DigiPoints Volume 1

Leader Guide

Module 10 – Local Area Network (LAN)

Summary

This module describes high-speed data networks that may be found on customers' premises. These networks make connections possible at speeds in excess of 10 Mbps between users, computers, servers, databases, and other peripherals.

Outcomes

Students who complete this lesson will become familiar with the applications, basic components, topologies, common hardware, operating systems, and the basic protocols of LAN systems. The student will also understand the importance of LANs to a business' success.

Module Objectives

Upon successful completion of the module, the student should be able to:

- Describe the four basic components of a LAN.
- Compare the various topologies used in LAN systems.
- Identify the typical hardware components found on a LAN.
- Describe the protocols that make it possible to move information across a LAN.
- Describe common LAN implementations.

Prerequisites

Students should have read Chapter 10 of *DigiPoints, Volume 1*.

Length

90 minutes

Materials/Preparation for Instructor

- One workbook per student
- Visual Aids
- Instructor should read Chapter 2 of *DigiPoints*, Volume 1.

©SCTE

Supplies/Equipment

- Dry Erase Board/Markers, chalkboard or flipchart
- Masking Tape
- Pointing Tool
- Tent Cards

Audience

The intended audience will be mid- to senior-level technicians or other associates who are seeking an understanding of digital basics.

Module Outline

This is an introductory level module that will provide a review of the following topics:

Objectives 1
Introduction 2
Origins 3
LAN Network Architecture 4
LAN Hardware 6
LAN Operating Systems 8
LAN Protocols 9
Common LAN Implementations 12
Summary 13
Appendix 14

©SCTE

Objectives

EXPLAIN

REFER TO WB 10.1

Tell students that when they have completed this module, they will be able to accomplish these objectives.

- Describe the four basic components of a LAN.
- Compare the various topologies used in LAN systems.
- Identify the typical hardware components found on a LAN.
- Describe the protocols that make it possible to move information across a LAN.
- Describe common LAN implementations.

©SCTE

Introduction

ASK

What does the acronym "LAN" stand for?

Use as intro and as a way to evaluate skill base of students

Answer:

◊ *Local Area Network*

What do these networks do?

DO EXERCISE IN LEADER GUIDE APPENDIX, PAGE 10.14

Answer:

◊ *Transport data at high speeds between various components connected to the network.*

Why are LANs important?

Answer:

◊ *Provide an easy way to interconnect equipment in an office environment. Allow sharing of resources, i.e. servers, printers, etc., between many users.*

DISCUSS

Origins

- Original computers filled a room.
  - ◊ One terminal connected to machine
  - ◊ Not as powerful as today's laptops
- Sophisticated software allowed more than one user access to mainframe.
- Users then wanted remote access.
- VLSI led to the development of PCs.
- PCs stood alone, needed connectivity.
  - ◊ Needed to share hardware resources
  - ◊ Needed to share software resources
- LANs came into being to meet these needs.
  - ◊ Defined as a peer-to-peer communications network
  - ◊ Broadcast nature of LAN necessitates encryption
  - ◊ LAN must have system to mediate access to the shared medium and devices

Using the whiteboard or flipchart, draw and build a LAN by drawing the components as you discuss them.

Start with a block representing a single computer.

Add terminals.

Add PCs.

Add file and print servers.

Show connectivity without intermediary switching nodes; explain the implication of broadcast mode.

LAN Network Architecture

DISPLAY VA 10.1
DISCUSS WB 10.2

LAN Components

- There are four basic components to any LAN:
  - User Work Station
  - Protocol Control
  - Medium Interface
  - Physical Path

DISPLAY VA 10.2
DISCUSS WB 10.3

LAN Topologies

- BUS
  - Bi-directional
  - Repeaters possible at end points
  - Traffic design considerations
  - Ethernet restricted to four repeaters between any two stations
  - 1 to 2.5 km maximum

DISPLAY VA 10.3
DISCUSS WB 10.4

- STAR
  - Can be logical bus or logical ring
  - Central Controller

DISPLAY 10.4
DISCUSS
WB 10.5

- RING
  - Unidirectional transmission on closed path with repeaters
  - The Repeater has four basic functions:
    - Terminate devices
    - Data insertion
    - Data reception
    - Data removal
  - A repeater can exist in one of three states:
    - Listen
    - Transmit
    - Bypass

DISPLAY VA 10.5

- Rings are susceptible to timing jitter.

