i341 Network & Distributed Applications

Introduction to Local Area Networks (LANs)

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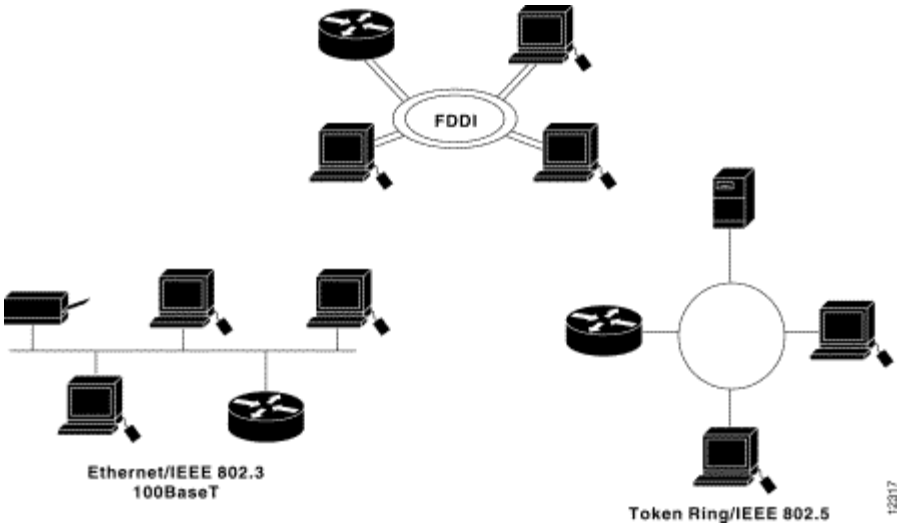
Various media-access methods, transmission methods, topologies, and devices are used in a local area network (LAN). The following figure *(IntroLAN Figure-01, LAN Implementations)* illustrates the basic layout of three LAN implementations.



IntroLAN Figure-01, LAN Implementations

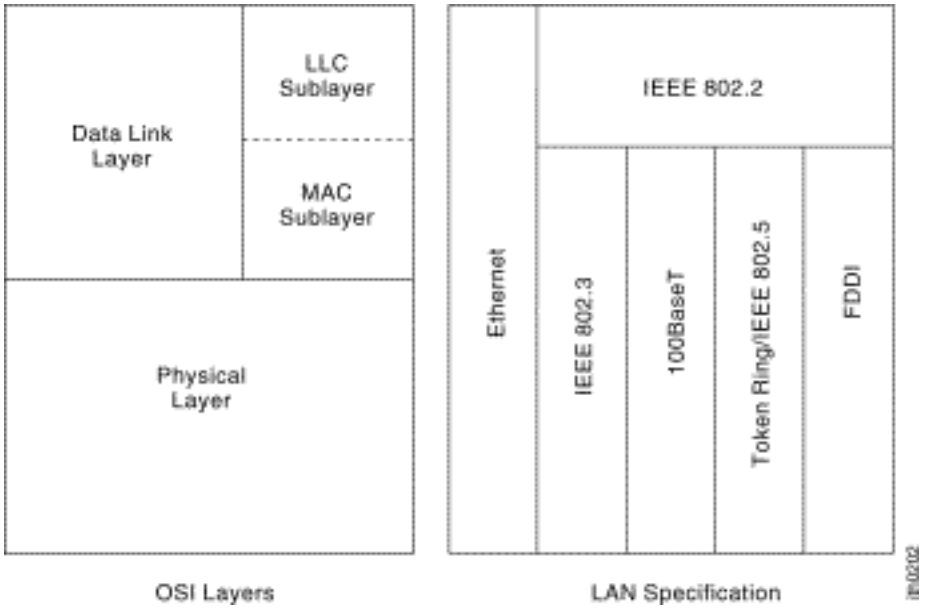
Definition of a LAN:

Local Area Networks are high speed (Million Bits per second), privately owned, geographically limited to a building or campus (generally < 2 Km), intelligent only devices on shared media.

A LAN is designed to serve a part of an organization located in the same area (floor or building), the entire building, or a campus facility where multiple buildings are located within 2 Km of each other. The LAN includes the media, software to manage the network, hardware to provide file and software storage and limited data processing and traffic on the LAN. The purpose of a LAN is to interconnect a group of terminals, printers, PCs, workstations and other intelligent devices to support resource and information sharing. The LAN replaces the cables, modems, multiplexers that are normally found on large on-line systems.

