Overview

Description

This unit contains five lessons:

- The first lesson describes the seven layers of the OSI Reference Model, the functions of each layer, and the importance of standards.

- The second lesson describes how computer devices prepare, interpret, and send data over transmission media. This lesson also covers analog and digital signals, binary coding, and packet structures.

- The third lesson discusses the basics of Ethernet networking and how Ethernet standards manage data transmission at the data link and physical OSI layers.

- The fourth lesson compares and contrasts Ethernet and (IEEE 802.3) and describes the characteristics and purpose of Ethernet media.

- The fifth lesson addresses the characteristics of several other network architectures including Token Ring, FDDI, ARCNet, and LocalTalk.

Unit Table of Contents

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</tbody>
</table>
Lesson 2-1: The OSI Model

At a Glance

The Open Systems Interconnection (OSI) model describes how computer services and protocols can be standardized to allow computers to share information. It was developed in the 1980’s by the International Standardization Organization (ISO). Its goal is to enable the interconnection of all types of networks despite differences in hardware, media, programming language, operating system, or application software.

The OSI model, though still evolving, is the most widely accepted network model today thanks, in part, to voluntary acceptance and compliance by manufacturers and vendors. Due to its widespread use, the OSI model provides the basis for reference, description, and comparison of most internetworking topics. Additionally, it is the most commonly used systematic guide to troubleshooting networks. A deeper understanding of the OSI model and its seven layers will help you to improve your internetworking knowledge and skills. Because the model is abstract and complex, it helps to learn about it in stages. Begin now to build your OSI knowledge base.

What You Will Learn

After completing this lesson, you will be able to:

- Explain the importance of the OSI model.
- List the seven layers of the OSI model and describe how they communicate with one another.
- Identify the functions performed by each of the OSI model layers.
- Match network elements with their appropriate OSI model layer.
- Demonstrate an understanding of the OSI model in the context of information technology careers.
Tech Talk

- **Host**—A host is a computer system (or node) that shares its resources within a network.

- **International Standardization Organization (ISO)**—The ISO is a non-governmental group of standards-setting organizations from more than 90 countries. The ISO proposes, revises, and publishes global standards and protocols for a wide variety of concerns including banking services, electrical products, sports equipment, toy safety, and so on.

- **Media**—The physical material used when transmitting information over a network is referred to as the media. This includes conductive cables, optical fiber, or air through which encoded information flows between sender(s) and receiver(s), routers, switches, and so on.

- **Network Architecture**—The overall connection design and layout for how computers, devices, and media transfer information on a network is described as the network architecture. The three main types of network architecture are star (ARCnet), Ethernet, and Token Ring.

- **Open Systems**—Networks working together for efficient information flow by jointly implementing protocols whose details are publicly available are called open systems. Open systems contrast with proprietary systems.

- **Open Systems Interconnection (OSI) Reference Model**—The OSI model is a 7-layered format for organizing and describing the standardization required to enable full communication between different computers and computer systems.

- **Operating System**—An operating system is software used to control the activity of an individual workstation and/or network. Examples include: DOS, Windows, and Macintosh OS for workstations and NetWare, UNIX, LINUX, Windows 95, and NT for networks.

- **Peer Entities**—Parties or resources involved in communication at the same level are referred to as peer entities.

- **Proprietary Systems**—Vendor-specific sets of protocols that are not typically supported by other vendors. Token Ring started as a proprietary system.

- **Protocol**—Rules that govern network data flow and product creation. Protocols are pre-established communication rules and conventions.
Importance and Impact of the OSI Model

The OSI model is important because it:

- Describes a non-proprietary, open system of interfaces and protocols for network interconnection.
- Provides a framework for standards development for productive cooperation among global competitive vendors.
- Can be generalized as a model across electronic, electromagnetic, and optical communications technologies.
- Encourages design for information sharing regardless of computer/network architecture, topology, or platform.
- Balances protection against obsolescence with opportunities for improvement.
- Assists systematic understanding of complex network design and troubleshooting.