Refer to Module 6 to review jitter as needed.

DISPLAY VA 10.6
DISCUSS WB 10.6

- TREE
  - Does not work well with baseband LANs
  - Use with broadband LANs

DISPLAY VA 10.7
DISCUSS WB 10.7

- MESH
  - ◊ Consists of interconnected subnetworks. Subnetworks may be connected because of:
    - ◊ Distance and geography
    - ◊ Performance
    - ◊ Reliability
    - ◊ Security
    - ◊ Easier Network Management

Note that broadband is defined by LAN industry as a network that moves data as a modulated signal.

Break class into small groups to answer questions on topologies (WB 10.3)

Review answers with class.

LAN Hardware

DISPLAY VA 10.8
DISCUSS WB 10.8

Use board to review the OSI Model as needed.

- BRIDGES
  - ◊ Layer 2 of OSI Model
  - ◊ Provide isolation between networks
  - ◊ Restricted to networks with same addressing scheme and frame size
  - ◊ Have five functions:
    - ◊ Filtering to monitor data PDUs
    - ◊ Input buffering
    - ◊ Switching
    - ◊ Output buffering
    - ◊ Output transmission
  - ◊ Do not operate on Layer 3 or higher PDUs

- ROUTERS
  - ◊ Layer 3 of OSI Model
  - ◊ Layer 3 PDUs known as packets
  - ◊ Consider network conditions
  - ◊ Prioritize delivery
  - ◊ Provide the firewall between internal and external network access
  - ◊ Maintain internal routing tables
  - ◊ Connect dissimilar networks and protocols
  - ◊ Must be managed

- BROUTERS
  - ◊ Equipment that has router and bridge functionality

- GATEWAYS
  - ◊ Perform protocol conversions for networks
  - ◊ Bi-directional
  - ◊ Networks connected through gateways are more complex than those connected through routers.

- PROTOCOL CONVERTERS
  - ◊ Similar to gateway, but file transfer in one direction only
  - ◊ Terminal emulation is typical function

- Interconnected device considerations
  - ◊ Distinction is not black and white
  - ◊ Review each vendor's equipment stated functionality

LAN Operating Systems

DISPLAY VA 10.9
DISCUSS
WB 10.9

- Supplements individual operating systems of the computers connected to the LAN.
- Special type: Network Operating System (NOS)
- Installed on Network Servers
- Multi-tasking, multi-user architectures
- Advanced systems support diagnostics, administration, and network management

Point out that Novell was the NOS leader; Microsoft was a challenger, but now dominates.

LAN Protocols

DISPLAY VA 10.10
DISCUSS WB 10.10 AND WB 10.11

- Developed by IEEE – Institute of Electrical and Electronic Engineers
- Compatible with OSI Model, Layers 1 and 2
- 802.x standards define three layers
  - ◊ Physical
  - ◊ Medium Access Control (MAC)
  - ◊ Logical Link Control (LLC)

Refer to DigiPoints Module 7 to review as necessary

PDUs passed

DISPLAY VA 10.11
DISCUSS WB 10.12

- PDUs are passed between upper and lower layers
- LLC PDU control header
  - ◊ Organizes data flow
  - ◊ Commands & responses
  - ◊ Error control
  - ◊ Recovery functions
- LLC PDU passed to MAC layer
  - ◊ Control information added
  - ◊ Becomes MAC frame

EXPLAIN

IEEE Defined Layers

The following discussion progresses from higher to lower layers.

