DigiPoints Volume 1

Leader Guide

Module 7 – Data Communications Protocols

Summary

This module describes basic data communications protocols. Protocols are the established rules that regulate data transmission between computers.

Outcomes

Students who complete this lesson will know the basic functions of data communications protocols, be familiar with the 7 layer OSI Model, be introduced to the Internet Protocol, TCP/IP, and learn the difference between Hierarchical and Layered Protocols.

Objectives

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

- Define the purpose of a data communications protocol.
- Describe the basic functions of a protocol.
- Compare and contrast layered versus hierarchical protocols.
- Describe the purpose of the OSI Model.
- Identify the 7 Layers of the OSI Model.
- Identify the basic components of the TCP/IP Protocol.
- Relate the OSI Model to the TCP/IP Protocol.

Prerequisites

Students should have read Chapter 7 of *DigiPoints, Volume 1*.

Length

75 minutes

Materials/Preparation for Instructor

- One workbook per student
- Visual Aids
- Instructor should read Chapter 7 of *DigiPoints, Volume 1*.
- Instructor may find William Stallings, *Data and Computer Communications, 4th Edition***,** ISBN 0-02-415441-5, © 1994, Macmillan Publishing Company, pages 421 - 461, to be useful.

Supplies/Equipment

- Dry Erase Board/Markers, Chalkboard or Flipchart
- Masking Tape
- Pointing Tool
- Tent Card

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
Functions of a Protocol 3
Layered Protocols 8
The OSI Model 9
OSI Layer Details 10
TCP/IP: The Internet Protocol 14
Hierarchical Architecture 15
Summary 17
Appendix 18

Objectives

EXPLAIN

REFER TO WB 7.1

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

- Define the purpose of a data communications protocol.
- Describe the basic functions of a protocol.
- Compare and contrast layered versus hierarchical protocols.
- Describe the purpose of the OSI Model.
- Identify the 7 Layers of the OSI Model.
- Identify the basic components of the TCP/IP Protocol.
- Relate the OSI Model to the TCP/IP Protocol.

Introduction

DISCUSS

Ask the students the following:

- What does the word "protocol" suggest to you?
- What purpose does a protocol serve in data communications?

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

Purpose of a protocol

Computer science definition:

A standard procedure for regulating data transmission between computers.

- It is a set of rules
- Governs communications between two or more data terminal devices

This definition can be written out and left posted in the room for the duration of the class

Functions of a Protocol

DISPLAY VA 7.1
REFER TO WB 7.2

- Point out that there are ten categories of general functions that protocols govern.

DISPLAY VA 7.2
REFER TO WB 7.3

Segmentation & Reassembly

- User data blocks can be of various sizes including continuous data streams.
- Segmentation puts this data into the proper size blocks that different data and transmission systems handle.
- Blocks of related data can transverse a network along different paths.
- The protocol has to provide a way to track this data.
- The protocol has to reassemble the data correctly at the receiving end.
- Why break up large blocks of data?

  Answer:

  - ◊ *Less buffering*
  - ◊ *Decreased costs*
  - ◊ *Decreased transmission delays and increased throughput*
  - ◊ *NEED additional overhead to track data blocks*
  - ◊ *Overhead is costly*

Point out different applications have different size data blocks.

DISPLAY VA 7.3
REFER TO WB 7.4

Encapsulation

- The process of adding overhead.
- This control information is found in the headers and trailers of the block.
- Directs the data through the network.

DISPLAY VA 7.4
REFER TO WB 7.5

Connection Control

- Established between the end terminals.
- Negotiates transmission parameters.
  - ◊ Connection speed
  - ◊ Timing
  - ◊ Size of data block

Flow Control

- Rate data moves across network
- Error control & correction

Error Control

- Related to Flow Control
- Dictates the amount of time between sending data and receiving ACK or NAK
- Dictates type of retransmission used

DISPLAY VA 7.5
REFER TO WB 7.6

Synchronization

- This is not "timing" as discussed earlier.
- This refers to events happening in an ordered fashion.
  - ◊ Establish connection
  - ◊ Acknowledge data receipt
  - ◊ Acknowledge data request
  - ◊ Terminate session
- Purpose is to have events occur in a logical, preordained order.

Sequencing

- This is related to the data blocks.
- This assures that the data blocks are reassembled in the proper order at the destination.

DISPLAY VA 7.6
REFER TO WB 7.7

Addressing

Locale's A, B, & C show different entities.

