eJPT Certification
Section: Networking
08/7/2020

Learning Objectives:

- Modern network protocols
- Ways computers talk to each other
- Sniffing and capturing the network traffic

Protocols:

- Are used in every computer network communication
- In a computer network, machines talk to each other by means of protocols
- The exchange of information between networked computers are called packets.
    - Packets are streams of bits running as electric signals on physical media used for data transmission.
        - This media can be a wire in a LAN (local area network) or the air in a WIFI network.
    - Every packet has the following structure: Header and Payload
        - Header- protocol-specific structure: This ensures that the receiving host can correctly interpret the payload and handle the overall communication
            - The header contains valuable information such as the IP version(version 4 or 6), source address, and destination address.
            - The header allows the nodes involved in the communication to understand and use IP packets.
        - Payload- the actual information. Could be many different types of information such as emails, media, files, etc.

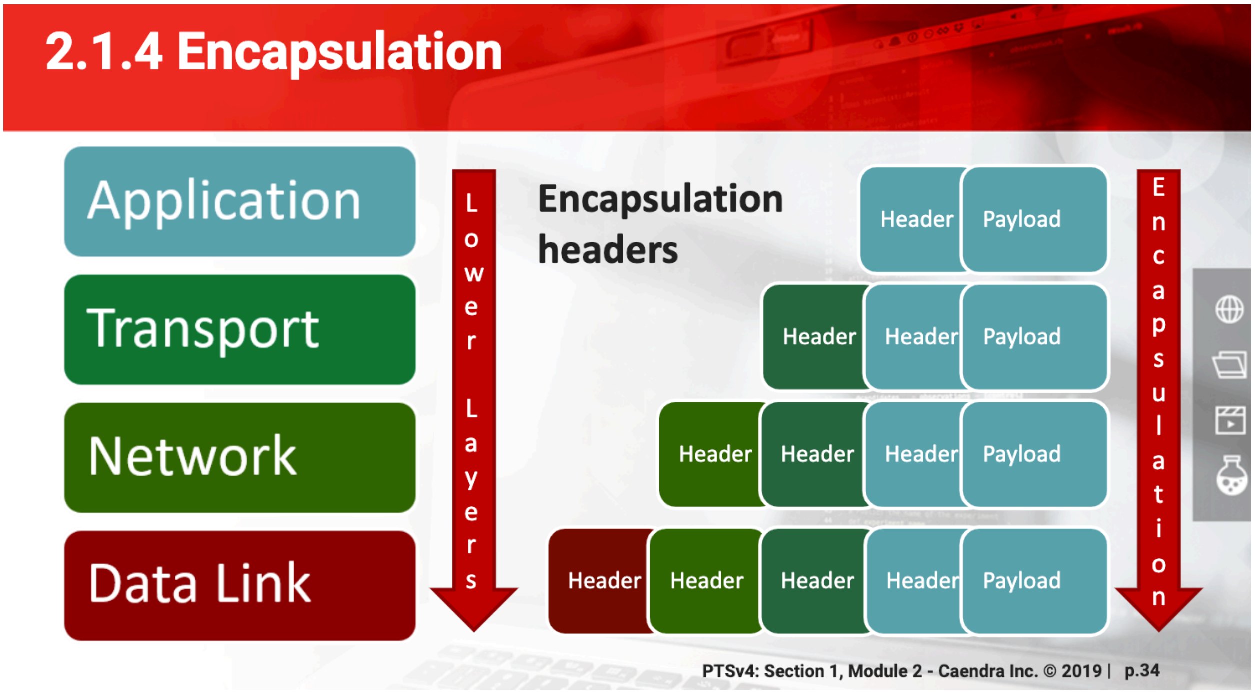
Protocol Layers:

- There are many protocols all of which have a specific purpose, such as:
    - Exchanging emails, files or performing VoIP calls.
    - Establishing a communication between a server and a client.
    - Identifying computers on a network.
    - Transmitting data.
- Features that a protocol provides:
    - Make an application (such as an email client, FTP, browser) work.
    - Transport data between processes (the server and the client programs).
    - Identify hosts.
    - Use the physical media to send packets.
- If we rewrite the previous list, it would look like the following:
    - Application layer.
    - Transport layer.
    - Network layer.
    - Physical layer.

- Each of these layers works on top of another, and every layer has its own protocol.
    - Furthermore, each layer serves the one above it (physical supports network, network supports transport, and transport supports application.)