Check Your Understanding

- Why have standards? Why not let equipment manufacturers and software firms strive for unique advantage and let competition decide the winner?
- What social impact can you relate to open systems communication?
- Complete the following sentence: A shrinking planet with less ignorance of others would...
Protocols Govern Network Communication

Open systems networks are based on agreed-upon rules that allow users to communicate with each other. These communication rules are called protocols and are used by product developers and system designers to create computer networks. Due to the number of protocols needed to make different equipment communicate over a variety of media, networking is a complex task. Standards and models have been developed to describe the topics covered by networking protocols from a general or higher level perspective.

The OSI Model

The OSI model uses the concept of seven stacked layers to define a network communications system.

The lower three layers, listed below, deal mostly with network-dependent (hardware) functions. Transmissions of bits, frames, and packets over LANs, MANs, and WANs are handled by these layers.

- Physical
- Data Link
- Network
The upper four layers, listed below, deal more with application-oriented (user or software) functions. Network operating systems applications such as Windows NT, Novell NetWare, and UNIX function at these upper layers.

- Transport
- Session
- Presentation
- Application

Each layer of the OSI model provides specific functions not provided by any other layer. Sets of protocols allow the peer layers of the sending and receiving computers to communicate with each other. Each level uses the services of the layer immediately below it and provides services to the layer immediately above it.

The information being shared is "hidden" or "shielded" from non-adjacent layers. This system of permitted and hidden exchange among the layers is what allows protocols in one layer to evolve or change without affecting the protocols of the other layers. Following the OSI model and using the agreed-upon protocol stack maximizes compatibility between network resources.
Seven Layers of the OSI Model

Layer 1: Physical

The OSI physical layer protocols handle the mechanical, electrical, and procedural functions needed to provide the physical link between devices and the network. An easy way to think about it is that the physical layer is anything you can touch that transmits the data—a plug, cable, fiber, and so on.

The physical layer defines:

- Physical network structures.
- Mechanical and electrical specifications for using the transmission medium (conductive cable, optical fiber or air).
- Bit transmission encoding and timing rules.

Network hardware normally associated with the OSI physical layer includes: Ethernet, twisted pair and coaxial cable, BNC connectors, RJ-45 connectors, network interface cards, repeaters, concentrators, and hubs.

The physical layer receives a frame from the data link layer above and converts the digital data to a signal compatible with the transmission media. The most common protocols between the physical layer and the data link layer are Ethernet and Token Ring.
Layer 2: Data Link

The data link layer, in simplest terms, functions to provide any service not found in the physical layer needed for communication between two devices attached to the same wire.

The Data Link Layer

The basic purposes of data link layer protocols are:

- To organize the physical layer’s bits (0’s and 1’s) into logical groups of information called “frames” (groups of contiguous bits forming a unit of data).
- To detect (and sometimes correct) errors.
- Control data flow.
- Identify resources on the network through physical device addressing.

The functions of the layers are normally split between two sublayers.

- Media Access Control (MAC) layer which controls the way devices share the same media channel. It determines when a device can transmit its data.
- Logical Link Control (LLC) layer that is in charge of establishing and maintaining communication between devices.
Network hardware associated with the OSI data link layer includes bridges, switches, and network interface cards (NICs).

Some protocols and standards implemented at this layer are Ethernet, PPP, FDDI, Frame Relay, and ATM.

Layer 3: Network

The network layer provides the functions not found in the first two layers that allow for the exchange of information between two devices on different wires, that is, on different networks.

The Network Layer

The objectives of the network layer are:

- To move data to specific network locations. This function is similar to the data link layer; however, the network layer deals with multiple independent networks, called subnetworks. For example, this layer provides the network addressing and routing structure of the Internet.

- To segment messages and deliver packets or datagrams by line switching or packet switching.

- To determine the “best” route for the data to travel from LAN to LAN.

Typical hardware at this level includes routers and layer 3 switches. The most common protocol associated with this layer is IP, the Internet Protocol.
Layer 4: Transport

The transport layer provides the functions needed to make a connection to a remote device. These transport layer protocols are designed to hide the complexities of the computer network structure from the upper layer processes. They organize higher level messages into segments and reliably deliver segments to higher layers.

The transport layer:

- Provides reliable connection-oriented (such as TCP) and connectionless (such as UDP) transmissions between end nodes.
- Corrects transmission errors.
- Confirms whether data was delivered or denied.