- This function ensures that the data blocks go to the correct termination point.
- Related to names for machines and users.
  - ◊ Local names are known by the entity's own system
  - ◊ Global names are those outside the local system
- Global names can be made up of the local name put into a hierarchical structure, such as:

To communicate beyond each locale

  - ◊ Network.System.Entity
  - ◊ Direct Node Address (DNA) could appear as: john.smith@acompany.com

Write on the board:
Network.System.Entity

  - ◊ Domain Name Service (DNS) could appear as: purdue.pucc!ihnp4!acompany!john.smith

DNA Example

  - ◊ DNS method does NOT specify a specific path

DNS Example

- Hierarchical systems are commonly used
  - ◊ Easy to add entities
  - ◊ Does not require standardization of naming conventions for ALL vendors
  - ◊ A "flat structure" would require a UNIQUE name for each entity found on the net.

Locale C has PC to be added.

- Other Addressing considerations include:
  - ◊ Addressing can go beyond entity level to multi-users in a group.
  - ◊ Connection name addressing is used for many messages over the same data connection. Use connection name for each subsequent message.
  - ◊ Connectionless service establishes a new path with each new message. Global name required for each message.

DISPLAY VA 7.7
REFER TO WB 7.8

Multiplexing

- This is not multiplexing as used in telephony or cable communications.
- Downward multiplexing
  - Used to provide increased reliability
  - An Upper level protocol uses multiple lower level connections
- Upward multiplexing
  - Used when only one lower level path available OR to maximize usage of a lower level connection
  - Multiple Upper level protocols use one lower level connection

Transmission Services

- Services is the key word, as in quality of service.
- Quality of service measurements in context of protocols consist of:
  - ◊ Throughput rates,
  - ◊ Delays, and
  - ◊ Priority routing.
- Security levels

Write these on the board

Layered Protocols

DISPLAY VA 7.8
REFER TO WB 7.9

- A type of protocol architecture. The other is Hierarchical.
- Layered architectures are the most common.
- OSI is the standard reference model for layered protocols.

DISPLAY VA 7.9

- Protocols are a set of rules.
  - ◊ Pertain to flow of data INTRA-layer
  - ◊ Pertain to flow of data INTER-layer
- Multiple protocols possible in a data communication system.
  - ◊ The architecture is the organization that ties the various protocols together.

ASK

Why layers?

Guide responses.

Answer:

- ◊ *Specialization or segmentation of tasks*
- ◊ *Separates different protocol functions*
- ◊ *Lower levels support higher levels*
- ◊ *Software engineers can work on different layers independently*
- ◊ *Functional symmetry across networks*

Interlayer Communications - Primitives

- Generic functions, not part of any software.
- Four Basic Transactions
  - ◊ Request
  - ◊ Indication
  - ◊ Response
  - ◊ Confirm

Write these on board:
Request
Indication
Response
Confirm

The OSI Model

DISPLAY VA 7.10
REFER TO WB 7.10

The International Standards Organization (ISO) established a committee in 1977 to develop the Open Systems Interconnect Model (OSI)

- Seven Layer Reference Model
  - Lowest levels are hardware intensive.
  - The upper levels are software intensive.
  - Layers 1 - 3 specify how a computer interacts with a network; focus is on the individual protocol data units.
  - Layers 4 - 7 specify the rules for end-to-end communications; ensure complete message transmitted.
- It is not an architecture
  - Generally regarded as the framework for any layered protocol architecture.
  - A particular architecture need not have all seven layers.
  - An architecture should be able to be directly related to the model.

OSI Layer Details

Layer 1 - Physical Layer

- Characteristics specified:
  - ◊ Functional - Type of information carried on the link.
  - ◊ Mechanical - The type of connection, e.g., EIA-232D.
  - ◊ Procedural - Order of events for that interface.
  - ◊ Electrical - Voltage levels and timing of voltage changes.

DISPLAY VA 7.11
REFER TO WB 7.11

Layer 2 - Datalink Layer

- These are line protocols that govern the flow of data between two entities.
- Purpose of this layer is to provide:
  - ◊ High throughput
  - ◊ Fast response
  - ◊ Data integrity
- Functions performed:
  - ◊ Synchronization
  - ◊ Flow Control
  - ◊ Error detection
  - ◊ Identification of communicating entities
  - ◊ Identification of type of information sent - control or data
- Examples of datalink protocols
  - ◊ HDLC
  - ◊ ADCCP
  - ◊ SDLC
  - ◊ LAP-B
- IEEE variation of this layer is two (2) distinct layers
  - ◊ Medium Access Control (MAC) - Rules tied to specific networks, e.g., Token ring, Ethernet, etc.
  - ◊ Logical Link Control (LLC) - Generic level two protocols independent of any particular network.

