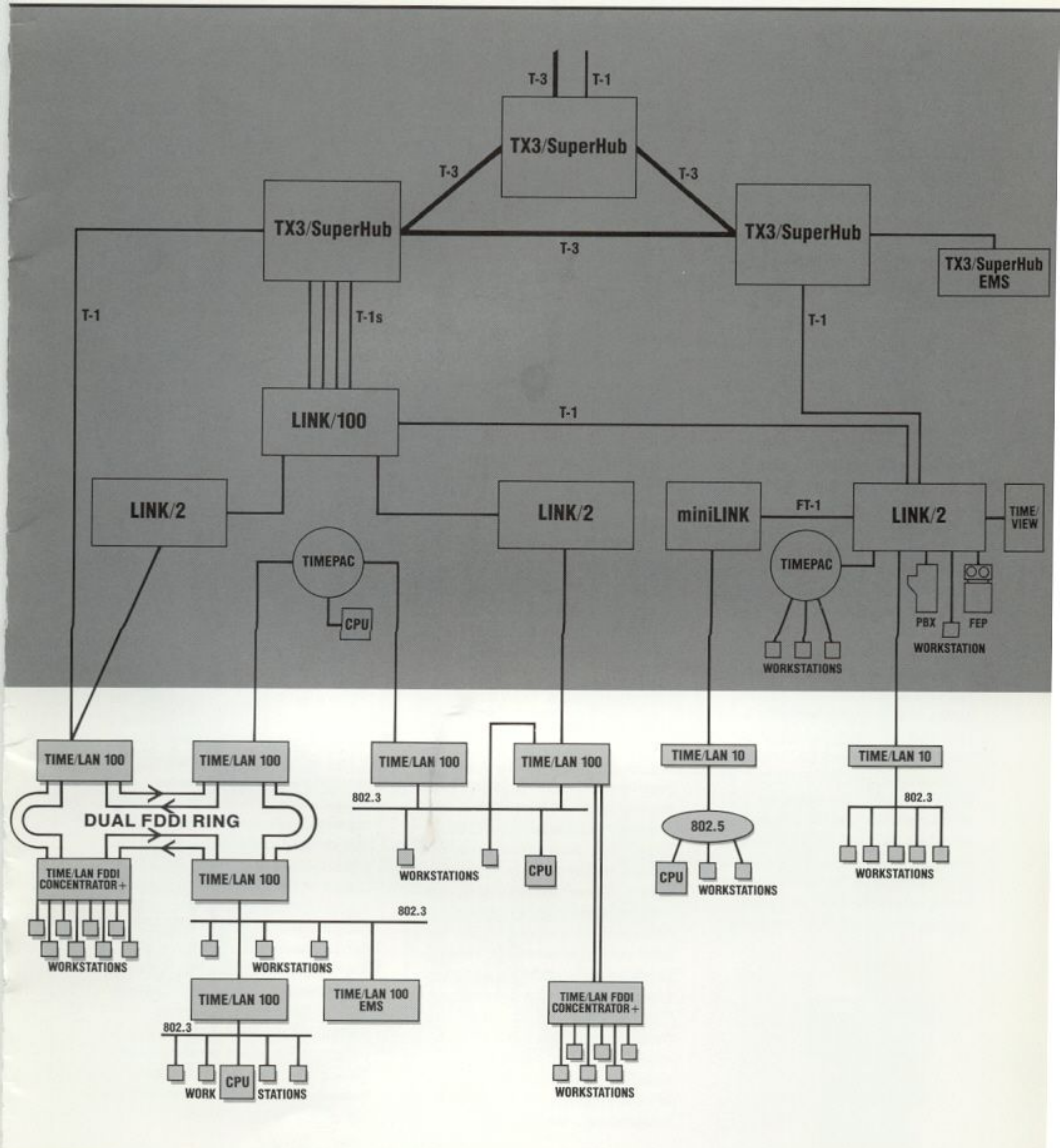
Most of today's growth in data communications is due to the increased use of high performance workstations and personal computers (PCs) for data intensive applications. More and more people are using workstations and PCs, and these users are demanding access to data sources across an entire enterprise. Data must be accessible when and where it is needed.

LANs have proven to be an extremely effective means of sharing data between devices (e.g., workstations and PCs), especially in situations where all users are located within a relatively short distance. As a result, the use of LANs has increased significantly in recent years to permit users to share expensive hardware resources, applications and data. For instance, studies show that there are approximately one million PC LANs in use today.

