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**CCENT/CCNA Chapter 1 – TCP/IP Networking**

Exam focuses heavily on TCP/IP

* **Enterprise network** – IT world refers to a network created by one corporation, or enterprise, for allowing its employees to communicate.
* Purpose move data from one device to another.
* **Networking model** – (network architecture or networking blueprint) – refers to a comprehensive set of documents.
  + IBM SNA (Systems Network Architecture)
  + **ISO (International Organization for Standardization**) created OSI to standardize data networking protocols to allow communication among all computers across the entire planet.
  + **IEEE (Institute of Electrical and Electronic Engineers)** – defines Ethernet LAN’s
    - Ethernet card built in to the computer implements some LAN standards by the TCP/IP model.
  + OSI model
    - **Application** – provides an interface from the application to the network by supplying a protocol with actions meaningful to the application (Telnet, HTTP, FTP, SMTP, POP3, VoIP, SNMP)
      * **PDU (Protocol Data Unit)** – represents the bits that include the headers and trailers for that layer as well as encapsulated data. LxPDU)
    - **Presentation** – This layer negotiates data formats, such as ASCII test, or image types like JPEG.
    - **Session** – This layer provides methods to group multiple bidirectional messages into a workflow for easier management and easier back out of work that happened if the entire workflow fails.
    - **Transport** – In function, much like TCP/IP’s transport layer. This layer focuses on data delivery between the two endpoint hosts. (TCP, UDP)
    - **Network** – Like the TCP/IP network, this layer defines logical addressing, routing (forwarding), and the routing protocols used to learn routes
    - **Data Link** – Like the TCP/IP data link layer, this layer defines the protocols for delivering data over a particular single type of physical network. (Ethernet, HDLC)
    - **Physical** – This layer defines the physical characteristics of the transmission medium, including connectors, pins, use of pins, electrical currents, encoding, light modulation, and so on. (RJ-45, Ethernet)
  + DOD helped build the TCP/IP architecture
    - TCP/IP avoids repeating work already done by others
    - 1 Architecture – TCP/IP Original
      * **Application** – HTTP, POP3, SMTP
        + **HTTP** – subsequent HTTP messages omit the header
        + **URL (Uniform Resource Locators)** – HTTP is used to transfer the web pages.
      * **Transport** – TCP/UDP
        + **TCP** – provides error recovery for Application layer. Guarantees delivery

**Segment** – TCP message with sequence number

Has each header and sequence number sent with each message.

* + - * **Internet** – IP
        + **IP** – defines that each host computer should have a different IP address

Routers act like the post office forwarding packets of data to the correct destination. Helps to be identified in the network.

**Packet** – message with an IP header

**Routers** - are networking devices that connect the parts of the TCP/IP network together for the purpose of routing IP packets to the correct destination.

**DDN (Dotted**-decimal notation) – 1.1.1.1

**Host** – refers to any device, regardless of size or power and has an IP address and connects to any TCP/IP network.

**IP Header** – includes a source IP address and a destination IP address of Bob’s IP

**IP Routing** – process of forwarding an IP packet.

**Data** – everything after the IP header

* + - * **Link (network access or network interface layer**) – Ethernet, PPP, Frame Relay, T1
        + Refers to physical connections, between two devices and the protocols used to control those links.
        + **Frame** – encapsulated IP packet between an Ethernet header and Ethernet trailer
    - 2 Architecture – TCP/IP Updated
      * **Application** – provide services to the application software running on a computer. Provides an interface between software running on a computer and the network itself. Defines services the application needs.
      * **Transport -** provides error recovery for Application layer. Guarantees delivery
      * **Network –** provides addressing and routing to the Transport layer. Upper layers ask lower layers to deliver a message. Provides a service for forwarding IP packets from one device to another.
      * **Data Link –** physical transmission of data and those indirectly related to the physical transmission of data.
        + **Encapsulation –** process of putting headers around some data.

Create and encapsulate the application data with any required application layer headers

Encapsulate the data supplied by the application layer inside a transport layer header

Encapsulate the data supplied by the transport layer inside a network layer IP header

Encapsulate the data supplied by the network layer inside a data link layer header and trailer

Transmit the bits.

* + - * **Physical -** physical transmission of data and those indirectly related to the physical transmission of data.
  + **Layers** – small number of categories broken down into functions
    - Each layer provides a service to the layer above it
    - **Adjacent-layer interaction** – refers to the concepts of how adjacent layers in a networking mode on the same computer work together.
    - **Same-layer interaction** – particular layer on one computer wants to communicate with the same layer on another computer.
* **Protocol** – set of logical rules that devices must follow to communicate.
  + RFC (Requests For Comments)
  + Use headers as a place to put information used by that protocol
* **SOHO** – smaller networks at home, when used for business purposes, often go by the name small office/home office
* **Cloud** – part of a network whose details are not important to the purpose of the diagram.

