**Introduction to the DNS service**

* A close up of a logo

  Description automatically generated**DNS Servers**
* **DNS Records**
* **Dynamic DNS**

A diagram of a computer server

Description automatically generated**DNS Servers:** DNS is the process that maps human friendly names to IP addresses. Without it, we would have to memorize numerous IP addresses.

* Domain Name System (DNS) is hierarchical (very structured) in nature. If the local DNS server apparatus doesn’t contain the needed record, it sends a request up the chain until a positive response is received (which gets passed back down to the original requestor). DNS does require a FQDN (fully qualified domain name) in order to function.
* **Different Levels of DNS Servers:**
  + **Local DNS Server:** The server on the local network that contains the HOSTS file that maps the FQDN to IP addresses in the local subdomain.
  + **Top Level Domain:** The server that contains the records for a top level domain
    - Examples include: com, org, net, edu, gov, mil, and int.
    - Each of these servers contains all of the information for their respective domains (kind of)
    - TLD servers do delegate down to second level servers to ease the load; however, the TLD server is the responsible server
  + **Root Server:** The server that contains the records for the TLD servers
* **Authoritative:**
  + An authoritative DNS server is one that responds to a request that has been specifically configured to contain the information
  + An authoritative response comes from the DNS server that actually holds the original record
* **Non-authoritative**
  + A non-authoritative DNS server is one that responds to a request with DNS information that it received from another DNS server
  + A non-authoritative response is not a response from the official name server for the domain. Instead, it is a second or third-hand response (or even further removed).
* A diagram of a computer system

  Description automatically generated

**DNS Records:**

* **A record:**  Maps hostnames to their IPv4 address
* **AAAA record:** Maps hostnames to their IPv6 address
* **CNAME record:** Maps canonical (alias) names to hostnames
* **PTR record:** Pointer record that points to a canonical name
* **MX record:** Maps to the email server that is specified for a specific domain. It is the record that determines how email travels from sender to recipient.

**Dynamic DNS:**

* **Dynamic DNS (DDNS)**
  + Permits lightweight and immediate updates to a local DNS database. This is very useful when the FQDN remains the same, but the IP addresses is able to change on a regular basis.
    - It is implemented as an additional service to DNS.
* **DDNS updating:**
  + A method of updating traditional name servers without the intervention of an administrator (no manual editing or inputting of the configuration files is required).
    - A DDNS provider supplies software that will monitor the IP address of a referenced system. Once the IP address changes, the software sends an update to the proper DNS server
    - DDNS is useful when access is needed to a domain whose IP addresses is being supplied dynamically by an Internet Service Provider (ISP)
      * People can still access DDNS while IP address is changing

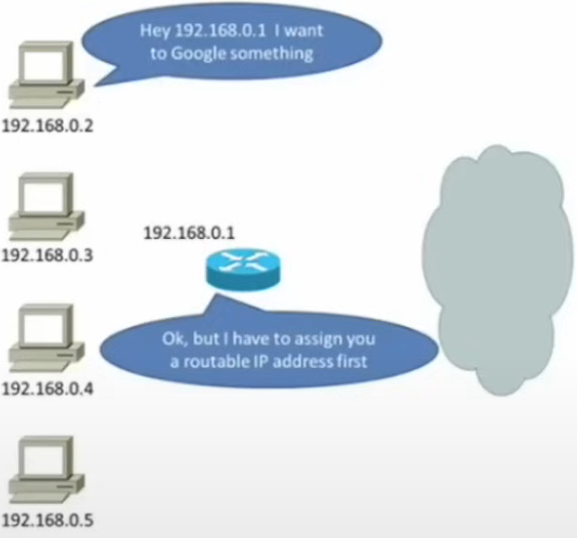
**Summary:**

* **DNS Servers:**  DNS is used to map human friendly names to IP addresses. It utilizes a set of servers (root, TLD, and local) to resolve the FQDN to the right IP address. Responses can be authoritative or non-authoritative
* **DNS Records:** A record maps hostnames to IPv4 addresses. AAAA record maps hostnames to IPv6 addresses. CNAME record maps canonical names to hostnames. PTR record points to canonical names. MX record points to the email server responsible for handling the email for a given domain
* **Dynamic DNS:** DDNS allows for lightweight adjustments to the local DNS database. It is useful on networks that don’t use static IP addresses. DDNS updating is used to automatically update DNS records without having to manually input the information.