The LAN market has witnessed a proliferation of both proprietary and industry standard LAN hardware and software products. These products include a variety of topologies (e.g., bus, ring, and tree), transmission media (e.g., shielded and unshielded twisted pair wire; baseband and broadband coaxial cable; and optical fiber), and medium access control techniques (e.g., token ring, token passing, and carrier sense multiple access with collision detection or collision avoidance).

The arrangement, or connectivity, of devices in a LAN is usually referred to as its topology. The two topologies most widely accepted are the bus and the ring. Other topologies, such as the tree and star, have found some acceptance in the marketplace.

An example of the bus topology is Ethernet LANs. The normal bus topology involves a linear, usually continuous, medium where all devices are directly attached via a short tap cable. Each device transmits (Tx) and receives (Rx) signals on the common bus medium according to the established access method protocols for the specific LAN. The signals usually travel in both directions on the bus medium from their point of transmission. The signals are dissipated in terminators installed at the ends of the bus medium. Coaxial cable is the most used bus topology medium.



Timeplex, worldwide leader in T-1 wide area networking, has expanded the market that it serves to include LAN/WAN and LAN/LAN connectivity.

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LAN LAYER 1 [illegible] PROTOCOLS

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OSI

OSI – Open Systems Interconnection – is an international set of standards for communication between systems. The purpose of OSI is to create an environment where devices can freely communicate with any other device to share data and applications transparently.

The OSI framework of standards is divided into seven levels or "layers" as follows:

Layer 1: Physical Layer. Defines the physical means of sending data over lines, providing electrical, mechanical, and functional control of data communications.

Layer 2: Data Link Layer. Defines procedures and protocols for operating communications lines and detecting and acting upon error messages. The Data Link Layer contains the Media Access Control (MAC) sublayer, which defines media-specific access control protocol within IEEE 802 specifications.

Layer 3: Network Layer. Defines how data is transferred and controls routing between devices.

Layer 4: Transport Layer. Manages transport of data, providing error recovery and flow control capability.

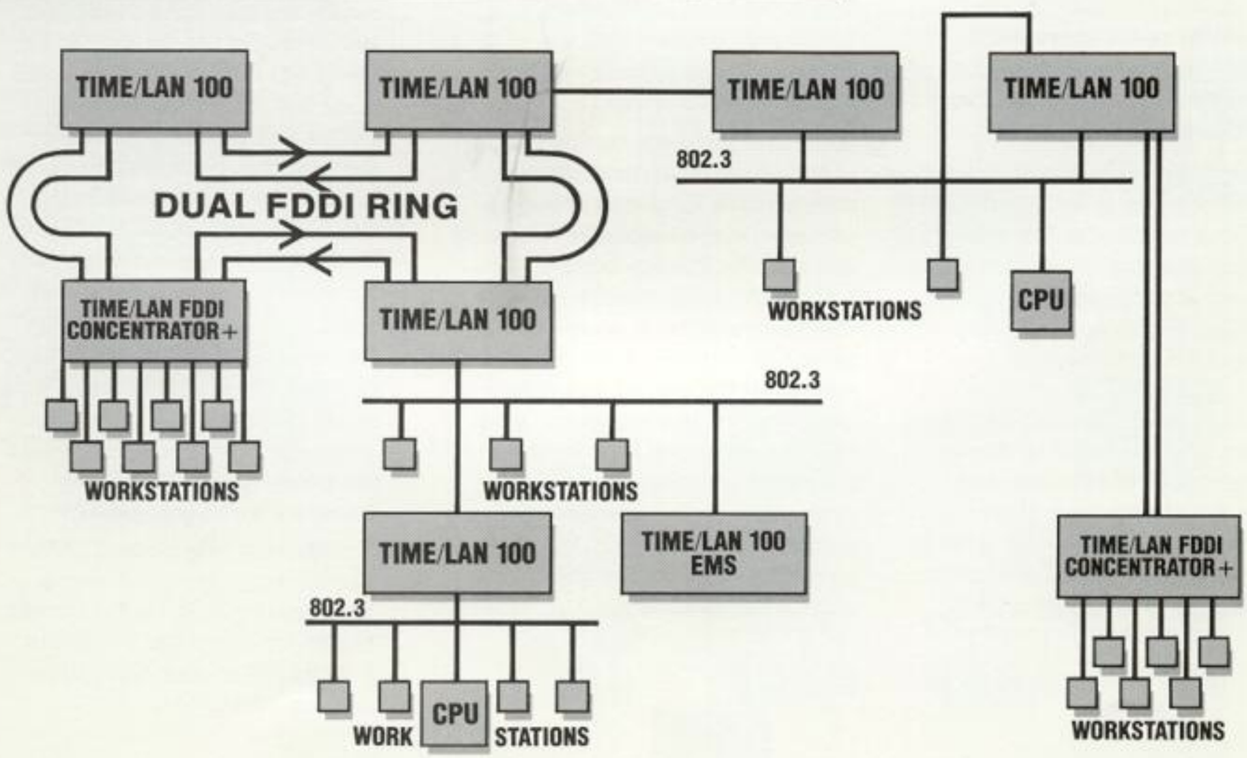
Layer 5: Session Layer. Controls the use of the basic communications facilities provided by the transport layer.

