Network + Section 3 - OSI Model

OSI Model Overview

- Open Systems Interconnection (OSI) Model - This is referred to as ISO 7498. May also be referred to as the OSI Stack.
    - The OSI model is the reference model we use (Pertaining to CompTIA)
    - There are seven layers in the OSI Model (Physical, Data Link, Network, Transport, Session, Presentation, Application)
- Exam Objective OBJ 1.1 Compare and contrast the Open Systems Interconnection (OSI) model layers and encapsulation concepts.
- Exam Objective OBJ 5.3 Given a scenario, use the appropriate network software tools and commands.
- OSI Model can serve as a reference model.
- There is also the TCP/IP model.
- When mentioning data it's referencing layer 7,6,5. Layer 4 deals with segments, Layer 3 deals with Packets, Layer 2 Frames, and Layer 1 bits.

Layer 1 (Physical Layer)

- Physical Layer - Where transmission of bits across the network occurs and includes physical and electrical network characteristics.
    - 0s and 1s.
- Transition Modulation - If it changes during the clock cycle, then a 1 is represented (otherwise, a 0 is represented).
- How are cables wired?
    - There are two standards used within a network.
        - TIA/EIA-568A
        - TIA/EIA-568B
- Layer 1 devices view networks from a physical topology perspective.
    - How is communication synchronized?
        - Asynchronous - Uses start and stop bits to indicate when transmissions occur from the sender to the receiver.
        - Synchronous - Uses a reference clock to coordinate the transmissions by both sender and receiver.
    - How is bandwidth utilized?
        - Broadband - Divides bandwidth into separate channels.
        - Baseband - Uses all available frequencies on a medium (cable) to transmit data.
            - Baseband uses a reference clock - sends information for both sender and receiver at a certain time. Example of a synchronous communication.
- How can we get more out of a limited network?
    - Time-Division Multiplexing (TDM) - Each session takes a turn, using time slots, to share the medium between all users.
    - Statistical Time-Division Multiplexing (StatTDM) - Dynamically allocates the time slots on an as-needed basis.

    - Frequency-Division Multiplexing (FDM) - Divides the medium into channels based on frequencies and each session is transmitted over a different channel.
- Multiplexing is getting more out of a limited network.
- Simultaneous use of a baseband connection.
- Physical Layer Device Examples
    - Cable (Fiber Optic, Coaxial, Ethernet (copper)).
    - Wireless - Bluetooth, Wi-Fi, NFC, etc.
    - Hubs, access points, and media converters.
- Their devices are not intelligent.

Layer 2 (Data Link Layer)

- Data Link Layer packages data into frames and transmits those frames on the network.
    - Media Access Control (MAC) - Physical addressing system of a device which operates on a logical topology.
        - Uses a 48-bit address assigned to a network interface card (NIC) (D2:51:F1:3A:34:65).
        - First 6 digits of the MAC address are the vendor code.
        - The last 6 digits of the MAC address are unique values.
    - Layer 2 devices view networks logically.
        - Logical Link Control (LLC) - Provides connection services and allows acknowledgements of receipt of messages.
            - LLC is the most basic form of flow control.
            - Provides basic error control functions. Does this by using a checksum. The last bit will be even or odd.
        - How is communication synchronized?
            - Isochronous - Network devices use a common reference clock source and create time slots for transmission.
            - Synchronous - Network devices use a common reference clock source and create time slots for transmission.
            - Networks operate in that devices can only communicate at frequencies specified by particular clock cycles.
            - Asynchronous - Network devices reference their own internal clocks and use start and stop bits.
    - Data Link Layer Device Examples
        - Network Interface Cards (NIC), Bridges, Switches, etc… Switches can use logic to learn which physical ports are attached to which devices.