**Introducing Network Address Translation**

* **The purpose of network address translation**
* **How network address translation works**

**The Purpose of Network Address Translation:** Network address translation (NAT) solves the problem of how to route non-routable IP addresses.

* As a partial effort to conserve the IPv4 address space, the private IPv4 addressing spaces were developed. These address spaces were removed from the public IPv4 address spaces and made non-routable across public IPv4 networks.
* Being non-routable prevents the private IPv4 addresses from communicating with remote public networks. NAT very simply solves this problem. A router with NAT enabled will translate a private IP address into a routable public IP address. When the response returns to the router, it passes the response back to the device that requested it

**How Network Address Translation Works**

* **The two categories of NAT:**
  + **Static NAT (SNAT):** each private IP address is assigned to a specific routable public IP address. This relationship is kept and maintained by the NAT enable router.
    - When a device needs access outside of the local network, the router translates the local IP address to the assigned public IP address. When the response comes back, the router will translate the public IP address back into the local one
    - SNAT is not flexible and leads to scalability issues. An individual routable IP address must be kept for every device that requires to access outside of the local network
  + **Dynamic NAT (DNAT):**  The NAT enabled router dynamically assigns a routable IP address to devices from a pool of available public IP addresses
    - A computer screen shot

      Description automatically generated with medium confidenceWhen a device needs access outside of the local network, the router performs the NAT function, only the public IP address comes from a re-useable pool of public IP addresses.
    - As initially designed, DNAT was more flexible than SNAT, but still led to some scalability issues. As more network traffic requires access to remote networks, the pool of available public IP addresses needs to increase or outside access cannot be achieved
  + **Port address translation (PAT):**
    - PAT is a type of DNAT that was developed to increase the scalability of NAT
      * A screenshot of a computer

        Description automatically generatedWhen a local network device requires access to a public network, the NAT enabled router dynamically assigns the public IP address to the device with the addition of dynamically assigning a port number to the end of the public IP address.
      * The router tracks the IP addresses and port numbers to ensure that network traffic is routed to and from the proper devices
      * PAT still requires a pool of public IP addresses, but the pool may only contain one address or it may contain several for a large private network.
      * This is the preferred method of implementing NAT for two reasons
        + Less public IP addresses are required
        + Easier for administrators to maintain
  + **The NAT Terminology:**
    - **Inside local address:** a private IP address on the local network
      * The private IP address assigned to a specific device
    - **Inside global address:** a public IP address referencing an inside device
      * The public IP address assigned to the inside device by the NAT enabled router to allow access outside of the network
    - A diagram of a diagram

      Description automatically generated with medium confidence**Outside global address:** a public IP address referencing an outside device.
      * The public IP address assigned to a device outside of the local network.
    - **Outside local address:** a private IP address assigned to an outside device.
      * The private IP address assigned to an outside device on the interior of the local network

**Summary:**

* **The Purpose of Network Address Translation:**  NAT solves the problem of how to route non-routable IP addresses. Private IP addresses cannot cross public IP networks, limiting private IP networks to being local only. NAT transforms the private IP address into a routable public IP address, which allows access outside of the local network
* **How Network Address Translation Works:** There are two main categories of NAT 🡪 static and dynamic. With SNAT, each private IP address that is allowed access outside of the local network is assigned a specific public IP address that is used for that access. With DNAT, when a device requires access outside of the local network, it is dynamically assigned a public IP address from a pool of available addresses. PAT was developed as a method of extending the capabilities of DNAT. NAT uses specific terminology to refer to IP addresses: inside local, inside global. Outside global, and outside local.