Layer 6: Presentation Layer. Allows noncompatible equipment from different vendors to communicate transparently by compensating for differences in data formats.

Layer 7: Applications Layer. Contains specifications for applications such as file transfer, remote line access, and virtual terminal.

SOURCE: Newton's Telecom Dictionary

Token Ring LANs: While Ethernet enjoys the lead in the number of installations today, the number of IEEE 802.5 Token Ring MAC protocol compliant products shipping today are equal to that of Ethernet. The number of installed Token Ring LANs is growing rapidly. The Token Ring protocol provides an efficient utilization of the ring topology. When a device has data to transmit, it "listens" to the ring medium until it detects a bit pattern denoting a token. Transmission is regulated by a token which is passed from one device to the next device around the ring. Only the device that possesses the token may transmit data. The device removes the token from the ring and then transmits a frame of data. When the frame has circulated back to the sending device, the device places the token back on the ring. The token will then circulate until it is taken off the ring by a device with data to transmit. Token Ring LANs work well from a performance perspective because of the



TIME/LAN™ 100 FDDI systems, which include an enhanced concentrator, routers, and an element management system, cost-effectively provide the benefits of high-speed premises networking.

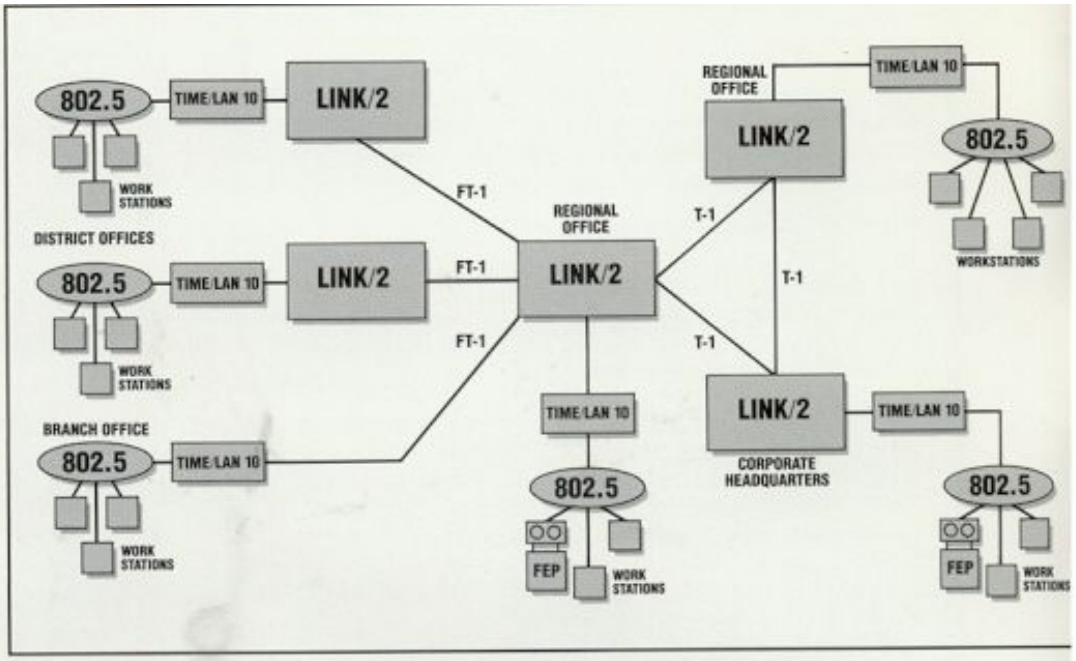
deterministic nature of the protocol. Even though the 4 Mbps version of IEEE 802.5 Token Ring operates at a lower data rate than the 10 Mbps Ethernet, the Token Ring LAN is more efficient than CSMA/CD LAN under a very heavy data transmission load. The net result is that the two LANs are about equally efficient in meeting peak data transmission demands.

