Day 31

Describe Network Communications Using Layered Models

If the CCNA had a skeleton, networking models would be it. A solid understanding of these models prevents your network knowledge from resembling spineless, shapeless jelly. The networking models from CCNA 1 provide a framework for the concepts and configurations covered throughout the Cisco Networking Academy Program curriculum. Today you cover the Open System Interconnection (OSI) and TCP/IP layered models described in Modules 2, 6, 9, and 11 from CCNA 1 and the Cisco three-layer hierarchical model described in Module 5 from CCNA 3.

Do not stop with the quick summaries provided today. Look in the curriculum for related charts and graphics. Many other online resources, such as Wikipedia (www.wikipedia.com), also have excellent explanations. You might even have something to add to the Wikipedia explanations after your studies.

CCNA 1, Module 2

2.3.1—As you track the flow of information across a network, you will notice specific points where data changes on its route to a destination. The layers of the OSI and TCP/IP models help to explain why these changes occur and the process that helps the data find its way from one node to the next.

2.3.2—When two nodes communicate, they follow a protocol or an agreed upon set of rules to ensure the successful transmission of data. Keep in mind that peer layers communicate with each other.

2.3.3—Initially, companies developed proprietary network technologies that naturally caused compatibility issues, so the OSI model was released in 1984.

The benefits of using the OSI model to describe networks and networking devices are as follows:

- Reduces complexity
- Standardizes interfaces
- Facilitates modular engineering
- Ensures interpolable technology
- Accelerates evolution of networks
- Simplifies teaching and learning

2.3.4 and 2.3.5—Here is Yet Another OSI Model Chart (YAOMC). It wouldn't be a CCNA book without one. Table 31-1 describes each layer of the OSI model. Note that the protocol data unit (PDU) for each layer is in italics. A mnemonic such as Please Do Not Throw Sausage Pizzas Away might help you to remember each of the seven layers quickly for the exam.

Table 31-1 The Open System Interconnection Seven-Layer Model

Layer Number	Layer Name	Function	Devices
7	Application	E-mail, FTP, and other programs that allow the user to enter *data*.	N/A
6	Presentation	Encryption and compression can occur. *Data* is represented in a standard syntax and format such as ASCII.	N/A
5	Session	Set up, management, and tear down for sessions between programs exchanging *data*.	N/A
4	Transport	*Segments* are transported with reliability, error detection, and flow control.	N/A
3	Network	*Packets* are routed over the network and receive a path based on their IP address.	Router
2	Data link	*Frames* traverse the LAN with a MAC address as the identifier.	Bridge, switch
1	Physical	*Bits* physically pulse or wave their way over the network media representing 1s and 0s.	Hub, repeater, copper, optical, wireless

2.3.6—The TCP/IP model achieves the same main goals as the OSI model. The U.S. Department of Defense developed the model to define a network that could withstand nuclear war. Table 31-2 matches the layers of the TCP/IP model with the OSI model.

Table 31-2 The TCP/IP Model Versus the OSI Model

TCP/IP Model	OSI Model
4 Application	7 Application 6 Presentation 5 Session
3 Transport	4 Transport
2 Internet	3 Network
1 Network Access	2 Data link 1 Physical

2.3.7—The PDUs identified in the OSI model are encapsulated as they travel through the layers and from host to destination. In the top three layers, the data remains data. When data enters the transport layer, it is packaged into segments. The network layer then packages the segments into packets and adds a source and destination IP address. The data link layer packages the packet into a frame and adds a source and destination MAC address. Finally, the frame becomes a series of bits for transmission over the physical media.

CCNA 1, Module 6

6.1.3—The data link layer of the OSI reference model consists of two sublayers:

- The upper sublayer is the Logical Link Control (LLC) sublayer. The LLC sublayer communicates with the upper layers of the OSI model.
- The lower sublayer is the MAC sublayer. The MAC sublayer controls access to the physical media. 802.3 Ethernet operates in the physical layer of the OSI model and in the MAC sublayer of the data link layer.

6.1.5—Layer 2 frames are made up of fields. These fields allow the receiving host to identify the beginning, end, destination, and successful transfer of a frame. Without frames, the transmission would be just a big stream of ones and zeros. The fields in a generic frame are as follows:

- **Start of Frame**—This field identifies the beginning of a frame.
- **Address**—This field contains the source and destination MAC address.
- **Length/Type**—If this is a length field, it defines the length of the frame; if it is a type field, it identifies the Layer 3 protocol for the frame.
- **Data**—Where the data resides that is processed by the upper layers. (In this case, *upper layers* refers to Layers 3–7 in the OSI model and Layers 3 and 4 in the TCP/IP model.)
- **Frame Check Sequence**—This field provides a number that represents the data in the frame and a way to check the frame and get the same number. Cyclic redundancy check (CRC) is a common way to calculate the number and check for errors in the frame.