***Review the IEEE 802.x information in Appendix A of* DigiPoints, Volume 2.**

EXPLAIN

Logical Link Control (LLC)

- Move data between two users without any switching.
- Receives user data from Layer 3 of OSI Model.
- Similar to Layer 2 OSI Model with a difference.
  - ◊ Needs MAC layer to do all Layer 2 functions
  - ◊ LLC does some Layer 3 functions
- Services provided by LLC include:
  - ◊ Unacknowledged Connectionless Service – LLC Type 1. No guarantees of data delivery.
  - ◊ Connection Mode Service – LLC Type 2. Checks connection prior to beginning data transmission.
  - ◊ Acknowledged Connectionless Service – LLC Type 3. Verifies connection for each protocol data unit exchanged.

Point out how this standard still relates to and functions within parameters of the OSI Model

Medium Access Control (MAC)

- Interface protocol between physical medium and the LAN.
- Customization required based on topology of a network.
- Common functions
  - ◊ Regulates WHEN communication is possible.
  - ◊ HOW a device communicates using Asynchronous Access Control.
- Asynchronous Access Control uses three methods:
  - ◊ Round Robin
  - ◊ Reservation
  - ◊ Contention

Review* DigiPoints, Module 4 *to review Synchronous Access Control as needed.

Review ALOHA method as described* DigiPoints, Volume One*, page 235, in the event of student questions

EXPLAIN

Physical Layer

- Defines non-intelligent hardware and network components.
  - ◊ Cable and repeaters
- Media used:
  - ◊ COAX
  - ◊ Twisted Pair, CAT 5
  - ◊ Fiber Optics

Common LAN Implementations

EXPLAIN

Ethernet

- Xerox developed prior to IEEE 802.3
- Based on CSMA/CD
- Differences between installations of "Ethernet"

Common attributes found in Ethernet installations include the following.

Carrier Sensing and Collision Detection

- Contention access
- Station transmits when ready
- Algorithms determine how data recovered if TWO stations transmit
  - ◊ Non-Persistent
  - ◊ 1-Persistent
  - ◊ P-Persistent

Physical Implementation

- NIC – Network Interface Card
- MAU
- 10BaseT

DISPLAY
VA 10.12
DISCUSS
WB 10.13

Token Ring

- IBM implementation
- Token determines "who" transmits
- MAU – Ring In/Ring Out

Summary

DISPLAY VA 10.13

REFER TO WB 10.15 THROUGH WB 10.17

Have students answer the study questions at the end of Module 10. Review the answers.

Answers in Appendix

Appendix

Exercise

There is one large envelope for each group of 9 people. The envelope contains seven index cards. Six cards have numbers on them corresponding to switches in the network. The 7th card is labeled “Destination”. In addition, there is a small envelope labeled “Source”.

One of the persons in the group is designated the network manager. This person distributes the index cards and the small source envelope to the other eight people, one item to a person. When this is completed, your nine people each have a role in the exercise, either as a switch, a source, a destination, or the network manager.

If your class size is smaller than nine, the instructor may elect to be the network manager, and/or have some students take a double role (i.e., becoming two switches, each independent of the other).

The start of a clock cycle is represented by a prearranged signal given by the instructor. The signal can be a bell ring, or if there’s no bell, just a loud thump will do.

The Network Manager must track the progress of the “packets” through the network. There is a chart in the package to aid the Network Manager in the tracking process. Each row in the table is one clock cycle (ring of the bell). Each column corresponds to a particular switch. A key for the instructor is included in the tools file on the floppy for the course.

The packets are lettered and have specific routing information on them. The instructor must remind the Network Managers immediately after giving the clock signal to indicate on their chart where each packet is within the network (which switch has the packet during the current clock cycle). NOTE: CYCLE 5 IS THE FIRST TIME ANY SWITCH HAS TWO PACKETS AT ONE TIME. THIS IS THE SIMULATION OF BUFFERING. IN CYCLE 6, ONE OF THE PACKETS, AND ONLY ONE, WILL BE ROUTED, ACCORDING TO THE PROTOCOL. (LOWEST ALPHA.)