LAN Protocols and the OSI Reference Model

LAN protocols function at the lowest two layers of the OSI reference model, between the physical layer and the data link layer. The following illustration shows how several LAN protocols map to the OSI reference model.



IntroLAN Figure-02: LAN protocols Mapped to OSI Reference Model.

LAN Media-Access Methods

LAN protocols typically use one of two methods to access the physical network medium: *carrier sense multiple access collision detect* (CSMA/CD) and *token passing*.

In the CSMA/CD media-access scheme, network devices contend for use of the physical network medium. CSMA/CD is therefore sometimes called *contention access*. Examples of LANs that use the CSMA/CD media-access scheme are Ethernet/IEEE 802.3 networks, including 100BaseT.

In the token-passing media-access scheme, network devices access the physical medium based on possession of a token. Examples of LANs that use the token-passing media-access scheme are Token Ring/IEEE 802.5 and FDDI.

LAN Access Methods (LAN Contention Methods)

There are three basic categories of Media Access Control:

Random Management, where explicit permission for transmitting on the network is not required, and any system can attempt to transmit at any time. In random contention, systems must check the medium to see if it is free before starting to transmit.

Distributed Management, where all systems in the network participate in distributed algorithms for managing access to the transmission medium. All systems must cooperate to ensure only one system has the ability to transmit at any one time.

Centralized Management, where one system controls the entire network and other systems/devices must receive explicit permission from the controlling station before transmitting on the network.

LAN Access Control Techniques:

CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance):

With CSMA/CA, a station wishing to transmit, listens to the medium and;

- If the medium is idle, transmit
- If the medium is busy, wait an amount of time (drawn from a probability distribution - the retransmission delay) and listen to the medium again (step 1).
- If there is a collision (determined by a lack of acknowledgment), wait a random time and repeat step 1.

CSMA/CA is used by LocalTalk (AppleTalk) devices.

CSMA/CA Disadvantage: If two devices were to actually transmit at the same moment (given the propagation delay and distance of a larger LAN, this is a distinct possibility) If two frames were to collide, the medium remains unusable for the duration of transmission of both damaged frames. For large frames, the amount of wasted bandwidth can be considerable.

CSMA/CD (Carrier Sense Multiple Access with Collision Detection):

With CSMA/CD, a station wishing to transmit, listens to the medium, if the medium is idle transmits. CSMA/CD differs from CSMA/CA in that it also listens while sending. If a collision is detected during transmission, a jamming signal is transmitted (by the closest device to the collision), to let all stations on the LAN know that a collision has occurred. After hearing the jamming signal, the devices (whose frames collided), wait for a random period (a random integer generated by the Network Interface/Adapter card) before attempting to transmit again. Now the amount of wasted bandwidth is reduced to the time it takes to detect a collision.

CSMA/CD is used by Ethernet and 802.3 attached devices.

CSMA/CD Disadvantage: On heavily utilized networks, being a probabilistic access method (instead of deterministic), it is possible that someone may never get access to the medium (network).

Token Passing: With Token Passing, there is a small frame called a Token, which travels through the network. A station wishing to transmit must wait until it detects a token passing by. The station (wishing to transmit), then marks the token busy (by changing one bit in the token). This transforms the token to a Start of Frame delimiter and adds any field required to construct a valid token ring frame. The station then appends to the token ring frame any data frames it has to send to someone else on the network. When the transmitting station has either used up the allotted time slot, or finished transmission, the transmitting station inserts a new token on the network. Other stations can now wait to the token if they have anything to send, or it could return to the station (if nobody else on the network required it) to finish transmitting, if it has not.

Token Passing is utilized on BOTH ring and bus networks, IEEE 802.5 is Token Ring, and IEEE 802.4 is Token Bus. Examples of Token Bus are GM's MAP (Manufacturing Automated Protocol) and ARCnet. Token Passing is a deterministic access method. Each station is treated fairly and guaranteed access to the medium (network).

Token Passing Disadvantages: Addition overhead of the token maintenance, to recover from situations such as lost or duplicate tokens.

LAN Transmission Methods

LAN data transmissions fall into three classifications: ***unicast, multicast,*** **and** ***broadcast***. In each type of transmission, a single packet is sent to one or more nodes.