**Chapter 2 - Ethernet LANs**

Ethernet LANs are wired LANs

* **IEEE (Institute of Electrical and Electronics Engineers)** – defines cabling, the connectors on the ends of the cables, the protocol rules, and everything else required to create an Ethernet LAN (802.3).
  + **UTP** – unshielded twisted pair. Saves money. T suffix
  + **Optical fibers** – wires inside the cable to send data over electrical circuits. More expensive. Longer. X suffix. Contains long thin strands of fiberglass encoding the bits as changes in the light.
  + 10 Mbps– Ethernet – 10BASE-T (2 wires)– 802.3 – Copper, 100 m
  + 100 Mbps – Fast Ethernet – 100BASE-T (2 wires) – 802.3u – Copper, 100m
  + 1000 Mbps – Gigabit Ethernet – 1000BASE-LX – 802.3z – Fiber, 5000m
  + 1000 Mbps – Gigabit Ethernet – 1000BASE-T (4 wires) – 802.3ab – Copper, 100m
    - Transmits and receives simultaneously on each wire pair.
  + 10 Gbps – 10 Gig Ethernet – 10GBASE-T – 802.3an – Copper, 100m
    - Cross over 4,5 to 7,8 to 1,2 and 3,6)
  + **Ethernet header/trailer** – bytes of overhead data that Ethernet uses to do its job of sending data over a LAN
  + **Ethernet frame** – refers to the header and trailer of a data-link protocol, plus the data encapsulated inside that header and trailer
    - **Preamble** – 7 Bytes – Syncrhonization
    - **Start Frame Delimiter** – 1 Byte – Signifies tha the next byte begins the Destination MAC address
    - **Destination MAC Address** – 6 Bytes – Identifies the intended recipient of this frame.
      * **MAC Address (Media Access Control\_ = 6**-byte long binary numbers that represent a single NIC or Ethernet port. Also called Unicast. Universal MAC addresses are global MAC addresses
      * **Unicast** – formal way to refer to the fact that the address represents one interface to the Ethernet LAN.
      * **OUI (Organizationally Unique Identifier)** – manufacturer agrees to give all NICS a MAC address that begins with its assigned 3-byte OUI defined by IEEE. Also assigns last 3 bytes
      * **Universal Address** – emphasize the fact that the address assigned to a NIC by a manufacturer should be unique among all MAC addresses in the universe.
      * **Group Addresses** – identify more than one LAN interface card.
      * **Other names** – LAN address, Ethernet address, hardware address, burned-in address, physical address, universal address, or MAC address.
    - **Source MAC address** – 6 bytes – Identifies the sender of this frame.
    - **Type** – 2 bytes – Defines the type of protocol listed inside the frame.
      * Identifies the type of network layer packet that sits inside the Ethernet frame.
    - **Data/Pad** – 46-1500 Bytes – Holds data from higher layer.
    - **Frame Check Sequence (FCS)** – 4 Bytes – Provides a method for receiving NIC to determine whether the frame experienced transmission errors.
      * Gives the receiving node a way to compare results with the sender to discover whether errors occurred in the frame. Analyzed by a math formula. Discards the frame if there is any error
  + **Ethernet LAN** – combination of user devices, LAN switches, and different kinds of cabling.
    - **Electrical circuit** – two individual wires that are inside the UTP cable completing a loop using circuitry on their Ethernet ports which allows electricity to flow.
    - **Encoding scheme** – to send data, the two devices follow some rules. Transmits node changes the electrical signal over time and interprets the changes as either 0 or 1.
    - **EMI (Electromagnetic interference)** – interferes with the electrical signals in nearby wires, including the wires in the same cable.
    - **Crosstalk** – EMI between wire pairs in the same cable)
    - **Ethernet Link** – physical cable between two Ethernet nodes
    - **Pins** – 8 physical location into which eight wires in the cable can be inserted.
    - **Ethernet port** – connectors on the cable so that the connectors on the ends of the cable can be connect to each node.
    - **Broadcast address** – frames sent to an address should be delivered to all devices on the Ethernet LAN
    - **Multicast address** – frames sent to a multicast Ethernet address will be copied and forwarded to a subset of the devices on the LAN that volunteers to receive frames sent to a specific multicast address.
    - **NIC (Network Interface Card)** – expansion card on the PC or built into the system.
      * **Straight through cable pinout** – connect the wire at pin 1 on one end of the cable to pin 1 at the other end so on. Uses opposite pairs for transmitting data. If the endpoints transmit on different pin pairs. NIC transmitters use the pair connected to pins 1 and 1; the NIC receivers use a pair of wires at pin positions 3 and 6. (PC NICs, Routers, AP)
      * **Pinout** – refers to the wiring of which color wire is placed in each of the eight numbered pin positions
      * **Crossover cable** – crosses the pair at the transmit pins on each device to the receive pins on the opposite device. If the endpoints transmit on the same pin pair. (Hubs/Switches)
        + **Cisco switch feature Auto-mdix** – notices when the wrong cable is used and automatically changes its logic to make the link work.
* **Ethernet LAN Switch** – provides many physical ports into which cables can be connected
  + **Full duplex** – device does not have to wait before sending; it can send and receive at the same time.
* **LAN hub** – uses half-duplex logic. Uses different rules for forwarding data with physical layer standards. Repeats the signal out to all other ports. Can cause collisions in data transfer.
  + **Half-duplex logic** – device must wait to send if it is currently receiving a frame; in other words, it can’t send and receive at the same time.
    - **CSMA/CD (Carrier Sense Multiple Access/ Collision Detection)** – takes care of unfortunate timing. Checks to see if income frames are coming at the exact same time.
* **Wireless LAN Access Point** – acts somewhat like an Ethernet switch in that all the wireless LAN nodes communicate with the Ethernet switch by sending and receiving data with the wireless AP.
  + Needs single Ethernet link to connect the AP to the Ethernet LAN
* **Wireless LANs** – standards defined by the IEEE 802.11 using radio waves to send the bits from one node to the next.
* **Ethernet cables** – general reference to any cable that conforms to any of several Ethernet standards.
* **Router** – connects the LAN to the WAN with Ethernet LAN interface and an Ethernet cable.