At the first clock cycle (ring of the bell), the source sends one packet into the network, according to the route on the back of the packet. The packet only goes to the first stop on the route when it comes out of the envelope.

After the first clock cycle, another packet is released from the source to the network, and the packet already in the network is allowed to continue to the next switch on its route.

Note the “rules” and point out this is a protocol for our network. Most importantly, switches can only route one packet at a time. If they possess two packets, one must wait. Packets only move when the bell rings; switches with two packets route the lowest alpha packet first.

Answers to the questions at the end of student workbook.

1. Define a Local Area Network.

   A LAN is a high-speed (typically in excess of 2 Mbps) data communications system wherein all segments of the transmission medium (typically coaxial cable, twisted pair, or optical fiber) are in an office or campus environment. The IEEE 802.x specifications define a LAN as a shared medium, peer-to-peer communications network that broadcasts information for all stations to receive. This definition must be modified now that switched LANs are being implemented. As noted in the chapter, switched LANs create dedicated connections within the LAN, effectively giving each LAN user the full bandwidth of the medium.

2. Topology is the word used to describe the interconnection of nodes in a LAN. It can be used in two ways. To make sure you understand both connotations:

   What are the four basic topological configurations for LANs?

   Within any given LAN, what are the three separate topologies, and to what do they refer?

   Devices on a LAN may be connected in one or more of the following topologies: bus, star, ring, and tree.

   Within any given LAN, there are physical, electrical, and logical topologies. Physical refers to the way cables are physically routed between devices on the LAN. Electrical is the way the wires are connected. Logical is the way data units are routed from one device to another. Most of the time, electrical and logical topologies are the same. Many times, however, the physical and electrical topologies of a LAN will differ.

3. What are the differences between a repeater, a bridge, and a router?

   Although all three types of devices are used to expand networks, they are different.

   A repeater is the simplest interconnection. It operates strictly at the physical layer (Layer 1), to join, for example, two bus networks together. Repeaters regenerate digital signals. They form new pulses at the same points where potentially degraded pulses previously appeared. They pass on data; they do not examine or process any of the information contained in the data.

A bridge operates at Layer 2 of the OSI reference model. Since it operates at the frame level, it is able to examine network addresses and only pass data units to another network when the address so indicates. A bridge can only pass data to an adjacent network. The adjacent network must have a consistent addressing scheme and frame size. In this sense, a bridge can perform limited protocol conversion (at Layer 2 only), and move data between, for example, an IEEE 802.3 and IEEE 802.4 network.

A router operates at Layer 3 of the OSI reference model. In addition to having access to the information contained in the Layer 3 PDU (commonly known as a packet), routers can be capable of considering network traffic and other network conditions to determine the best path from one network to another. Routers can also prioritize data delivery, and create "firewalls" to prevent selected data traffic from entering or leaving a network. To perform these functions, a router must create and maintain an internal routing table, which directs how data will be forwarded to another network. Routers have no restriction on the interconnected device protocols. They can, therefore, connect dissimilar networks (IEEE 802.3 to X.25). The router address must, however, be known to all networks attached to it.

4. What is a Network Operating System, and how does it differ from an Operating System used in a mainframe or stand-alone PC?

Network Operating Systems manage resource allocations of complete networks. A PC or mainframe operating system is concerned only with the resources of its own machine.

5. What are the protocol layers defined by the IEEE for LANs; what is the function of each; and how do they map onto the OSI protocol reference model?

The IEEE 802.x standards define three LAN protocol layers which fit within Layers 1 and 2 of the OSI reference model. The Physical layer is equivalent to OSI Layer 1. The Logical Link Control and Medium Access Control functions fall under the OSI Layer 2 definition.

The Logical Link Control (LLC) layer is concerned with the movement of data between two users with no intermediate switching. It is used by multiple 802.x standards, and its structure is designated in 802.2.