FDDI LANs: The X3T9.5 FDDI protocol is similar to that of the Token Ring protocol. At the physical level, FDDI specifies the use of an optical fiber ring operating at a data rate of 100 Mbps. The high data rate and large distances supported between devices make FDDI an excellent choice for backbone networking. It is becoming increasingly unusual for LANs to be utilized in isolation. New FDDI based products can be effectively used to interconnect multiple LANs. Further, the high capacity of FDDI is needed to help meet the growing worldwide demand for increased data communications capacity.

LANs help users share data throughout an enterprise. But as their popularity grows, current limitations become clear.

In today's data communications environment, the growing number of devices attached to LANs and the increasing use of bandwidth-intensive applications are rapidly exceeding the capacity of many current LAN technologies.

For instance, an Ethernet LAN can become heavily loaded by five to ten high-speed devices running CAD/CAM applications. High-resolution imaging also can quickly deplete the available bandwidth of an Ethernet or Token Ring LAN.



TIME/LAN 10™ Routing Bridges provide the connectivity required to internetwork LANs.

Another limiting factor of LANs is distance. For example, the user in the engineering department wants to network with other engineers in the same building, the R&D center across the street, manufacturing in another state, and accounting in another country.

The need is to interconnect LANs and WANs – and to connect LANs to each other locally and remotely.

Organizations are actively seeking solutions which allow them to internetwork local area networks across an entire enterprise nationally and globally. The key benefit of LAN/WAN internetworking is that users can share resources via access to data and other computing resources throughout an entire organization, on a worldwide basis. It is this accessing and sharing of information resources that enterprises require to compete successfully in today's global, fast-paced, information-oriented business environment.

LAN/LAN connectivity takes place in several forms:

- Existing, independent, colocated LANs may be connected directly, enabling users to share additional data and resources.
- Large LANs that are overloaded may be divided into subnetworks which are then linked together. Subnetworks can be sized to fit the needs of their primary users, ensuring cost-efficient use of media without compromising performance. For instance, a small group might get an unshielded twisted-pair Ethernet (1 Mbps) while a larger department gets a coax cable Ethernet (10 Mbps).
- Instead of directly connecting Ethernet LANs to Ethernet LANs, or Token Ring LANs to Token Ring LANs, these various lower speed networks may be interconnected via a high-speed (100 Mbps) premises backbone network.
- Finally, remotely located LANs may be interconnected over a wide area network via T-1 circuits, DDS lines, fractional T-1 and/or T-3 circuits or over X.25 public data networks.

The end result of LAN/WAN and LAN/LAN connectivity is the "extended LAN" – a LAN that provides data communication from any device on any LAN to any other device on any other LAN within an enterprise.

Today vendors offer a variety of solutions to achieve LAN/WAN and LAN/LAN connectivity.

The basic devices that are used to connect LANs include bridges, routing bridges, and routers.

Bridges. A basic bridge provides connectivity between two LANs that utilize the same link level protocol, e.g. Ethernet to Ethernet or Token Ring to Token Ring. Bridges offer high throughput but have limited networking functionality. Local bridges connect LANs locally, remote bridges connect LANs via a wide area network. Bridges operate at the OSI Layer 2 and are transparent to OSI Layer 3 (Network Layer) and above protocols.

Routing Bridge. A routing bridge can interconnect more than two LANs. A routing bridge passively "learns" the locations of devices on each of its directly connected networks. A routing bridge looks only at the OSI Layer 2 addresses to create its own address tables. An intelligent path selection is made by the routing bridge while maintaining protocol transparency. While routing bridges only look at level two addresses, they implement proprietary routing schemes that do not perform all the processing of a Layer 3 router product.

Routers. Routers operate at the OSI Layer 3, the Network Layer. The router, which is Layer 3 protocol dependent, routes packets based on internal packet data, network loading or congestion and the availability of network trunk paths. The basic difference between a bridge and a router is that a bridge is usually transparent to end devices while the router is addressed specifically by the end device on a LAN in order to request services for internetwork communication. Routers provide attributes desired in enterprise networks including high survivability capabilities, dynamic internetwork path selection, and security features. Routers do require more processing than bridges to forward packets.