6.2.1—Three Layer 2 technologies that control how the physical media is accessed are Ethernet, Token Ring, and FDDI. As part of the MAC sublayer, these technologies can be divided into two groups: deterministic and nondeterministic. FDDI and Token Ring are deterministic in that they provide a way to take turns accessing the media. Ethernet is nondeterministic and uses carrier sense multiple access collision detect (CSMA/CD) as the protocol for accessing the media. This means that a node will first check to see if there is already a transmission and begin sending if the line is available. If two nodes transmit at the same time, a collision will occur and both nodes will wait a random amount of time before trying again.

CCNA 1, Module 9

9.1.1—Do not confuse the OSI and TCP/IP models despite the fact that some of the layers have the same name. The same layers in the different models have different functions. Unless otherwise noted, most CCNA questions will reference the OSI model. Pay close attention to the layer name and model name in any layered model question.

9.1.2—The application layer of the TCP/IP model includes programs and protocols that prepare the data to be encapsulated in the lower layers. Examples of these programs are as follows:

- FTP
- TFTP

- Simple Mail Transfer Protocol (SMTP)
- Simple Network Management Protocol (SNMP)
- Telnet
- Domain Name System (DNS)

9.1.3—TCP and UDP operate as protocols of the TCP/IP transport layer. Both TCP and UDP segment data from the TCP/IP application layer and send the segments to the destination host. UDP is a connectionless protocol that sends the data without verifying a successful transfer. TCP, however, ensures reliable transfer with acknowledgments and sequencing, provides flow control, and is classified as a connection-oriented protocol.

9.1.4—The TCP/IP Internet layer finds the path for packets over the network. This layer includes the connectionless protocol IP and Internet Control Message Protocol (ICMP). The TCP/IP internet layer also uses Address Resolution Protocol (ARP) to find a MAC address and Reverse Address Resolution Protocol (RARP) to find an IP address.

9.1.5—The TCP/IP network access layer, also called the host-to-network layer, provides the protocols to access the physical media and the standards for the media (wires, fiber, and radio frequency). Examples of these protocols are as follows:

- Ethernet
- Fast Ethernet
- Point-to-Point Protocol (PPP)
- FDDI
- ATM
- Frame Relay

9.1.6—Pay close attention to the fact that the application layer of the TCP/IP model includes the application, presentation, and session layers of the OSI model and that the TCP/IP network access layer includes the data link and physical layers of the OSI model. The OSI model appears more in academic and theoretical situations, whereas the TCP/IP model is the basis for development of the Internet. Know both models.

CCNA 1, Module 11

11.1.1—When you think about the transport layer, consider flow control and reliability. The transport layer achieves these goals through sliding windows, segment sequence numbers, and acknowledgments.

11.1.2—When two hosts establish a logical TCP connection at the transport layer, they agree on a reasonable flow of information. This flow control allows the receiving host to process the information in time to receive new segments from the sending host.

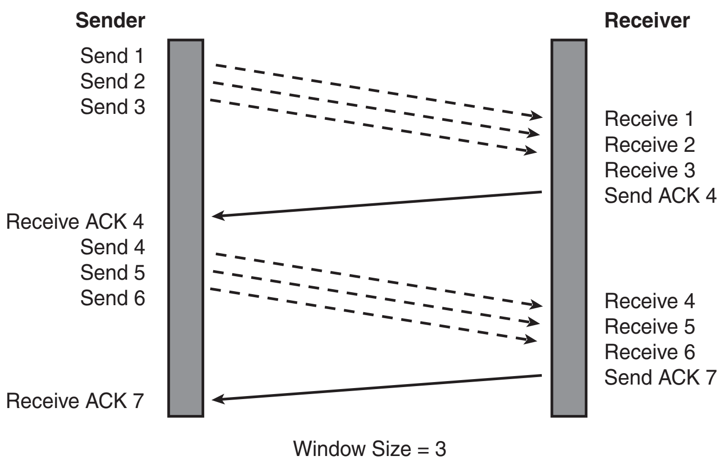
11.1.3—In order to start passing segments at the transport layer, two hosts must set up and maintain a session. The application initiating the connection and the operating system communicate with the receiving host's application and operating system to set up and synchronize a session. TCP avoids congestion at the transport layer by allowing the receiving host to send **ready** and **not ready** indicators to the sending host.