**Chapter 3 – WAN fundamentals**

* **WAN**
  + You lease with WAN. Wide
  + **DSL (Digital Subscriber Line) –** uses analog phone lines that are already installed in homes. Provides a short physical link from a home to a telco’s network. RJ-11 connectors.
    - **PSTN (Public Switched Telephone Network) –** supports the ability to setup voice calls, take them down, and forward the voice through the worldwide voice network.
    - DSL equipment is added in the user home and at the CO.
      * DSL modem – connects to a spare outlet
    - **DSLAM (DSL access multiplexer)** – splits out the voice signals over to the voice switch on the upper right.
    - Support asymmetric speeds, downstream faster, upstream not as fast.
  + **Cable –** uses cable TV (CATV) cable.
    - Asymmetric speeds
  + **Ethernet WAN –** connects ethernet link using a router interface
    - **POP (Point of Presence) –** Ethernet link leaves the customer building and connects to some nearby SP.
    - **Ethernet emulation –** service acts like one Ethernet link
    - **EoMPLS (Ethernet over Multiprotocol Label Switching) –** point to point connection between two customer devices or behavior as if a fiber ethernet link existed between the two devices.
      * Can send data in both directions at the same time. Two routers can send Ethernet frames to each other over the link.
      * Uses the same Ethernet LAN link protocol
      * Used to forward IP packets from one site to another.
      * Uses layer 1 and layer 2. Each frame data link header and trailer are different. Discards old data-link header/trailer and adds a new set.
  + **Leased line WAN** – send data from the remote LAN back to the rest of the existing network and vice versa. Company using it doesn’t own it. Pay a monthly fee. Works like a crossover cable connecting two routers. Crooked line between routers described a lease line.
    - Uses two pair of wires one pair for sending data in each direction. Uses full duplex mode.
    - Longer lead times to get the service installed. High cost.
    - Telco installs a large network of cables and specialized switching devices to create its own computer network. It acts like a crossover cable.
    - Some physical path must exist between the two routers on the ends of the link.
    - **Central Office** – Telco’s put their equipment in builds. They install cables from the CO to most every other building in the city
    - **HDLC (High-Level Data Link Control) –** control the correct delivery of data over a physical link of a particular type. Provides similar functions to data link layer. Provide the means to encapsulate the network layer packet correctly so that it crosses the link between routers.
      * Frame can only go to one place. Has an address field, the destination is implied.
      * In the past telco’s offered multidrop circuits so there was more than one possible destination
      * ISO standard HDLC doesn’t have a type field. Cisco uses a variation of HDLC that adds a Type field.
      * **Flag** – lists a recognizable bit pattern so that the receiving nodes realize that a new frame is arriving
      * **Address** – identifies destination device
      * **Control** – Mostly used for purposes no longer in use today for links between routers.
      * **Type** – Identifies the type of layer 3 packet encapsulated inside the frame.
      * **FCS** - a field used by the error detection process.
    - **CPE (Customer Premise Equipment)** – includes the router, serial interface card, and CSU/DSU. Each router uses a serial interface card that acts like a NIC
    - **CSU/DSU (Channel Service Unit/Data Service Unit) –** physical link requires this. Integrates into the Serial interface card in the router or sit outside the router as an external device.
      * Includes a short serial cable plus the cable installed by the telco.
      * Serial cable connects the router serial interface to the external CSU/DSU with a RJ-48. Speeds come in multiples of 64 Kbps or 1.5 Mbps.
      * Lab:
        + **DTE (Data Terminal Equipment)** – serial cable used between a router and external CSU/DSU. Straight through.
        + **DCE (Data Communications Equipment)** – female connector in a cross over fashion
        + Need clock rate configured as the CSU/DSU controls that function when to send bit through signaling over the serial cable.
    - **Service Provider** – refer to a company that provides any form of WAN connectivity, including internet services.
    - **Other names:**
      * **Leased Circuit, Circuit –** used as synonyms. Circuit references to the electrical circuit between the two endpoints
      * **Serial Link, Serial line –** Serial refers to the fact that the bits flow serially, and that routers use serial interfaces.
      * **Point to point link, point to point line –** topology stretches between two points and two points only
      * **T1 –** specific type of leased line that transmits data at 1.544 Mbps
      * **WAN link, link –** no reference to any specific technology
      * **Private line –** data sent over the line can’t be copied by other telco customers. Data is private.
  + Connect LAN using a WAN, the internetwork uses a router connected to each LAN with a WAN link between the routers.
* **LAN**
  + You own and pay for LAN. Local
* **Internet core** – exists as LANs and WANs owned and operated by Internet service providers (ISP). Create a mesh of links between each other in the core.
  + **Internet access link** – phones create their WAN link using wireless technology.