Let's take a look at these solutions in more detail.

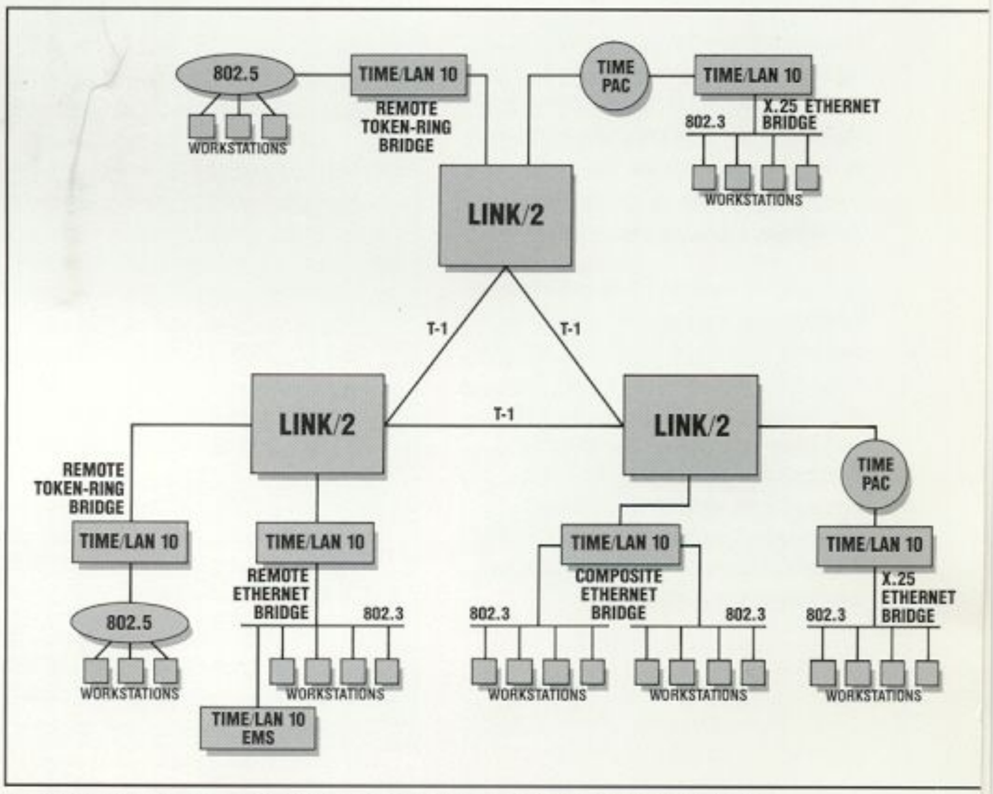
A bridge is the simplest, easiest to install, and generally the highest speed LAN-to-LAN connectivity device.

There are two basic types of bridges. A local bridge is used to directly connect one LAN to another colocated LAN. A remote bridge connects geographically separated LANs.

The bridge filters all packets on the LAN to determine which packets remain local and which packets must be forwarded to another LAN. If a packet is destined for another LAN, the bridge checks its destination address against a routing table containing a list of addresses, then forwards the data packet to the appropriate LAN.

Although basic bridges are fast, they usually do not provide networking or routing functionality. The bridge can only determine where to send data, not which path to send it on.

The main application for bridges is for networking a limited number of LANs – either directly or via a wide area network – where high data transfer rates are desired.



TIME/LAN 10™ Routing Bridges enable connections between 802.3 Ethernet and 802.5 Token Ring LANs...an Ethernet LAN to an X.25 packet switching network...or to connect to a T-1 WAN.

Bridges are simple to use and easy to install. Bridges operate at Layer 2 (Data Link Layer) of the OSI model, and are independent of higher protocol levels. As a result, a mix of a high level of protocols can pass concurrently over a bridge.

Routers provide LAN/WAN and LAN/LAN connectivity with a greater degree of network functionality.

A router performs a function similar to a bridge, but with a greater degree of networking intelligence.

Routers connect LANs at Layer 3 (the Network Layer) of the OSI model. At this layer, the router "understands" the hierarchical structure of network addresses. This enables the router to receive, forward, and route packets of data to specific devices on other LANs. Routers allow each "sub-LAN" within an enterprise-wide network to maintain its own independent address schemes. Routing tables and algorithms in the router's software determine how traffic is switched.

The router handles a network topology with several paths. It performs the routing function by looking at the packet's destination address and choosing the most efficient, reliable path for data transfer.