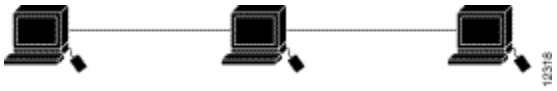
In a **unicast** transmission, a single packet is sent from the source to a destination on a network. First, the source node addresses the packet by using the address of the destination node. The package is then sent onto the network, and finally, the network passes the packet to its destination.

A **multicast** transmission consists of a single data packet that is copied and sent to a specific subset of nodes on the network. First, the source node addresses the packet by using a multicast address. The packet is then sent into the network, which makes copies of the packet and sends a copy to each node that is part of the multicast address.

A **broadcast** transmission consists of a single data packet that is copied and sent to all nodes on the network. In these types of transmissions, the source node addresses the packet by using the broadcast address. The packet is then sent into the network, which makes copies of the packet and sends a copy to every node on the network.

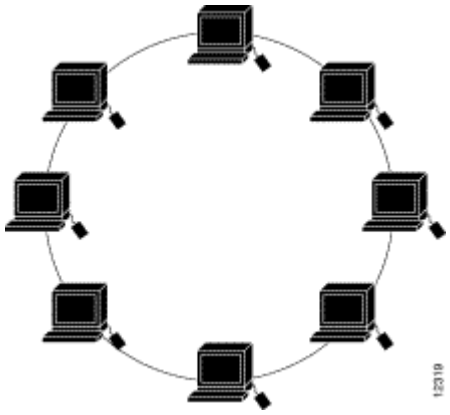
LAN Topologies

LAN topologies define the manner in which network devices are organized. Four common LAN topologies exist: bus, ring, star, and tree. These topologies are logical architectures, but the actual devices need not be physically organized in these configurations. Logical bus and ring topologies, for example, are commonly organized physically as a star. A bus topology is a linear LAN architecture in which transmissions from network stations propagate the length of the medium and are received by all other stations. Of the three most widely used LAN implementations, Ethernet/IEEE 802.3 networks— , including 100BaseT—, implement a bus topology, as illustrated in the following figure;



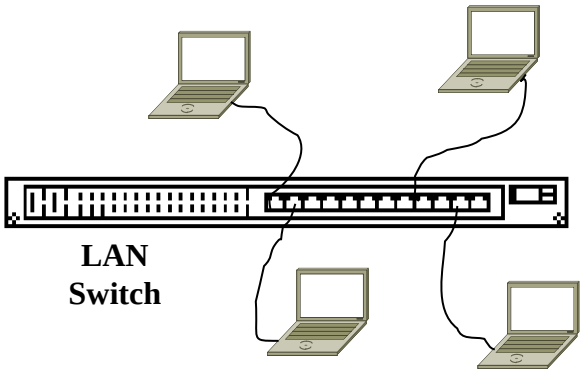
IntroLAN Figure-03: LAN Bus Topology

A ring topology is a LAN architecture that consists of a series of devices connected to one another by unidirectional transmission links to form a single closed loop. Both Token Ring/IEEE 802.5 and FDDI networks implement a ring topology. The following figure depicts a logical ring topology.



IntroLAN Figure-04: LAN Ring Topology

A star topology is a LAN architecture in which the endpoints on a network are connected to a common central hub, or switch, by dedicated links. Logical bus and ring topologies are often implemented physically in a star topology, which is illustrated in IntroLAN Figure-5: LAN Star Topology



IntroLAN Figure-05: LAN Star Topology

LAN Topologies:

The topology of a network concerns both the physical configuration of the cabling used to interconnect devices, and the logical manner in which systems view the structure of the communications network. The three principle network topologies utilized in LAN environments are star, bus and ring.

Bus - simply devices tapping into a single cable.
Example - Baseband (thicknet) Ethernet)

Bus advantages:
Easy to tap and add new devices
Single cable vs. pt to pt connection to a hub for each LAN device

Bus disadvantages:
Difficult to troubleshoot
If tap too deep, impedance can adversely affect/corrupt cable (entire LAN).
Network Contention (CSMA/CD)

Ring - wire ends looped to form a complete circle (or ring).

Example - IBM Token Ring

Ring advantages:
Dual Wire paths (if supported) provide redundant path

Ring disadvantages:
Typically difficult to expand (add new users/devices)
If not bi-directional, any cable related problem will adversely affect/corrupt ring.