**Chapter 4 – Fundamentals of IPv4 Addressing and Routing**

* **IP Routing** – process of hosts and routers forwarding IP packets (Layer 3 PDU) while relying on the underlying LANs and WANs to forward the bits
  + **Hosts** – end-user computers. OS has TCP/IP software, including the software that implements the network layer.
  + **Path selection** – routing protocols select the best route among the competing routes to the same destination.
    - PC on different LAN goes to nearby router to forward the packet.
    - Sender sends a data-link frame across the medium to the nearby router. (default router)
    - **Default router** = default gateway.
  + **IP Routing Table** = IP Address groupings – IP networks and IP subnets. Like driving on a highway. Compares packets destination IP address to the entries in the routing table and makes a match.
    - IP network like a zip code
    - Rest like addresses
  + Routers build new data-link headers and trailers, because the new headers contain data-link addresses.
  + **ARP (IP Address Resolution Protocol)** – dynamically learns the data-link address of an IP host connected to a LAN.
  + **Layer 3 protocol data units (L3 PDU)** – process of routing forwards Layer 3 packets based on the destination Layer 3 address in the packet.
  + The routing process uses the data link layer to encapsulate the Layer 3 packets into Layer 2 frames for transmission across each successive data link.
  + Network layer protocol groups addresses both by location and actual address values.
  + IP has 20-bit header- Version, Length, DS Field, Packet Length, Identification, Flags, Fragment Offset, Time to Live, Protocol, Header Checksum and Destination/Source IP
  + Hosts need to know IP address of default router and routers need to know routes so they can forward packets.
* **IP Addressing** – addresses used to identify a packet’s source and destination host computer. Addressing rules also organize addresses into groups, which greatly assists the routing process.
  + **Internetwork** – generally to a network made up of routers, switches, cables, and other equipment.
  + **IP Host** – any device that has at least one interface with an IP address can send and receive IP packets.
  + IPV4
    - 32-bit number written in DDN (Dotted Decimal Notation)
    - Octet is just a vendor neutral term for byte. 8-bit number. 0 – 255
    - IP networks – TCP/IP grouped IP addresses into sets of consecutive addresses
    - All IP addresses in the same group must not be separated from each other by a router
    - IP addresses separated from each other by a router must be in different groups.
    - Class A – 1-126, holds 126 networks with 16,777,214 hosts
    - Class B – 128 – 191, holds 16384 networks with 65,534hosts
    - Class C – 192 – 223, holds 2,097,152 networks with 254 hosts
    - Class D – defines multicast addresses
    - Class E – experimental addresses. Reserved for future use.
    - 127 is reserved
* **IP routing protocol** – Protocol that aids routers by dynamically learning about the IP address groups so that a router know where to route IP packets so that they go to the right destination host.
* **Other utilities** – The network layer also relies on other utilities. For TCP/IP, these utilities include DNS, ARP, and ping.