Because of their built-in networking intelligence, routers are used to connect a large number of LANs in a complex network topology for enhanced network management and improved network integrity. Routers are the preferred LAN connectivity device of network managers who have large networks requiring multiple active paths and intelligent path routing.

FDDI

FDDI – Fiber Distributed Data Interface – is a relatively new type of LAN that is based on fiber optic technology.

FDDI uses a dual, counter-rotating token ring protocol. Attached devices are connected to each other in series through duplex fiber optic cables forming a dual fiber optic ring.

Data is transmitted, in frames, on both rings in opposite directions, which is why FDDI is called "counter-rotating." Each frame contains a maximum of 4,500 8-bit bytes.

FDDI's dual-ring design is self-healing, meaning that if one of the ring segments fails (e.g. breaks), FDDI automatically "wraps" the rest of the ring together so that the FDDI LAN continues to function, bypassing the failed segment.

In addition, an optical bypass capability enables you to detach or power down any dual-attached device on the LAN without adversely affecting the operation of the network. (A tiny reflective prism snaps into position, routing the light beam around the device.)

In multimode operation, FDDI uses a 1,300 nanometer LED light source transported over graded index fiber to allow data communication between workstations up to 2 kilometers apart. In single mode operation, the LED light source is replaced with a laser, increasing the maximum distance between nodes.

The FDDI specification, introduced to the ANSI Standards Committee X3T9.5 in the 1980s, meets ISO standards and is now being adopted as a worldwide standard for fiber optic LANs. The FDDI standard contains the following layers:

PMD. Physical Medium Dependent. Optical parameters defining single and multimode operation.

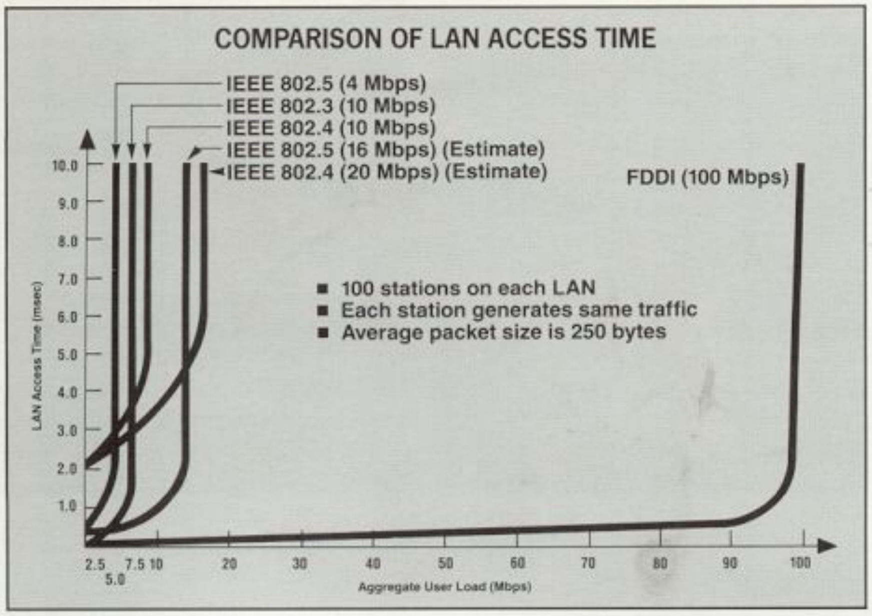
PHY. Physical Layer. Implements a 4B/5B algorithm for encoding and decoding of data transmissions.

MAC. Media Access Control. For routing and allocation of synchronous and asynchronous traffic.

LLC. IEEE 802.2. A data link layer standard.

SMT. Station Management. Controls station functions such as initialization, ring control, addressing, and bandwidth allocation.

NOTE: The SMT layer, still under standards committee consideration, is the only layer of the FDDI specification not ratified. So it's important that your FDDI vendor guarantees that equipment purchased now will be upgraded to the final version of SMT when it is available. Timeplex makes that guarantee.



FDDI can handle an aggregate user load approaching 100 Mbps. This makes it ideal for internetworking lower-speed LANs.

Routing bridges for LAN/WAN internetworking

A routing bridge combines the LAN/WAN internetworking of a remote bridge with routing capability.

Routing bridges operate at the MAC sublayer of OSI Layer 2 (Data Link Layer). They use sophisticated algorithms to build routing tables that contain the complete topology of the enterprise-wide LAN network.