Star - use of a central hub, each device wired point to point to hub.

Example – Ethernet 10/100/1000Mbps LAN hub/switch

Star advantages:
Centralized control
Network Management Visibility
Easier to troubleshoot since each device a pt to pt connection.

Star disadvantages:
Expensive investment in cable (since everything point to point).
Single Point of failure

Overview of LAN Protocols

To support LAN topologies, you can configure a device with Ethernet, FDDI, or Token Ring circuits. This section provides overview information about these LAN technologies:

Ethernet Overview

Ethernet is a 10-megabit/second (Mb/s) or 100-Mb/s LAN that uses the Carrier Sense Multiple Access with Collision Detection (CSMA/CD) protocol to control access to the physical wiring (*media*).

Data Flow

When a node on an Ethernet LAN (*endstation)* transmits data, every endstation on the LAN receives the data. Each endstation checks each data unit to see whether the destination address matches its own address. If the addresses match, the endstation accepts and processes the packet. If they do not match, it disregards the packet.

Medium Access Control

End-stations use CSMA/CD to monitor the media and wait until it is idle before transmitting data.

Carrier Sense Multiple Access

Before attempting to transmit a message, an endstation determines whether or not another endstation is transmitting a message on the media. If the media is available, the endstation transmits the message; if not, the endstation delays its transmission until the other endstation has finished sending.

Collision Detection

If two end-stations transmit data simultaneously, a collision occurs and the result is a composite, garbled message. All end-stations on the network, including the transmitting end-stations, detect the collision and ignore the message. Each endstation that wants to transmit waits a random amount of time and then attempts to transmit again. The random transmission delays reduce the probability that the end-stations will transmit simultaneously again.

Ethernet Frame Formats

There are two MAC-layer frame format specifications used in Ethernet LANs. The first specification is called Ethernet. The second, standardized by the IEEE, is called 802.3. One way that they differ is in message format *(Figure 2-1)*. Instead of a Length field in the MAC-layer header, Ethernet messages include a Type field, indicating which higher-layer protocol is used in the Data field.

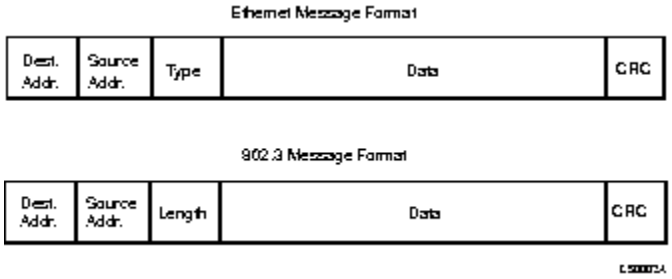


Figure 2-1. Ethernet and 802.3 Message Formats

Ethernet Media

10-Mb/s Ethernet LAN (10Base-T) uses thick or thin Ethernet (coaxial cable) or Category 3 twisted-pair cable.

100-Mb/s Ethernet LAN (100Base-T, sometimes called *fast Ethernet*) uses three different media interfaces:

- 100Base-TX uses two pairs of unshielded twisted-pair wires and allows both full-duplex and half-duplex operation.
- 100Base-FX uses fiber cabling that supports half- and full-duplex operation.
- 100Base-T4 uses new physical layer signals to run over four pairs of Category 3 unshielded twisted-pair wires. The signals use all four wire pairs, so only half-duplex operation is supported.

Each 100Base-T port supports 100Base-TX or MII physical interfaces. The integral 100Base-TX transceiver enables Category 5 twisted-pair wire to be directly connected to its RJ-45 connector. The MII interface enables external transceivers to be attached to the MII connector. This allows the use of a variety of different transmission media, such as Category 3 unshielded twisted-pair wire (100Base-T4) and fiber-optic (100Base-FX) cable.

When using the 100Base-T Link Module, larger packet sizes yield better performance than smaller packet sizes. In general, you should configure your application to use the largest packet size possible.

Ethernet Topologies

Thick and thin Ethernet LANs use a bus topology, in which devices connect directly to the backbone at both the physical and logical levels *(Figure 2-2)*.