11.1.4—Applications that use the connection-oriented protocol TCP at the transport layer must first set up a session. Send a SYN, receive an ACK, send back an ACK +1, and you are connected using the TCP protocol. This three-way handshake defines the sequencing for TCP communication. Remember that both hosts must send an initial sequence number and receive an acknowledgment for communication to proceed.

11.1.5—TCP can play with these ACKs to define how much can be sent using sliding windows. A host initially sends a segment with a window size of 1. The receiving host could respond with an acknowledgment and identify that it would like a window size of 2. The sending host shoots back two segments and the receiving host acknowledges and asks for a window size of 3. If at some point during this transfer the receiving host does not acknowledge the transfer, the sending host tries again with a smaller window size. These sliding windows control flow between the two hosts.

11.1.6—How does the sending host know to retransmit a segment? As mentioned previously, retransmission occurs in the negotiation of a window size. To further explain the process, the sending host's need to retransmit relies on the numbers sent with acknowledgments. If a sending host fires segments 1, 2, and 3 over to the receiving host and receives an ACK 4, it knows to send segments 4, 5, and 6, as shown in Figure 31-1. If the receiving host were to return only an ACK 3, the sending host would have to retransmit segment 3. Try illustrating this process. (You can use the "Your Notes" section that appears after today's summary.) If you need help, visit module 11.1.6 in the CCNA 1 curriculum.

Figure 31-1 TCP Sliding Window



11.1.7—FTP, HTTP, SMTP, and Telnet use the transport layer TCP protocol. All of these protocols benefit from the connection-oriented, reliable transfer that TCP provides. The fields of a TCP segment are as follows:

- Source port
- Destination port

- Sequence number
- Acknowledgment number
- Header length (HLEN)
- Reserved
- Code bits
- Window
- Checksum
- Urgent pointer
- Option
- Data

11.1.8—TFTP, SNMP, DHCP, and DNS use the connectionless transport layer protocol UDP. UDP streams its segments at the receiving host and leaves the error checking to the upper-layer protocols. Notice in the following UDP fields that there are no acknowledgement, sequence, and window fields:

- Source port
- Destination port
- Length
- Checksum
- Data

11.1.9—If someone connects to your desktop on port 27015, you are likely hosting a video game. This port is not one of the well-known port numbers assigned by the Internet Assigned Numbers Authority (IANA) because it provides standard port numbers below 1024 for protocols such as FTP (port 21 TCP) and HTTP (port 80 TCP). The destination host must connect on a standard port number while the source host dynamically assigns a number above 1023 for the source port number. Memorize the common registered TCP and UDP port numbers for the protocols included in Table 31-3.

Table 31-3 Transport Layer Ports

Application Layer Protocol	Transport Layer Port/Protocol
http	Port 80 TCP
FTP	Port 21 TCP
Telnet	Port 23 TCP
SMTP	Port 25 TCP
DNS	Port 53 UDP and TCP
TFTP	Port 69 UDP
SNMP	Port 161 UDP
RIP	Port 520 UDP

11.2.1–**11.2.7**—Each of the application layer protocols in Table 31-4 provides a key function for Internet use.

Table 31-4 Application Layer Protocols

Protocol	Description
DNS	The DNS represents an IP address with a domain name. Each domain name has an extension such as .com that helps to identify the purpose of the site.
FTP and TFTP	FTP allows connection-oriented TCP-based file transfer between a client and a server. TFTP uses the connectionless UDP protocol to transfer files without the feature set of FTP. It is possible to transfer Cisco IOS images using TFTP.
HTTP	HTTP uses TCP and allows a user to navigate web sites on the Internet using a browser.
SMTP	SMTP uses TCP at OSI Layer 4 to send e-mail.
SNMP	SNMP allows an administrator to observe activity and troubleshoot problems on a network. A network management system can collect information provided by network devices.
Telnet	Telnet provides a command-line interface to a remote host.

CCNA 3, Module 5

5.2.1—Networking engineers use a three-layer hierarchical model to describe and design networks. This model consists of the core, distribution, and access layers, which provide an outline for the types of devices and connectivity necessary in a large network. The core layer serves as the backbone reserved for high-speed transmission. The distribution layer divides the core layer from the access layer and provides policy-based connectivity. The access layer connects users and remote sites to the network.

Summary

The OSI model and its seven layers cover each aspect of networking as data changes to segments, to packets, to frames, and then to bits. Only four layers comprise the TCP/IP model. The three-layer hierarchical model has three layers. In the "Your Notes" section that follows, it would be wise to diagram each of these layers and their characteristics from memory. If you have the *CCNA Flash Cards and Exam Practice Pack* (CCNA Self-Study, exam #640-801), Second Edition (ISBN: 1587200791), published by Cisco Press, now is a good time to review pages 13–34.

Your Notes