The routing bridge can route packets in multipath networks with alternate links and loops. This makes them ideal for connecting distant LANs over a corporate wide area backbone network; the routing bridge has alternate routing capability and other functionality typically found in wide area networks. The routing bridge can choose the best path among multiple active loops and redundant links based on delay time and cost-effectiveness.

FDDI is ideal for internetworking LANs.

FDDI – Fiber Distributed Data Interface – is a fiber optic local area network that overcomes many of the speed and distance limitations inherent in existing LANs.

To begin with, FDDI operates at 100 Mbps – many times the rate of Ethernet and Token Ring LANs. A highly efficient bandwidth access algorithm further enhances throughput.

In addition, the use of fiber optic cable enables data communication at greater distances. Up to 500 dual attachment connections can be made to an FDDI dual ring, and the distance between each device can be up to 2 kilometers (1¼ miles). This means that FDDI can be used as a backbone for premises-wide networks or even for networks that span an entire metropolitan area, as well as for local area networks.

What's more, one or more of the dual attachment devices can be FDDI concentrators; these devices enable you to connect multiple single attachment devices to the FDDI dual ring. Each device can be extended up to 2 kilometers from the FDDI concentrator. This not only extends the reach of the FDDI LAN, but also drives down the cost per connection to the LAN.

Advantages of FDDI

FDDI has the capacity to handle an increasing number of users, higher-speed workstations, and bandwidth intensive applications such as the transmission of high-resolution images. By networking existing LANs over a high-speed FDDI LAN backbone, you can provide users within a campus or a metropolitan area with an "extended LAN" with the speed and bandwidth they need.

Not only can FDDI LANs cover large geographic areas and provide 100 Mbps bandwidth, but they also can take advantage of the inherent superiorities of fiber optics. For example, FDDI LANs are immune to electromagnetic and radio frequency interference and are not affected by lightning or power surges. Compared with copper, fiber optic cables are lighter, less bulky, and have a very low bit error rate.

FDDI networks can offer great security. For instance, Timeplex's FDDI TIME/LAN™ 100 Routers and TIME/LAN FDDI Concentrator + give you the ability to set up "Virtual Private LANs" within a network (extended-LAN) so that you can control the level of access assigned to each user.

FDDI was originally developed as a high-speed, back-end connection between closely coupled hosts and peripherals. But today it is also used as either a front-end LAN for a geographically dispersed user community or as a premises-based backbone for interconnecting lower speed LANs.

FDDI enables direct host connectivity to support multi-tier architecture for distributed processing via workstations, departmental systems, and mainframes. And, FDDI is the only local area network with the capacity to efficiently handle high-resolution imaging, optical disk storage, video capture and transfer, and other high-bandwidth applications.

The FDDI Concentrator + provides central-point hubbing for office and campus environments.

A new class of device, the Timeplex TIME/LAN FDDI Concentrator + allows multiple single-attachment devices or TIME/LAN 100 Routers to be connected to an FDDI backbone. The single-attachment devices (e.g., workstations) are connected to the TIME/LAN FDDI Concentrator +, which itself is dual-attached to the FDDI dual ring. Fiber from the dual ring is terminated at the TIME/LAN FDDI Concentrator +, which provides ring attachment and management capability.

The FDDI Concentrator + provides cost-effective, multiple device connections for FDDI networks combined with IP router functions. The use of TIME/LAN FDDI Concentrator + devices simplifies FDDI network topology – and decreases the cost per connection – by providing a common connection point for multiple devices.

An electrical bypass feature allows any of the devices attached to the FDDI Concentrator + to be disconnected or inserted without disrupting the primary FDDI ring. Intelligent network access management features provide validation of FDDI devices and isolate failed attachments from the ring.

Network management systems optimize LAN/WAN internetworking and LAN/LAN connectivity.

To achieve an enterprise-wide extended LAN, routers, concentrators, routing bridges, and bridges must function, as much as possible, as networking devices. This means that the network manager needs a network management system capable of controlling these devices as part of a total network.

Today, most bridges and routers do not have network management software. Some vendors offer a separate software package specific to each device.

The network management system for an enterprise-wide extended LAN functions similarly to a network management system for a wide area network. A network topology map displays the physical and logical map of the extended LAN, while a configuration management tool enables the network manager to update both device configuration data as well as network device parameters – and to verify these changes at a central console or terminal.