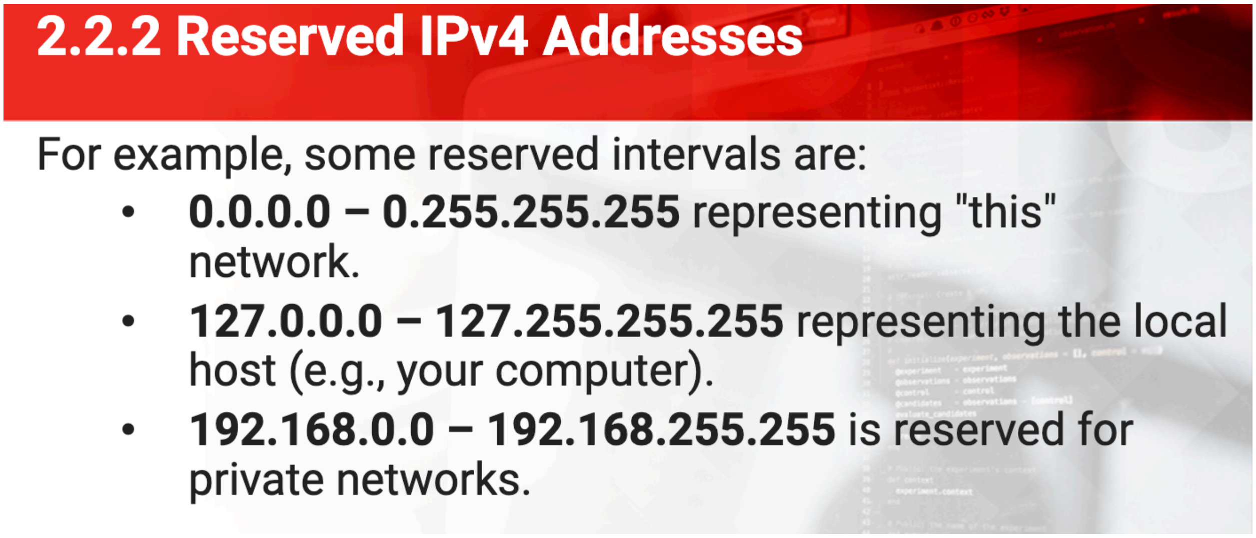
ISO/OSI:

- **ISO**- International Organization for Standardization, which in 1984 published a theoretical model for network systems communications: **The Open System interconnection (OSI) model**.
    - **ISO/OSI** was never implemented, but it's widely used in literature or when talking about IT networks.
    - **Microsoft windows operating systems** use a network architecture that is based on the seven-layer network model developed by ISO.
- OSI has seven layers (every protocol has its own header and payload to help communicate when the next layer)
    - Application
    - Presentation
    - Session
    - Transport
    - Network
    - Data Link
    - Physical
- **Encapsulation**
    - How do protocols work together?
        - The entire upper protocol packet (header plus payload) is the payload of the lower one; this is **encapsulation.**
    - **IP Protocol suite (TCP/IP)**
        - Protocol stack used on the internet.
        - TCP/IP has four layers:
            - Application
                - App layer gives its packet to the transport layer, which adds its own header.
            - Transport
                - The app packet is now the transport protocol's payload.
            - Network
                - The transport packet is now handed off to the network layer which adds its own header.
            - Data Link
                - The network packet is now handed off to data link layer where is adds its own header.
        - During encapsulation every protocol adds its own header to the packet, treat it as a payload.
        - This happens to every packet sent by a host.



Internet Protocol (IP):

- Why is this important?
  - Understand network attacks
  - Using network attack tools at their maximum
  - Studying other networking protocols
- The **Internet Protocol (IP)** is the protocol that runs on the internet layer of the IP suite, also known as TCP/IP.
- IP is tasked w/ delivering the datagrams (IP packets) to the hosts involved in a communication, and it uses IP addresses to ID a host.
- Any host on a computer network, be it a private network or the internet, ID by a **unique IP address.**
- Most networks run IP version (IPv4).
  - IPv4 consists of four bytes, or octets; a byte consists of 8 bits.
    - Ex: 73.5.12,132 (8 bits)
    - Each integer or group of integers separated by "." Is an octet.
    - With 8 bits you can represent up to 2^8 different values from 0 255.
    - Some addresses are reserved for special purposes.
      - Ex:



IP/Mask:

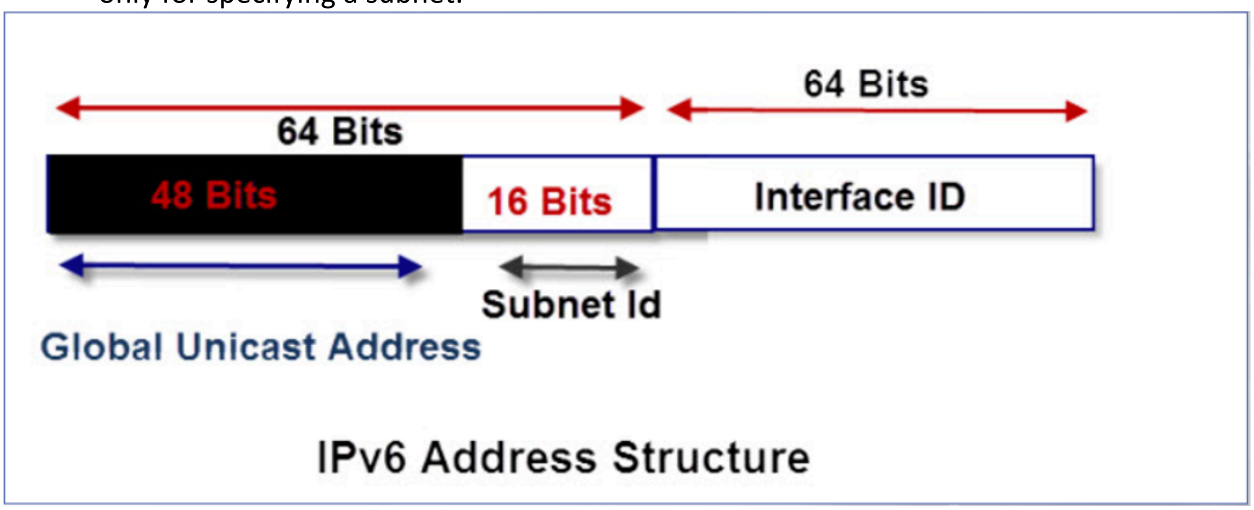
- To correctly ID a host you must know it's network you will need an IP address and a netmask or subnet mask.
- With an IP/netmask pair, you can accurately ID the network and host parts of the IP address.
    - Example:

- To find the network part you have to perform a bitwise AND operation between the netmask and the IP address.
- Example: 192.168.33.12/255.255.224.0
    - Convert the IP address and subnet mask to their binary form.
        - IP & Mask = Network
        - Which will give you the network prefix in decimal notation: 192.168.32.0
    - 192.168.32.0 is the network prefix. You can now ID the network by using the following notation: 192.168.32.0/255.225.224.0
    - Or, 192.168.32.0/19, because the netmask is made by 19 consecutive "1" bits
        - Known as Classless Inter-Domain Routing (CIDR) notation.
- We can find the host part of the IP address by performing a bitwise AND with the inverse of the netmask.
- IP & ¬Mask = Host
- Which gives you the Host part in decimal notation: 0.0.1.12
- The inverse of the netmask lets us know how many hosts a network can contain.

- In this example, we have 13 bits to represent the hosts; this means that the network can contain 2^13 = 8192 different addresses.
- There are two special addresses:
  - One with the host part made by all zeros.
  - Another with the host part made by all ones.

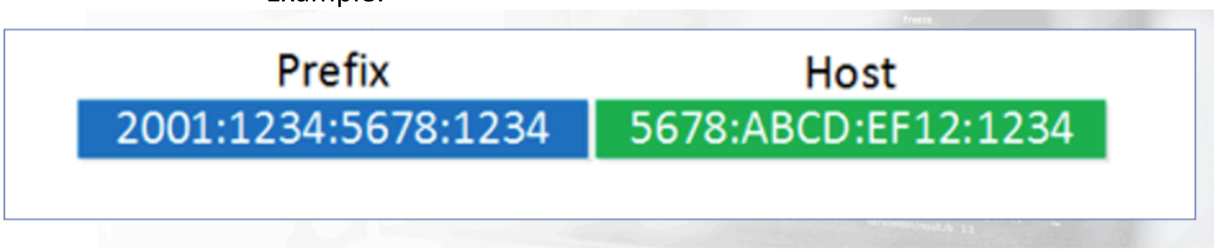
IPv6:

- **IPv6** address are 128 bits. 2^128 = 2^32 * 2^96 possible addresses. 2^96 = 79 octillion addresses.
- **IPv6** address consists of 16-bit hexadecimal numbers separated by a colon (:). Hexadecimal numbers are case insensitive. Zeroes can be skipped.
- Examples of IPv6 representation:
  - Regular form: 1080:0:FF:0:8:800:200c:417A
  - Compressed form: FF01:0:0:0:0:0:0:43, which becomes FF::43 as a result of skipping zeros.
  - IPv4- compatible: 0:0:0:0:0:013.1.68.3 or ::13.1.68.3 after skipping zeros.
- IPv6 has reserved addresses which cannot be used.
  - Example: ::1/128 is a loopback address.
  - ::FFFF:0:0/96 are IPv4 mapped addresses.
- IPv6 address can be split in half (64 bits each). Network part and device part.
- The first 64 bits ends with a dedicated 16-bits space (one hex word) that can be used only for specifying a subnet.