A well-known protocol operating at this level is TCP, the Transmission Control Protocol, which is used on the Internet and is part of the TCP/IP protocol stack.
Layer 5: Session

The session layer facilitates communication between sending and receiving computers.

The session layer protocols:
- Control mechanisms that establish connections and synchronize how two devices communicate.
- Provide the user interface to the network (passwords and login).
- Monitor and maintain connections between two devices, reporting error messages to users and providing monitoring and billing procedures for shared systems.

A popular personal computer session layer protocol is NetBIOS.

FTP and Telnet protocols (from the TCP/IP stack) use the connection-oriented services of this layer.
Layer 6: Presentation

The presentation layer translates data into a standard format that can be understood by each network application and the computers on which they run. The protocols in this layer also provide for compression/expansion and/or encryption/decryption of data and security services. This layer also takes care of file locking, which prevents two users from modifying the same file at the same time.

The Presentation Layer

Protocols at this level deal with rules for representation of complex, structured data across a session (for example, MIME).
Layer 7: Application

The application layer handles the management of the OSI network and provides the representation of a connection to an end user such as HTTP. The protocols in this layer also perform network functions such as file and print.

The Application Layer

This layer does not include the actual application software, but does include the technologies that allow user software to access network services such as:

- Printing and viewing.
- Interfacing databases, email, web browsers, and word processing to network resources.

Examples of TCP/IP protocols running at this layer are HTTP and SMTP.
Data Flows Both Ways through Stacked Layers

When data is transferred from one host to another over a network, it begins its flow from the uppermost (application) layer of the originating host and continues through each lower stacked layer of that host. Each layer adds information such as framing and addressing to the data flow. This data is called a header. Layer 2 also adds a trailer.

Data Flows Through the Layers of the OSI Model

As data crosses the physical medium (Layer 1) to the destination host, the data flows back up through the layers in the opposite order, from lowest (physical) to the highest (application) layer. Each layer in the receiving system communicates with its peer layer in the sending system by reading and processing the (header) control information. When successive layers remove all headers, the receiving system sees the data in original format.

It is interesting to note that as data flows from one host to another, each layer functions as if it alone is involved in communication with its peer layer at the destination host. Individual layers are unaware of the functions of layers above and below them.

OSI Layers Work as a Stack

The seven OSI layers work together as a stack to encode and send messages through an open system. Peer layer protocols in another connected network or network device then process these messages.
Check Your Understanding

♦ List the layers of the OSI model.

♦ Bonus Option: Indicate the stack order of the layers.
Try It Out

The OSI Model

Materials Needed
- Internet Connection (optional)
- OSI research materials

1. Form seven groups, one for each of the seven layers of the OSI model. Pick a group to join.

   If you have already identified a particular layer that matches your area of interest in networking, you could pick that group. Or you could pick the layer you know the least about and want to understand better. If your first choice has too many members, join another group.

   For example, if you are most interested in solving problems with users, you might pick the application layer group; if you want to learn more about routing and switching, you might join the network layer group. If bit-stream framing sounds intriguing, join the data link layer group. If it’s all pretty confusing, think of a number between one and seven and prepare to learn a lot about that layer.

2. Work together as a group to create a hard copy description of your chosen layer. Bring hard copy to class for all members of your group to read and compare.

3. Synthesizing from at least four of your sources, compile a one page summary of key word descriptors, issues, concerns, network elements, protocols, and so on, that best describe your layer. Cite the sources used. Organize and format your work for duplicating and sharing with each of the other six groups.

4. As a group, present your information to the class, respond to questions, and participate in discussion. Individually ask questions during presentations by the other groups.

5. Add your group’s summary and those of your classmates to your portfolio. Refer often to this expanded information on OSI layers. Review prior to interviews and/or contacts with networking employers.
## Rubric: Suggested Evaluation Criteria and Weightings

<table>
<thead>
<tr>
<th>Criteria</th>
<th>%</th>
<th>Your Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group research summary (on-time delivery)</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Analysis and synthesis of source information</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Summary organized and in a format suitable for reproduction</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Presentation and communications skills</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Individual questions to other group presenters</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
Stretch Yourself

Classify the Classifieds

Materials Needed

- Help Wanted Advertisements from newspaper, Internet, etc.