**WAN Technologies I**

* **Public Switched Telephone Network**
* **Broadband Cable**
* **Fiber**

**Public Switched Telephone Network:** What makes a WAN a WAN, as opposed to a LAN?

* As a general rule, if you own and control the line that the data is using to get from one place to another, you are not using wide area network (**WAN**) technology. On the other hand, if you are using a form of transmission that you don’t own (e.g., you are leasing it or paying for the use of it), then you are likely using WAN technology
* One of the most common physical infrastructures used in WAN technology is the public switched telephone network (**PSTN**) due to its widespread availability
* **Dial-UP**
  + Utilizes the PSTN to transmit network traffic as an analog signal
    - Requires an analog modem to format the network traffic
  + Maximum theoretical speed is 56 Jbps
* **ISDN (Integrated Services Digital Network)**
  + Digital point-to-point WAN technology using the PSTN
  + Completely digital service
    - Requires the use of a terminal adapter (TA) for the connection to the end node (often called a digital modem)
  + A Primary Rate Interface (**PRI**) uses 23 64 Kbps B channels and one 64 Kbps D channel for call setup and link management
    - Achieves 1.544 MBps speed (T-1 leased line).
  + Commonly implemented as a Basic Rate Interface (**BRI**), using two B channels and one D channel
    - Achieves 128 Kbps speed
  + Not as capable as a **DSL** (digital subscriber line), but it can often be implemented where DSL cannot be installed
* **xDSL**
  + A digital WAN technology using the PSTN
  + Requires the use of a digital modem
  + Dedicated digital line between the end point and a class-5 central office (**CO**)
    - It is only possible within 18,000 feet of the CO
  + Carries voice and data (filters are put in place to get voice)
* **SDSL (Symmetric DSL)**
  + Synchronous in nature (upload and download speed is the same)
  + Does not carry voice communications
    - If voice service is required, an additional line is needed
  + A diagram of a device connected to a device

    Description automatically generatedUsed by businesses that don’t need the performance of a T-1 leased line, but that do require the symmetrical upload and download speeds
* **ADSL (Asymmetric DSL)**
  + Asynchronous in nature (upload speed is slower than download speed).
  + It can carry data and voice
  + Common upload speeds of 768 Kbps with download speeds of up to 9 Mbps
  + Most common implementation of DSL in the SOHO environment.
* **VDSL (Very-high-bit-rate DSL).**
  + Asynchronous in nature.
  + Used when high quality video and VoIP is necessary
    - Commonly limited to a download speed of 52 Mbps and an upload speed of 12 Mbps
    - It is only possible when located within 4,000 feet of a CO
    - Current standard allows for up to 100 Mbps over PSTN
      * To achieve that, the end point must be within 300 meters of a CO

**Broadband Cable**

* **Coaxial cable networking**
  + Broadband connection to a location delivered by the cable company.
    - It can deliver voice, data, and television – all through the same connection
  + **Headend:** all cable signals are received a this point; signals are processed and formatted then transmitted to the distribution network
  + **Distribution network:** smaller service areas served by the cable company. The distribution network architecture can be composed of fiber optic cabling, coaxial baling and/or hybrid fiber-coaxial cabling (HFC)
    - Unlike DSL, the bandwidth is shared by the distribution network; this can lead to increased latency and congestion.
    - Final distribution to the premise is usually though a coaxial cable
    - Data over cable service interface specification (**DOCSIS**): the specifications for how the signal will be received. All cable modems and similar devices must measure up to the ISP’s required DOCSIS standard