Status monitoring tools report on the performance of routers, concentrators, routing bridges, and bridges throughout the extended LAN. The network management system indicates when a device has failed and activates an alarm when performance falls below some predetermined threshold. The software should also collect performance data and traffic statistics indicating usage and frequency of LAN-to-LAN communication.

Other key features of the extended LAN network management system include on-line help, database management, accounting management, trap reporting, diagnostic routines, fault isolation and detection, access control, and user authentication. Security features are especially important when you need to restrict access to select LANs within the enterprise-wide extended LAN.

The next step

An enterprise can achieve many benefits by implementing the new internetwork products to connect its separate LANs whether they are colocated in one building or spread over a campus or metropolitan area – or accessible only via wide area networks. Internetworking will allow more users to share more data, to share specialized hardware (e.g., laser or color printers), to share applications, to improve performance with higher capacity FDDI LAN products, to improve access security and to subnet LANs to eliminate some local performance bottlenecks. These benefits can be realized while preserving an enterprise's significant investment in existing LANs.

It is therefore important, when implementing an enterprise-wide extended LAN, that you talk to a vendor who offers an array of FDDI devices as well as experience in wide area networking for LAN/WAN internetworking. The full range of expertise is essential for the success of your network.

Timeplex, a company with over 20 years experience in communications networking, now offers a full line of LAN/WAN internetworking and LAN/LAN connectivity systems. For details on LAN networking, or to receive product-specific information on the Timeplex line of routers, concentrator, and routing bridges, contact your Timeplex representative or call us at (201) 930-4600.

GLOSSARY

Colocated LANs. LANs located near one another.

Distributed processing. The sharing of tasks, data, and applications among several small or mid-size processors versus one large mainframe.

Dual attachment workstation. A workstation that attaches to both rings of an FDDI LAN to enable the workstation to benefit from FDDI's self-healing features.

Enterprise. Refers to the whole of an organization (as opposed to its individual locations, divisions, offices, etc.)

Extended LAN. A "super" LAN (or enterprise network) that provides users throughout the enterprise access to all computing resources via internetworking of LANs over WANs within the enterprise.

Ethernet. A LAN connecting computers and terminals, usually within the same building, and operating at 10 Mbps using the Carrier Sense Multiple Access with Collision Detection (CSMA/CD) media access method.

FDDI. Fiber Distributed Data Interface. A fiber-optic LAN operating at 100 Mbps.

FDDI Concentrator+. A device used to attach multiple devices to an FDDI LAN using only one dual-attach connection to the LAN. The Timeplex FDDI Concentrator+ can also be used as a standalone FDDI LAN.

LAN. Local Area Network. A data communications network operating within a small geographic area.

LAN/LAN connectivity. Direct connection of closely located (colocated) LANs via router, bridge, or similar device.

LAN/WAN internetworking. Connecting two or more remote LANs over a wide area network.

Local bridge. A high-throughput device that provides direct connection of colocated LANs.

MAC. Media Access Control. Media-specific access control protocol within IEEE 802 specifications.

Mbps. Megabits per second.

Network management system. Software for managing and controlling multi-point networks from a central or remote location.

OSI. Open Systems Interconnection. An international framework of standards for data communication in a multi-vendor environment.

PC gateway. Provides PC connectivity/access to a variety of other devices.

Remote bridge. A high-throughput device for connecting remote LANs via a wide area network.

Resilient. Refers to a LAN's ability to provide uninterrupted service following detection of recoverable failures, typically through built-in redundancy and automatic rerouting.

Router. Performs a function similar to a local or remote bridge, but routing occurs at Layer 3 of the OSI reference model.

Routing bridge. A LAN/WAN internetworking device that uses sophisticated algorithms to choose the best path among multiple active loops and redundant links based on delay time and cost.

Self-healing. Refers to a LAN's ability to compensate for damage to any portion of the transmission medium by rerouting traffic or reconfiguring the LAN to provide uninterrupted service.

Subnetworking. Breaking a large LAN into a number of smaller, more manageable LANs which are connected using bridges, routing bridges, or routers.

Token Ring. A LAN which uses a ring-shaped layout and token-passing access method to carry data from device to device. IEEE 802.5 compliant LANs operate at 4 Mbps or 16 Mbps.

T-1. Circuit operating at 1.544 Mbps.

T-3. Circuit operating at 45 Mbps.

Topology. The layout of a network, i.e., the arrangement of circuits, nodes, and switches.

WAN. Wide Area Network. A communications network operating over long distances.

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