In pairs, photocopy or clip five or more current networking job ads from your local (or nearby metropolitan) newspaper or download posted positions from Internet sites. Determine when the newspapers you select run the most ads for information technology positions. Try to get a good variety of different job titles. Concentrate your efforts, if you wish, on jobs that sound interesting to you.

1. Summarize at least five jobs with one-liners or notes in each of the following four categories (use the worksheet found after the sample script):
   - Job title
   - Major duties or responsibilities
   - Experience required or preferred
   - Salary range and location (if given)

2. Identify which OSI layers are most involved in each of your selected job openings.

3. Rank the jobs to show your first, second, and third choices and identify what factors you find appealing.

4. Select two job ads that list telephone/fax numbers or e-mail addresses, and contact the employer. Identify yourself as a student in Internetworking Fundamentals at Your School and ask if you can make an inquiry about the advertised job for a class assignment. If so, consider adapting the provided sample script to guide your conversation.
Sample Script: Employer Teleconference

To whomever answers:

Hello, my name is _____________.

I am a networking student in __teacher’s name__ class at __school__.

I am working on a school assignment to classify information technology jobs according to the Open Systems Interconnection Reference Model.

May I speak briefly with the hiring manager for the __opening__ which you advertised in the __edition__ of __newspaper__?

I have just a few questions to ask to fulfill my assignment.

Thank you.

(Repeat as necessary until you have connected with the hiring manager or leave your name, number, and a time for receiving a requested callback).

To the hiring manager:

(Repeat parts of above introduction as necessary).

Sir/Madame: For your advertised position opening of __title__, I have classified the job activities as dealing primarily with layers __no to __of the OSI model. Am I correct?

Can you tell me a little more about what you are looking for?

Prepare several alternative follow-up questions such as: How many employees are involved with networking in your organization?

Thanks very much. You are welcome to come and visit our class. We meet __when__.

Rubric: Suggested Evaluation Criteria and Weightings

<table>
<thead>
<tr>
<th>Criteria</th>
<th>%</th>
<th>Your Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group summary of five ads (on-time delivery)</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Completed worksheet</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Communication skills</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Script and summary of professional contacts</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>100</td>
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</tr>
</tbody>
</table>
### Worksheet:
Name_______________________________

**Classify the Classifieds: OSI Layer Job Match**

<table>
<thead>
<tr>
<th>Example</th>
<th>OSI Layer #___</th>
<th>OSI Layer #___</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job Title:</td>
<td>Help Desk Coordinator</td>
<td>Job Title:</td>
</tr>
<tr>
<td>Major Duties:</td>
<td>Training, application support &amp; troubleshooting via phone and face-to-face</td>
<td>Major Duties:</td>
</tr>
<tr>
<td>Experience:</td>
<td>1-6 yrs plus application knowledge. A degree a plus.</td>
<td>Experience:</td>
</tr>
<tr>
<td>Salary Range Location (if given):</td>
<td>Up to $75,000 Boston area</td>
<td>Salary Range Location (if given):</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OSI Layer #___</th>
<th>OSI Layer #___</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job Title:</td>
<td></td>
</tr>
<tr>
<td>Major Duties:</td>
<td></td>
</tr>
<tr>
<td>Experience:</td>
<td></td>
</tr>
<tr>
<td>Salary Range Location (if given):</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OSI Layer #___</th>
<th>OSI Layer #___</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job Title:</td>
<td></td>
</tr>
<tr>
<td>Major Duties:</td>
<td></td>
</tr>
<tr>
<td>Experience:</td>
<td></td>
</tr>
<tr>
<td>Salary Range Location (if given):</td>
<td></td>
</tr>
</tbody>
</table>
Network Wizards

The OSI Model

Materials Needed

- None

1. Provide seven one-paragraph statements nominating specific individuals (staff and/or students) to form a seven-member school academic network start-up and/or support team:

Within each paragraph, justify your choices in terms of your perception of knowledge and skills required to deal with responsibilities at each of the seven OSI layers. Some layers are more difficult to define and understand than others, but give it your best effort. Refer back to the key words and descriptors in the group Try It Out activity summary sheets for guidance.