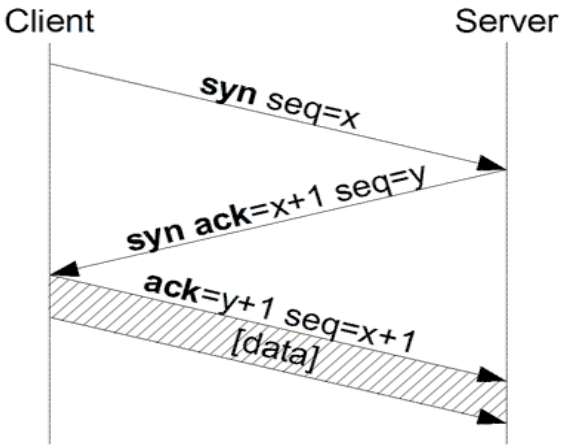
Layer 3 Network

- Network Layer - Forwards traffic (routing) with logical addresses.
    - Logical Addressing
    - Switching
    - Connection services
    - Route discovery and selection
    - Bandwidth usage
    - Multiplexing strategy

- How should data be forwarded or routed?
    - Packet Switching - Data is divided into packets and then forwarded.
    - Circuit Switching - Dedicated communication link is established between two devices.
    - Message Switching - Data is divided into messages which may be stored and then forwarded.
    - Most networks use packet switching.
- Route Discovery and Selection - manually configured as static route or dynamically through a routing protocol.
    - RIP
    - OSPF
    - EIGRP
- Connection Services - Augment Layer 2 connection services to improve reliability.
    - Flow Control prevents the sender from sending data faster than the receiver can get it.
    - Packet reordering allows you to take a big chunk of data, break it into little packets, and send the packets off in different locations.
- Internet Control Message Protocol - Sends error messages and operations information to an IP destination.
    - Traceroute is a variation of ICMP that traces the packets through the network and tells you every single router along the way.
- Layer 3 devices
    - Routers, Multiplayer Switches.
- Ipv4 and Ipv6 are layer 3 protocols. ICMP.

Layer 4 Transport

- Transmission Control Protocol (TCP) - Connection-oriented protocol that is a reliable way to transport segments across the network.
- 3-Way-Handshake (SYN, SYN-ACK, ACK)
- User Datagram Protocol (UDP) - Connectionless protocol that is an unreliable way to transport segments across the network.
- If dropped, send is unaware. (UDP functions greate for streaming video, audio).
- Windowing - Allows the client to adjust the amount of data in each segment as it goes through the transmission.
    - Sends less data with increased retransmissions.
    - Sends more data with decreased retransmissions.
    - Opening and closing the window to maximize our throughput and our bandwidth.



- Buffering - Occurs when devices allocate memory to store segments if bandwidth isn't readily available.
    - Routers have a special memory in them to store segments if the bandwidth isn't readily available (buffer)
- Layer 4 devices
    - TCP and UDP think of Layer 4

    - WAN accelerators to get through our network faster.
    - Load Balancers and Firewalls can operate in Layer 4 by blocking and allowing different ports and protocols.

TCP	UDP
Reliable	Unreliable
Connection-oriented	Connectionless
Segment retransmission and flow control through windowing	No Windowing or retransmission
Segment sequencing	No sequencing
Acknowledgment segments	No acknowledgment

Layer 5 Session Layer

- Session Layer - Keeps conversations separate to prevent intermingling of data.
    - Set up Session - Checking of user credentials and assigning numbers to sessions to help identify them.
    - Maintain transfer data
    - Reestablish connection
    - Acknowledge receipt tear down
- Transfer Data Session - Ending of a session after the transfer is done when the other part disconnects.
- Examples of Layer 5 devices
    - H.323 - Used to set-up, maintain, and tear down voice and video connections. (Operates over RTP Real Time Protocol) (Streaming Audio or Video)
    - NetBIOS - Used to share fields over a network.
    - Not devices more along the lines of protocols and software.