**Fiber**

* **Fiber-optic networking**
  + Using light to transmit data and voice.
    - Allows for more bandwidth over greater distances
  + More expensive to install, but is also less susceptible to line noise.
  + The fiber synchronous data transmission standard in the U.S is Synchronous Optical Network (**SONET**)
  + The internation standard is Synchronous Digital Hierarchy (**SDH**)
    - SONET and SDH define the base rates of transmission, which are known as Optical Carrier (**OC**) levels.
  + Dense wavelength-division multiplexing (**DWDM**) is a method of multiplexing several OC levels (up to 32 channels) into a single optical fiber, effectively increasing the bandwidth of a single optical fiber
  + Coarse wavelength-division multiplexing (**CWDM**) is similar to DWDM but only allows for up to 8 channels on a single fiber
  + Passive Optical Network (**PON**) is a point-to-multipoint technology that uses a single optical fiber to connect multiple location to the internet
    - It uses unpowered optical splitters

**Summary:**

* **Public Switched Telephone Network:** One of the best indications of a WAN is if the infrastructure is not owned by a single entity. The PSTN is one of the most widely used WAN infrastructures. The PSTN can be used to carry analog traffic through a dial-up connection or digital traffic through ISDN or xDSL connection
* **Broadband cable:** Cable companies can provide broadband cable connections to customers. These are capable of carrying voice, data, and television –all through the same cable. The signal is formatted at the headend and delivered to the distribution network to be sent on to the end users. The end users all share the bandwidth of the distribution network
* **Fiber:** Fiber is a fast, high bandwidth WAN technology that uses light to transmit voice and data down a fiber optic cable. It is capable of achieving multiple gigabit transmission levels. SONET (U.S) and SDH established the base rates of the OC levels. DWDM and CWDM are the methods used to multiplex multiple OC levels into a single fiber optic cable.

**WAN Technologies II**

* **GSM/CDMA WAN connections**
* **WiMAX WAN connections**
* **Satellite WAN connections**

**GSM/CDMA WAN connections:** Cellular carriers use one of two methods for connecting devices to their networks –and they are not compatible

* Currently in the United States, AT&T and T-Mobile use Global System for Mobile (GSM) to connect their devices to their networks. Sprint and Verizon use Code Division Multiple Access (CDMA) as their method of connecting to networks
* The majority of the rest of the world utilizes GSM as the method of accessing cellular networks
* **Cellular networking:**
  + Cellular networking involves using the cellular phone system for more than just phone calls
  + 1G cellular was only capable of voice transmissions
  + **2G** cellular added simple data transmission capability (TEXT)
    - **2G EDGE** offered some basic cellular networking connectivity and was a stopgap between 2G and 3G
  + **3G** cellular is the beginning of cellular WAN networking.
  + **4G cellular consists of LTE and WiMAX**
  + **HSPA+ (Evolved High Speed Packet Access):** a stopgap between 3G and 4G
    - The current standards allow fro up to a maximum data rate of 84 Mbps
  + **LTE (Long Term Evolution):**  uses an all-IP based core with high data rates. It is compatible with 3G and WiMAX
    - The current standards allow for up to 300 Mbps in download speed and up to 75 Mbps in upload speed

**WiMAX WAN connections**

* **World Wide Interoperability for Microware Access (WiMAX) networking**
  + WiMAX was originally developed as a last mile alternative for use when DSL or cable was not available
    - Provides an alternative broadband connection to a fixed location
  + It uses microwave transmissions as an over-the-air method to transmit voice and data
    - Requires a line of sight between relay stations
  + WiMAX can be used to cover significant geographic distances
    - Many municipalities are exploring the use of WiMAX as a means of providing reasonably priced broadband to their citizens without wiring each household
  + It is often considered to be a type of 4G technology because it is compatible with LTE networks
    - WiMAX is not compatible with 3G type networks