Examples: A business or computer applications teacher may be appropriate for applications layer issues where user software knowledge and customer relations skills are needed. A maintenance/electrical staff person could handle responsibilities for physical layer concerns such as cable connections and power supply. A programmer friend may be the perfect choice for one of the mid-layers.

2. Provide a one-page summary discussing leadership, training, budget, and any other issues you feel would be critical to success of the effort.

3. Add your documentation to your portfolio.

Rubric: Suggested Evaluation Criteria and Weightings

<table>
<thead>
<tr>
<th>Criteria</th>
<th>%</th>
<th>Your Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-time delivery of assignment</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Content and quality of nomination paragraphs and summary</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Thoughtful analysis of skills/characteristics required for each of the seven individuals</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Organization, spelling, grammar</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
Summary

In this lesson, you learned the following:

- The importance of the OSI model.
- The seven layers of the OSI model and how they communicate with one another.
- The functions performed by each of the OSI model layers.
- To match network elements with their appropriate OSI layer.
- An understanding of the OSI model in the context of information technology careers.

Review Questions

Lesson 2-1: OSI Model

Part A

1. Explain why the OSI model is important.

Part B

1. List the seven layers of the OSI model in stacked order (Layer 7 at the top).
2. Describe how the layers of the OSI model communicate with each other.
Part C

1. Match the OSI layer with the appropriate function from the list below.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 – Application</td>
<td>A. Routes and addresses messages</td>
</tr>
<tr>
<td>6 – Presentation</td>
<td>B. Translates data so software applications can read it</td>
</tr>
<tr>
<td>5 – Session</td>
<td>C. Allows user software to access network services</td>
</tr>
<tr>
<td>4 – Transport</td>
<td>D. Enables network logins</td>
</tr>
<tr>
<td>3 – Network</td>
<td>E. Frames and controls data flow</td>
</tr>
<tr>
<td>2 – Data Link</td>
<td>F. Provides reliable transmission and confirmation</td>
</tr>
<tr>
<td>1 – Physical</td>
<td>G. Defines media specifications</td>
</tr>
</tbody>
</table>
## Part D

1. Label network hardware elements and functions with the appropriate OSI layer.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Device and Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeater</td>
<td>a connector that filters, amplifies and retransmits information to allow signals to travel further along a network.</td>
</tr>
<tr>
<td>Bridge</td>
<td>connects small numbers of similar LANs into an internetwork or splits an overloaded network into smaller parts without translation.</td>
</tr>
<tr>
<td>Router</td>
<td>connects different networks together and directs information by best route (using algorithms) to destinations.</td>
</tr>
<tr>
<td>NIC</td>
<td>provides connection of computer to transmission medium on the network.</td>
</tr>
<tr>
<td>Gateway</td>
<td>links different network types together. Can be hardware or software that allows different protocols to exchange information.</td>
</tr>
<tr>
<td>Hub</td>
<td>provides central location with ports where cables on a network come together for connection</td>
</tr>
<tr>
<td>Modem</td>
<td>allows computers on a network to exchange information by translating into binary form for transmission over telephone lines.</td>
</tr>
<tr>
<td>Cable</td>
<td>wires used to connect devices on a network.</td>
</tr>
</tbody>
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### Scoring

**Rubric: Suggested Evaluation Criteria and Weightings**

<table>
<thead>
<tr>
<th>Criteria</th>
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<tbody>
<tr>
<td>Part A: Explain the importance of the OSI model.</td>
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<tr>
<td>Part B: List the seven layers of the OSI model and describe how they communicate with one another.</td>
<td>35</td>
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<tr>
<td>Part C: Identify the functions performed by each of the OSI layers.</td>
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</tr>
<tr>
<td>Part D: Match network elements with their appropriate OSI layer.</td>
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<tr>
<td><strong>Try It Out:</strong> Demonstrate an understanding of the OSI model through the context of information technology careers</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td><strong>Stretch Yourself:</strong> Demonstrate an understanding of the OSI model in the context of information technology careers.</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td><strong>Network Wizards:</strong> Identify functions performed by each of the OSI layers</td>
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<td></td>
</tr>
<tr>
<td><strong>FINAL TOTAL</strong></td>
<td>400</td>
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# Resources