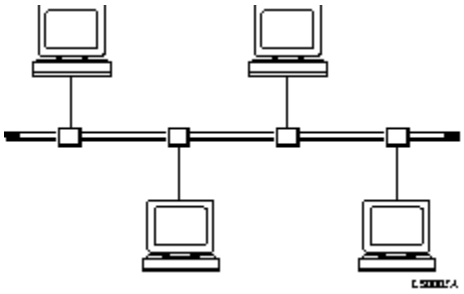


Figure 2-2. Ethernet LAN, Bus Topology

Physically, an Ethernet LAN using twisted-pair cable comprises a string of star topologies, in which devices connect to a central concentrator *(Figure 2-3)*. Logically, however, the cabling still has a bus topology.

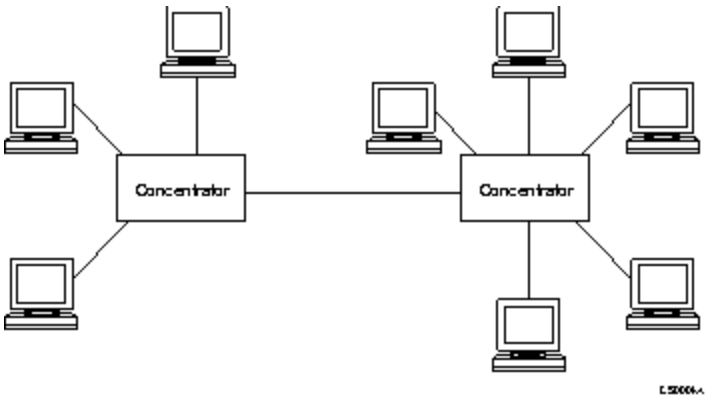


Figure 2-3. Ethernet LAN, Star Topology

Token Ring Overview

Token Ring is a 4-Mb/s or 16-Mb/s token-passing, baseband LAN that operates in a ring topology. Token Ring conforms to the IEEE 802.5 standard. A Token Ring LAN uses shielded or unshielded twisted-pair cable.

Overview topics in this section include:

- Token Ring Topology
- Data Flow and Media Access Control

The Token Ring/802.5 interface is IEEE 802.5-compatible with IEEE 802.2 Type 1 (connectionless) and Type 2 (connection-oriented) support. You can configure the interface to operate at 4 or 16 Mb/s to respond to different network requirements. The interface supports IBM Type 1 and Type 3 cabling.

Token Ring Topology

Stations on a Token Ring network attach to the network using a multistation access unit (MAU). Although the Token Ring is logically a ring, it is physically a star, with devices radiating from each MAU *(Figure 2-7)*.

MAUs connect a limited number of devices, typically two, four, or eight. You can extend the Token Ring by connecting the Ring Out (RO) port of one MAU to the Ring In (RI) port of the next *(Figure 2-7)*. You must complete the ring by connecting all RI and RO ports.

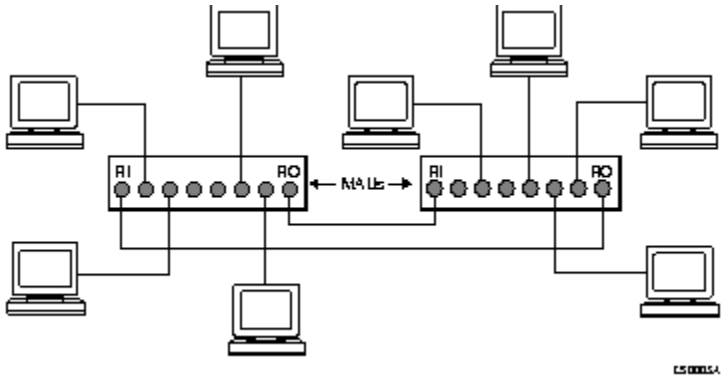


Figure 2-7. Token Ring LAN

Data Flow and Media Access Control

Devices on a Token Ring network get access to the media through token passing. Token and data pass to each station on the ring, as follows:

1. *The devices pass the token around the ring until one of them needs to transmit data.*

2. *The device that wants to transmit takes the token and replaces it with a frame.*

3. *Each device passes the frame to the next device, until the frame reaches its destination.*

4. *As the frame passes to the intended recipient, the recipient sets certain bits in the frame to indicate that it received the frame.*

5. *The original sender of the frame strips the frame data off the ring and issues a new token.*