**Satellite WAN connections**

* **Microwave satellite networking**
  + Uses microwave transmissions as an over-the-air method to transmit voice and data
  + Can be an effective means of extending networks into places that are hard to reach
  + **Microwave radio relay:** is the method of transmitting through the atmosphere
    - Requires line-of-site relay stations, but can cover vast distances
    - The distances covered by the satellite network may lead to latency problems.
  + A **communication satellite** (comsat) forms part of the microwave relay network
  + Comsats may use a variety of orbits
    - Molniya, geostationary, low-polar, or polar orbits are all used for microwave radio relay networks.
  + **Low-polar and polar orbits**  are used to boost the microwave signal before sending the signal back to EARTH

**Summary:**

* **GSM/CDMA WAN connections:** GSM and CDMA are the two main methods of connecting cellular devices to cellular networks and they are not compatible. True WAN cellular connections were not available until HSPA+, which is a stop gap measure between 3G and 4G networking. The emerging standard for cellular networking is 4G, which currently consists of LTE and WiMAX
* **WiMAX WAN connections:** WiMAX was originally designed as a last mile solution for areas in which DSL and cable were not available. It utilizes microwave signals between line-of-sight relay stations to deliver broadband traffic to a fixed location. It is compatible with LTE so it is considered a 4G technology. It can span significant geographic distances
* **Satellite WAN connection:** Satellite uses microwave radio transmissions as a method of transmitting data over the air. Uses microwave radio relays and satellites to span large distances that are still line of site. These vast distances often lead to latency in the transmission (LAG)

**WAN Technologies III**

* **Metro Ethernet WAN connections**
* **Leased line WAN connections**
* **Common Standards**

**Metro Ethernet WAN connection:** A metro Ethernet connection is when the service provider connects to the customer’s site through an RJ45 connector

* The customers view the WAN connection as an Ethernet connection, while, in reality, the type of connection will be dependent on the level of service that has been purchased
* The service provider may use a variety of WAN technologies behind the scenes, but the customer will only view it as being Ethernet
* Metro Ethernet is commonly deployed as a WAN technology by municipalities at the metropolitan area network (MAN) level

**Leased line WAN connections:**

* **Leased line**
  + A leased line is a dedicated circuit (connection) between two end points used for communication
    - It is usually a digital point-to-point connection
  + A leased line can utilize either a plain old telephone service (POTS) line on the public switched telephone network (PSTN), or it can be a fiber optic circuit provided by a telecommunications company
  + Leased lines tend to be more expensive for the customer, as the circuit cannot be utilized by any other entity so the whole cost is born by the customer
  + Most often, the speed is limited by what the customer is willing to pay.
  + Multiplexing technology can be used to increase the amount of channels that are provided on the connection.
  + Point-to-Point Protocol (PPP) is a common data link layer (OSI Layer 2) protocol used with leased line networks.
    - PPP simultaneously transmits multiple Layer 3 protocol (e.g., IP and IPX) through the use of control protocols (which are specific to the Layer 3 protocol being transmitted)
    - PPP includes a feature called Multilink PPP, which allows for multiple physical interfaces to be bonded together and act as a single logical interface –effectively increasing the available bandwidth
* **Types of leased line connections**
  + T-carrier (U.S, Japan, and South Korea)
    - Each T line circuit level is composed of 24 digital signal channels; these are called Digital Signal 0 (DS)) channels (each channel is capable of carrying 64 Kbps).
    - The 24 DS0s make what is called a Digital Signal 1 (DS1) channel
  + E-carrier (Europe)
    - Each E line circuit level is composed of 30 digital signal channels, these are also called DS0 channels
    - The 30 DS0s also make up a DS1
  + Optical carrier (OC) lines
    - The OC data rates per channel are established by both the SONET (U.S) and SDH (international) networking standards. These rates are the same across the two standards.
    - Using dense wavelength-division multiplexing (DWDM) allows for up to 32 separate channels on a single fiber cable.
    - Using Coarse wavelength-division multiplexing (CWDM) allows for up to eight separate channels on a single fiber cable.