DISPLAY VA 7.12
REFER TO WB 7.12

Layer 3 - Network Layer

- Regulates how groups of networks communicate.
- Purpose of this layer is to resolve issues concerning:
  - ◊ Different sizes/formats for Protocol Data Units
  - ◊ Different timers and timeouts
  - ◊ Different quality of service requirements
  - ◊ Different addressing methods
  - ◊ Different performance levels
  - ◊ Different routing methods
  - ◊ Different user interfaces
  - ◊ Different security levels
  - ◊ Different troubleshooting, diagnostic, and maintenance procedures
  - ◊ Cost and billling allocations
- Primary Layer 3 protocols used:
  - ◊ Connectionless Mode Network Service
  - ◊ Internet Protocol (IP)
  - ◊ X.75
- Internet Protocol details (similar to Connectionless Mode
  - ◊ Lifetime - Each PDU has a life span ~500 msec.
  - ◊ Segmentation - Very large PDUs on one network may have to be broken down for another network into smaller PDUs.
  - ◊ Routing - Determines how PDUs travel across network.
- Addressing - Different networks have one of three Internet addressing classes: A, B, C.

DISPLAY VA 7.13
REFER TO WB 7.13

Layer 4 - Transport Layer

- Five major functions handled
  - End-to-end data integrity
  - Management of interface between the upper and lower layers
  - Establishment and termination of network session
  - Detection of lost, out of sequence, or duplicate data
  - Control of data flow

Layer 5 - Session Layer

- Five major functions handled
  - Coordinate data exchange between applications - logically creates/releases dialogs between applications
  - Provide synchronization check points
  - Structures user application interactions
  - Provides rules for users exchanging data
  - Prevent lost data by closing dialogs properly

DISPLAY VA 7.14
REFER TO WB 7.14

Layer 6 - Presentation Layer

- Operates on the syntax of the data
  - Sender and receiver can use different syntax
  - Syntax includes codes used, order of data fields, formats, number notations, etc.
- Functions performed in this layer
  - Negotiate syntax of data
  - Translate syntax of data being exchanged

Layer 7 - Application Layer

- Directly interfaces with the end user applications
- Application Service Elements (ASE) support this layer
- Four major ASEs
  - Association Control Service Element (ACSE) - regulates end user requests between applications
  - Reliable Transfer Service Element (RTSE) - notifies sender of successful/failed deliveries, recovers from communication failures
  - Remote Operations Service Element (ROSE) - facilitates interactive communications
  - Commitment, Concurrency, and Recovery (CCR) - manages database interactions with end user applications

TCP/IP: The Internet Protocol

ASK

DISPLAY VA 7.15
REFER TO WB 7.15

How does this differ from the OSI Model?

Answer:

- ◊ *Hierarchical structure created by the Department of Defense - most widely used data communications protocol*
- ◊ *TCP - Transmission Control Protocol*
- ◊ *IP - Internet Protocol*

TCP/IP developed for ARPANET - interconnect private and government networks. It is a middle layer.

- Between many computers with own layer 1 and 2 protocols, and
- Between large host systems with layer 5, 6, 7 protocols

IP addressing consists of 32 bits.

- Addressing scheme on the internet:
  - ◊ 32 bits for address
  - ◊ 4 distinct numbers, each between 0 - 255, e.g. 254.9.123.31 or
    11111110 → 254
    00000101 → 9
    01111011 → 123
    00011111 → 31
  - ◊ Each of the 4 - Base 10 numbers are represented by 8 bits (27)
  - ◊ Four classes of addresses are A, B, C, & D.
  - ◊ Class A addresses - reserved for countries or giant organizations.
  - ◊ Class B addresses are for medium size networks
  - ◊ Class C addresses for small network of 255 addresses or less
  - ◊ Class D addresses for multicast addresses.

Write 32 bit address on board:

11111111.
00000000.
11111111.
00000000

Write on board:

A B C D

See the appendix for how these addresses are created.

Show students on board.

Hierarchical Architecture

- A different type of protocol
- Also layered
  - ◊ But one layer can skip over the adjacent layer
  - ◊ A layer can be totally self-contained for a particular service
- Department of Defense ARPANET is the most well known.
  - ◊ Consists of four layers and three agents
  - ◊ Layers are defined as network access, Internet, host-to-host, and process application
  - ◊ Agents are defined as host, process, and network
- Agents
  - ◊ Processes are executed on hosts.
  - ◊ Processes communicate via networks.