- IPv6 Scope
  - IPv6 has three types of addresses:
    - Global Unicast Address- These addresses are global ones and reside in global internet.
    - Unique Local – Scope Internal Network or VPN- Internally routable but not routed on Internet.
    - Link Local- Scope network link-not routed internally or externally.
  - Addresses can be translated into binary

- IPv6 Subnets
    - IPv6 addresses has a dedicated subnetting portion.
    - Network Address Range- the first 48 bits are for internet global address.
    - Subnetting Range- the 16 bits from the 49th to the 64th are for defining subnets.
    - Device (Interface) Range- the last 64 bits are for device interface ID's.
- IPv6 Subnetting
    - There are prefixes instead of subnets blocks.
        - Example: 2001:1111:1234:1234::/64
            - The number after the slash (64) is the number of bits that is used for a prefix. Everything behind it can be used for hosts of the subnet.
        - Each 4-digit hex word is 16 bits so the IPv6 address can be divided into groups of four.
        - Example:



Routing:

- Routers are devices connected to different networks at the same time, thus providing a valid path for packets to follow. They are able to forward IP datagrams from one network to another.
    - Forwarding policy is based on **routing protocols**.
- The router inspects the destination address of every incoming packet and then forwards it through one of its interfaces.
- **Routing Table:**
    - The router performs a look up in the routing table, where it finds an IP-to-interface binding.
    - Default address- this entry is used when the router receives a packet whose destination is an *unknown network.*
- Routing Metrics
    - Ensures that if two paths have the same number of hops, the fastest route is selected. The metric is selected according to the channel's estimated bandwidth and congestion.

Link Layer Devices and Protocols:

- Packet forwarding also happens in the lowest layer of the TCP/IP stack: the Link Layer.
    - Link layer devices and protocols only deal with the next hop.
- Hubs and switches are network devices that forward frames (layer 2 packets) on a local network.

- They work with the link layer network addresses: MAC addresses.
- MAC addresses:
    - Ip addresses are the layer 3 (Network layer) addressing scheme used to identify a host in a network, while MAC addresses uniquely identify a network card (layer 2).
    - MAC (Media Access Control) address is also known as a physical address.
        - 48 bits (6 bytes) long and expressed in hexadecimal form.
    - Commands too look up MAC address:

      00:11:AA:22:EE:FF

        - Ipconfig /all (windows)
        - Ifconfig (MAC)
        - Ip addr Linux
    - Every host on a network has both a MAX and IP address.

-- **Stopped Taking Notes** --

Notes:
Review converting the subnet masks to binary equivalent.

Switches:
- Steps for packet forwarding
    - The switch reads the destination MAC address of the frame.
    - It performs a look-up in the CAM table.
    - It forwards the packet to the corresponding interface.
    - If there is no entry with that MAC address, the switch will forward the frame to all its interfaces.

ARP (Address Resolution Protocol)
- With ARP a host can build the correct IP address- MAC addresses binding.
- Fundamental protocol for any modern network.
- When a host creates an ARP request it sends a packet containing the destination ID to the switches because it will send the packet to every host.
    - Once the correct destination receives the packet, it will send back a response with it's MAC address.
- Checking the ARP Cache
    - arp -a on Windows
    - arp on *nix OS (Mac)
    - ip neighbour on Linux

TCP and UDP:
- When designing a transport layer protocol you must consider limitations.

- Example, **TCP (Transmission Control Protocol)**:
    - Guarantees packet delivery. Because of that, an application that needs a guaranteed delivery will use TCP as the transport protocol.
    - Must be connection oriented. Must establish a connection before transferring data.
- Most used transport protocol on the internet is TCP. Most apps use it and the IP protocol suite often called TCP/IP.
    - Email clients, web browsers and FTP clients are some common apps using TCP
- **UDP (User Datagram Protocol)**
    - Does not guarantee packet delivery.
    - Connectionless.
    - Faster than TCP and provides better throughput (number of packets per second)
        - For example, a glitch in a streamed video or song. (think Spotify and Netflix)

TCP	UDP
Lower throughput	Better throughput
Connection-oriented	Connectionless
Guarantees delivery	Does not guarantee packet delivery

Three Way Handshake:

- Establishes a connection between two hosts running TCP: Once a three-way handshake is established then the data transmission may begin.
    - The header fields involved in a handshake are:
        - Sequence number
        - Acknowledgement numbers
        - SYN and ACK flags.