The Medium Access Control (MAC) layer provides the interface protocol between the physical medium of the LAN and the logical operation as defined in software at the upper layers of the protocol. MAC protocols are particular to the topology of the network, so, for example, Ethernet and Token Ring have their own MAC layer definitions. One of the main functions of the MAC layer is to give a device permission to communicate with other devices on the LAN.

The Physical layer defines the hardware and network components of the LAN that do not have any intelligence, such as the cable and repeaters.

6. What is the IEEE standard corresponding to the type of LAN developed and marketed by Xerox Corporation, and what is the common name of that type of LAN?

   IEEE standard 802.3 specifies Carrier Sense Multiple Access/Collision Detection, or CSMA/CD. This standard is based on Xerox's Ethernet product. Ethernet has become the common name for802.3 LANs, although implementations of Ethernet may differ from the IEEE standard.

7. What is the IEEE standard corresponding to the type of LAN developed and marketed by IBM, and what is the common name of that type of LAN?

   IEEE standard 802.5 specifies Token Ring, which is the name for the type of LAN first implemented by IBM.

8. True or False, and why: Logical Link Control is the same for all IEEE-specified LANs.

   True. LLC operates above the MAC layer. It specifies how data units move between two users, and the type of service that will be provided. Since it is above both the physical and MAC layers, it is completely hardware independent, and can be common to all IEEE LAN specifications.

9. True or False, and why: Medium Access Control is the same for all IEEE-specified LANs.

   False. Medium Access Control is the interface between the physical medium of the LAN and the logical operation of the LAN described in software. Since it is associated with the physical medium, it must be separately specified for each IEEE 802.x specification.

10. Give a general description of how CSMA/CD handles access contention.

    CSMA/CD is an access contention control method. It permits users to place data units on the shared medium, after they check to see if anyone else on the network has already done so. If no other user has a data unit outstanding, the user may send its PDU. However, if another data unit is already on the medium, the user must wait until it has been processed. Unfortunately, there are windows of time where other units of data may not be detected before the user places its data on the medium. In this case, a collision occurs, and all users on the network are notified to not attempt to send data until the collision is resolved. Resolution is accomplished by having one of the offending users resend data at a different time than the other, using predetermined algorithms.

11. Give a general description of how a token passing LAN handles access contention.

    With token passing, a network user cannot transmit data unless it "possesses" the data token. The token is not possessed in a physical sense. Rather, it is a protocol data unit that is passed from user to user on the network, and contains a set of bits which are set to a possession state when a user is ready to transmit. All other users on the network recognize the token as being owned by the user wishing to transmit when the bits have been sent, and will not attempt to send until the token possession bits have been reset to the non-possessed state.

12. Describe the components of a typical high-speed data access system for a service offering by a cable telecommunications company, and explain how a subscriber is part of a LAN. In your descriptions, be sure to include the physical form of the digital signal at the interfaces to each component.

    The cable company will probably want to offer Internet access via cable modems. In this case, the system would consist of headend, transmission, and customer premises equipment. At the headend, there would be a router, RF demodulator, and frequency conversion units to allocate the data ports on the router to input and output channels.

    There would be transmission facilities on the trunk and line sides. On the trunk side, the router would need to connect to an Internet Service Provider via a high-speed data line, most likely a T1 or higher speed digital facility. On the line side, the same system that provides video signal to the subscriber would be used for the data signal.

    Customer premises equipment would include a cable modem and an Ethernet network interface card in the subscriber's personal computer. The cable modem provides the interface between the Ethernet interface card and the RF transmission medium used by the cable company.

The customer's PC would be a user on an Ethernet LAN. The bus structure of the Ethernet would go from the headend router to the PCs of the various subscribers. The output of the network interface card would be an Ethernet signal, usually a digital voltage, which varies according to a Manchester coding scheme. The Ethernet signal passes to the cable modem, where it is modulated onto the RF frequency assigned to the data channels for this service. At the headend, a demodulator removes the digital information from the transmission medium, and provides a digital input to the router. The router would connect to a public packet switched network, using some access protocol such as frame relay.