**Common Standards**

* **T lines:**
  + T-carrier:
    - T1 composed of 24 DS0 channels (also known as a DS1) = 1.544 Mbps speed
    - T3 composed of 28 T1 lines (also known as a DS3) = 33.736 Mbps speed
* **E-carrier lines**
  + E1 composed of 30 DS0 channels = 2.048 Mbps speed
  + E3 composed of 16 E1 lines = 34.368 Mbps speed
* **Optical Carrier Lines**
  + OC-1 = 51.83 Mbps speed
  + OC-3 = 155 Mbps speed
  + OC-12 = 622.08 Mbps speed
  + OC-48 = 2.488 Gbps speed
  + OC-192 = 9.953 Gbps speed

**Summary: IGNORED**

**WAN Technologies IV**

* **Circuit switched vs. packet switched networks**
* **Frame relay vs. Asynchronous Transfer Mode**
* **Multiprotocol Label Switching**

**Circuit Switched vs. Packet Switched Networks**

* **Circuit Switched Networks**
  + Circuit switched networks have a dedicated circuit (connection) between two end points used for communication
    - While set up, the circuit can only be used for communication between those end points
    - An example of this is a phone call using a land line
  + Circuit switched networks are most common in networks with leased line communication
  + Best use is when there needs to be a fair amount of continuous data traffic between two points
  + There is only one path
* **Packet Switched Networks**
  + In packet switched networks, data is broke up into smaller chunks and moved through the network, only to be reassembled at the other end.
    - Data traffic is routed using the destination address
    - Data may take different paths through the network
  + As a general rule, packet switched networks are less expensive to maintain
    - The user doesn’t have to maintain a dedicated circuit 24/7

**Frame relay vs. Asynchronous Transfer Mode**

* **Frame Relay:**
  + Frame relay is a WAN technology in which variable length packets are switched across a network.
  + Frame relay is less expensive than leased lines
  + Can be made to look like a leased line though the use of a virtual circuit (**VC**)
  + Frame relay tracks a VC using a data link connection identifier (**DLCI**)
  + **Access rate:**  the max speed of the frame relay interface
  + **Committed information rate (CIR):** guaranteed bandwidth (may go faster but never slower)/
* **Asynchronous Transfer Mode (ATM):**
  + ATM is a WAN technology in which fixed length **cells** (each cell is always 53 bytes long) are switched across a network
  + Can handle real time voice and video
  + Very fast technology; poor bandwidth utilization (the small cell size reduces the efficiency of the technology)
  + Common ATM speeds are 51.84 Mbps and 155.52 Mbps

**Multiprotocol Label Switching:**

* MPLS is a topology that is growing in popularity
  + It is scalable
  + It is protocol independent
* MPLS can be used to replace both frame relay switching and ATM switching
  + IT can also be used to packet switch both frame relay and ATM network traffic. This allows MPLS to be used in conjunction with both frame relay and ATM technologies
* MPLS is used to improve the Quality of Service (QoS) and flow of network traffic
* **Label edge router (LER):** adds MPLS labels to incoming packets if they don’t have them
* **Label switching router (LSR):** forwards packets based on their MPLS labels

**Summary:**

* **Circuit switched vs. Packet Switched Networks:** A circuit switched network involves a dedicated point to point connection between two nodes. They are commonly used with leased line networks. In a packet switched network, data is broken down into smaller packets and routed thourgh the network using the destination address. The data may take differing paths to reach the final destination
* **Frame relay vs.** Asynchronous Transfer Mode: A packet switching technology in which network packets can be different sizes. Frame relay may be set up to mimic a circuit switched network. ATM technology uses a fixed cell size (53 bytes) to quickly move network traffic. While ATM is a fast technology, it doesn’t use the available bandwidth efficiently due to the fixed size of all of the cells
* **Multiprotocol Lable Switching:** MPLS is a WAN packet switching technology that has gained in popularity because of its scalability and protocol independence. It can be used to replace both frame relay and ATM, or it can be used in conjunction with either or both of those technologies. It uses LERs to insert MPLS labels into packets and L:SRs to route the packets to their destinations.