Firewalls:

- Firewalls can work on different layers of the OSI model
    - Provide different features and protections.
- Firewall features:
    - Packeting sniffing- rules can be setup to filter packets according to specific criteria such as: source IP address, destination IP address, Protocol, Source port, Destination port.

- When firewalls are in place you may notice the following behavior:
    - TCP SYN are sent, but there is no TCP SYN/ACK replies.
    - TCP SYN packets are sent but a TCP RST/ACT reply is received.
    - Packet filters inspect the header of every packet and how to treat it, common action are:
        - Allow- packets are allowed to pass.
        - Drop- drop the packet without any diagnostic message to the packet source host.
        - Deny- do not let the pass, but notify the source host.
    - Packet filtering is not enough to stop layer 7 attacks because any kind of application layer traffic will pass through the firewall.

Intrusion Detection Systems (IDS):

- Inspect application payload trying to detect any potential attack.
- A well-configured IDS can detect pretty much every kind of network threat.
- Support firewalls by providing an extra layer of security from mainstream and well-known attack vectors.
- Two main category types:
    - Network Intrusion Detection Systems (NIDS)
        - Inspect network traffic
        - Placed on routers or in networks with high intrusion risk.
    - Host Intrusion Detection Systems (HIDS)
        - Monitor application logs, file-system changes and changes to the operating system configuration.

Intrusion Prevention Systems (IPS):

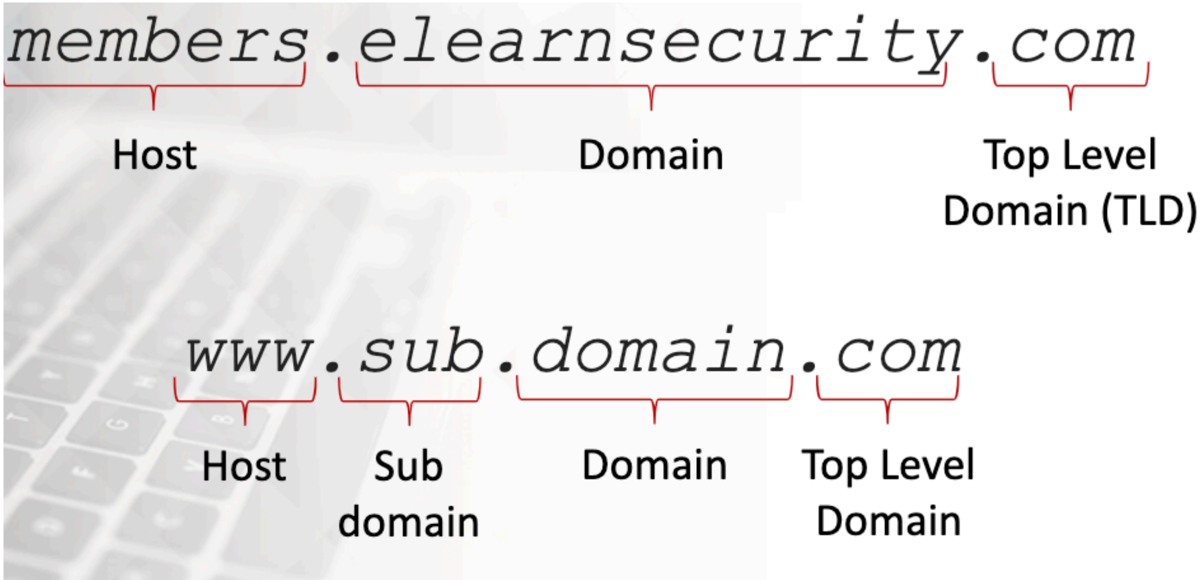
- Can drop malicious request when the threat has a risk classification above pre-defined threshold.

Network Address Translation (NAT) and IP Masquerading:

- Two techniques used to provide access to a network from another network.
- The NAT will provide a default gateway, which means it will route internet traffic through it.
    - The NAT device will rewrite the source IP address of every packet setting, thus masquerading the original client's IP address.
    - A machine on the internet will never know the original client's IP address.

DNS :

- **DNS structure**



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Host
Domain
Top Level
Domain (TLD)
www.sub.domain.com
Host
Sub
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Domain
Top Level
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