Layer 6 Presentation Layer

- Presentation Layer - Formats the data to be exchanged and secures that data with proper encryption.
    - Data formatting - Data is formatted by the computer to have compatibility between different devices. (Examples…ASCII American Standard for Computer Information Interchange. GIF, JPG, PNG)
        - ASCII - Ensure data is readable by the receiving system, to speak the same language.
            - Negotiates data transfer syntax for the Application Layer (Layer 7)
    - Encryption - Used to scramble the data in transit to keep it secure from prying eyes and provide data confidentiality. (TLS Transport Layer Security).
    - Examples of Layer 6 supported items
        - Scripting Languages

            - HTML
            - XML
            - PHP
            - JavaScript…etc.
        - Standard Text
            - ASCII
            - Unicode
            - EBCDIC
        - Pictures
            - GIFs
            - JPGs
            - TIFs
            - SVGs
            - PNGs
        - Movie Files
            - MP4s
            - MPGs
        - Encryption Algorithms
            - SSL/TLS

Layer 7 Application

- Application Layer - Provides application level services when users communicate with the computer.
- Applications Services - Unites communicating components from more than one network application.
- Lower level protocols - for example email which may use POP3, SMTP, IMAP.
- Service Advertisement - Sending out of announcements to other devices on the network to state the services they offer.
- Layer 7
    - Email applications - POP3, IMAP, SMTP
    - Web browsing - HTTP, HTTPS
    - Domain Name Service - DNS
    - File Transfer Protocol - FTP, FTPS, SFTP
    - Remote Access - Telnet, SSH, SNMP
- Encapsulation and Decapsulation
    - Encapsulation - The process of putting headers (and trailers) around some data.
    - Protocol Data Unit (PDU) - A single unit of information transmitted in a computer network.
        - L7 PDU
        - L1 Bits
        - L2 Frames
        - L3 Packets
        - L4 Segments (TCP) Datagram (UDP)

TCP Header (20 bytes)			
Source Port		Destination Port	
Sequence Number			
Acknowledgment Number			
Offset	Reserved	TCP Flags	Window
Checksum		Urgent Pointer	
TCP (Optional)			

- TCP flags - SYN/ACK/FIN/RST/PSH/URG
- SYN Synchronization - Used to synchronize connection during the three-way handshake.
- ACK Acknowledgment - Used during the three-way handshake, but also used to acknowledge the successful receipt of packets.
- FIN Finished - Used to tear down the virtual connections created using the three-way handshake and the SYN flags.
- RST Reset - Used when a client or server receives a packet that it was not expecting during the current connection.
- PSH Push - Used to ensure data is given priority and is processed at the sending or receiving ends.
- URG Urgent - Similar to PSH and identifies incoming data as urgent.
- User Datagram Protocol is another Layer 4 header.

UDP Header (8 Bytes)
Source Port
Destination Port
Length
Checksum

- Layer 3 as we move down another layer we are going to encapsulate the data within another header. It will be encapsulated with the IP header.

IP Header			
Version	Length	Type of Service	Total Length
Identifier	Flags	Fragments Offset	
Time-to-Live	Protocol	Head Checksum	

Source IP Address
Destination IP address
Options and Padding

- Layer 2 the data-link layer that will encapsulate the data in an Ethernet header.

Ethernet Header
Destination MAC Address
Source MAC Address
Ether Type
VLAN Tag (Optional)

- A frame being sent at Layer 2 will also contain a payload.
    - 42 bytes Using VLANs
    - 46 bytes no VLANs
    - When sending payload there is MTU - Maximum Transmission Unit. By default Ethernet uses an MTU of 1,500 bytes at its maximum.
    - A header is larger than 1500. You need to use a Jumbo frame. You will need to reconfigure your MTU size larger than 1500 bytes.
- As data moves down the layers, data will be encapsulated.
    - Segment - Add our source and destination ports.
    - Packet - Add our source and destination IP addresses.
    - Frame - We add our source and destination MAC addresses.
    - Bits - We are transmitting our Layer 2 frames as a series of “1’s” and “0’s”.