VA 7.15 remains up. Go to board and write:

Layers: 4
Agents: 3

Agents:
Processes
Hosts
Networks

- Layers
  - ◊ Network access provides access to computer network according to rules for communicating node to node.
  - ◊ Network access rules provide for communications on same network.
  - ◊ Internet provides rules for routing data between networks.
  - ◊ Internet layer is where gateways are found.
  - ◊ Host-to-host layer has rules needed to transfer data between two processes on different host computers.
  - ◊ Host-to-host can be logical connection at the higher levels without involving lower levels.
  - ◊ Process application layer provides rules for computer-to-computer resource sharing and remote access.
- ARPANET formed the basis for today's Internet.
- TCP and IP are military specifications.
- OSI versus TCP/IP
  - ◊ DOD architecture de facto standard
  - ◊ Needed to meet immediate need
  - ◊ OSI is a reference model
- Why protocols?

Layers:
Network Access

Internet

Host-to-Host

Process Application

Review with students.

Summary

REFER TO WB 7.16 AND WB 7.17

Have students answer the study questions at the end of Module 7. Review the answers.

Answers in Appendix

Appendix

Address Creation for Internet Applications

For the purposes of this class, the 32-bit address is going to be discussed. The 32 bit address consists of four (4) sets of eight (8) bits, such as:

10100101.11110000.00001111.01011010

This "dot address" is called *dotted quad notation*. The above 32-bit binary number represents the Base 10 numbers of:

165.240.15.90

These 32 bits are used to establish addresses for different size networks. The bits are used as follows:

Class A Networks (large networks with many devices)

0 binary + 7 bits (Network) Local Address 24 bits (8+8+8)

Network.Local.Local.Local

Class B Networks (medium size networks)

10 binary + 14 bits (Network) Local Address 16 bits (8+8)

Network.Network.Local.Local

Class C Networks (small networks with 256 or few devices)

110 binary + 21 bits (Network) Local Address 8 bits

Network.Network.Network.Local

Class D Networks (multicast network)

1110 (Multicast Network) Multicast Address 28 bits (4+8+8+8)

Answers to questions at end of Student Workbook

1. Why do protocols exist?

   Protocols are rules for communications between two or more entities. They provide a framework for exchanging information.

2. What are the two types of protocol architectures that have been discussed in this issue? How do they differ? How are they similar?

   We discussed layered and hierarchical architectures. Both contain layers, or defined segments where certain communications tasks are performed. Layered protocols are a system of rules where information must pass from one layer to an adjacent layer in a protocol stack, without skipping layers. Lower layers provide services for higher layers. In contrast, hierarchical protocols do not require that all communications pass through adjacent layers of the architecture. Any layer of a hierarchical protocol can provide services for any other layer.

3. What is the function of a primitive, and what are the four basic types of primitive?

   Primitives are the building blocks of a protocol. Although they are generic in the sense that they are not written in any particular software code, they contain parameters that specify the information needed by the software and hardware developer. The four types of primitive are request, indication, response, and confirm.

4. Explain the relationship of protocols, architectures, reference models, and primitives.

   Protocol is a general name for a set of rules governing communications. Protocol architectures describe the way that the layers or parts of the protocol relate to each other. Protocol reference models are standards for designing specific protocols. Primitives are basic communications building blocks that are design specifications for developers of hardware and software for specific protocols. They specify the type of information that is to be exchanged by the protocol, and under what circumstances.

©SCTE

5. List the ten general functions of any protocol.

Segmentation and reassembly, encapsulation, connection control, flow control, error control, synchronization, sequencing, addressing, multiplexing, and transmission services.

6. List the seven layers of the OSI model. Which pertain to channel or network services, and which pertain to end-to-end communications?

Physical, Datalink, Network, Transport, Session, Presentation, Applications.

Physical, Datalink, and Network pertain to channels and network services. The remainder pertain to end-to-end communications. Although the Network layer manages routing across multiple computers in a network, it is not looking at the content of the communications as it moves from end to end to ensure a complete message is sent.

7. Why was TCP/IP developed? Where was it first used, and where is it used today?

TCP/IP was developed to manage the flow of communications across multiple computer networks. It was first used by the US government in the Department of Defense network. It is now used in the Internet.

8. *Lifetime* is the concept that a protocol data unit only has a given time to go from one end of a network to the other.

9. List at least 5 issues that are resolved by Layer 3 (Network Layer) protocols.

Different sizes and formats for Protocol Data Units in each network
Different timers and timeouts
Different quality of service
Different addressing schemes
Different levels of performance
Different routing methods
Different user interfaces (Connectionless vs. Connection-oriented)
Different levels of security
Different troubleshooting, diagnostics, and network maintenance
Cost and billing allocations

©SCTE