Networking

IPv4 and IPv6

CYBER.ORG
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IPv4

- IPv4 has been around since the early 1980's
- One of the most used protocols to route traffic across the internet
- IPv4 uses 32-bit addresses that contain 4 octets separated by three periods
  - In binary, the IPv4 addresses range from 00000000.00000000.00000000.00000000 – 11111111.11111111.11111111.11111111
  - In decimal, the IPv4 addresses range from 0.0.0.0 - 255.255.255.255
  - There are 4,294,967,296 possible IPv4 addresses
  - CYBER.ORG's IP Addresses which is 67.207.83.25.

IPv6

- 4.2 billion IPv4 addresses are not enough for all devices that can connect to the internet
- The IPv6 protocol was created in 1998 and officially ratified in 2017
- IPv6 has over 340 trillion, trillion (or 340,282,366,920,938,463,463,374,607,431,768,211,456) IP addresses
- IPv6 addresses have 8 groups separated by colons, that contain 4 hexadecimal numbers each
  - An example of an IPv6 address is d778:e150:0000:81d6:37a4:0000:8eee:d64d, and this can be shortened to d778:e150::81d6:37a4::8eee:d64d.

APIPA

- **Automatic Private IP Addressing**
  - This is for IPv4 protocol, NOT IPv6
  - When a device is connected to a private network, the DHCP assigns that device an IP address for that network
  - If the DHCP server is not working, APIPA can auto-assign an IP address for that device on the network
  - The IP address range for APIPA is 169.254.0.1 – 169.254.255.254 and cannot assign addresses outside of these

EUI-64

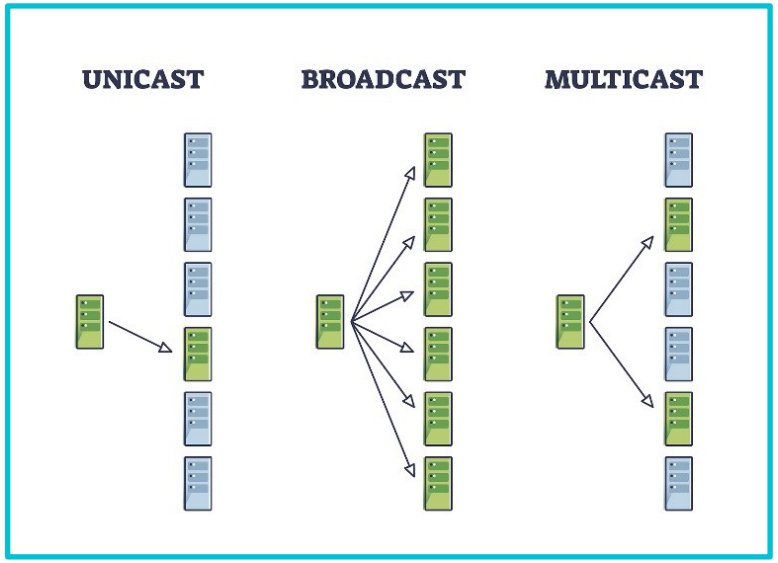
- **Extended unique identifier**
  - IPv6's way to uniquely assign a system their own unique 64-bit IPv6 interface identifier
  - Does not involve a DHCP or some other system on the network manually configuring this
    - Works by using two things, the MAC address of the machine and the 16-bit hex value 0xFFFE
    - The MAC address is 48-bits long, and is split in half, so 24 on each side and the 16-bit hex value is inserted in between them
    - MAC address is unique to the device, this keeps the address unique and can be designated to that specific machine

Multicast, Unicast, Anycast

- **Multicast**
  - Routing scheme that works on both IPv4 and IPv6 protocols
  - This allows for packets to be delivered to multiple addresses set by the sender
- **Unicast**
  - Routing scheme that works on both IPv4 and IPv6 protocols
  - Only sends the packets to 1 specific device
- **Anycast**
  - This only works on IPv6
  - Mix of Unicast and Multicast
  - A group of addresses can be assigned to receive the packets like in multicast, however, in the end only 1 of those devices on the group end up receiving the packets

Broadcast

- All packets go to every other device on the network
- When a sender sends out the packets, every other device on the network acts as a receiver and gets them
  - Inefficient, thus IPv6 does not use this feature, it can only be used with IPv4 protocol.



Link-local, Loopback, and Default gateway

- A **link-local** address connects to a network and is not automatically assigned an IP
  - It will ask the network, does anyone have 169.254.1.1, and then use it if no one has it. If someone did, it would go to 169.254.1.2, and so on
  - The range of link-local for IPv4 is 169.254.0.0/16 and IPv6 is in the block FE80::/10.
- The **loopback** address allows a machine to send packets to itself
  - Useful for debugging and testing purposes
  - Data packets are sent to the network and sent back to where they came from
  - The loopback address on IPv4 is 127.0.0.1 and the loopback for IPv6 is 0:0:0:0:0:0:0:1, which can be shortened to ::1
- The **default gateway** is a critical network component that allows devices on different networks to communicate
  - These devices find the easiest route to another machine, they can even connect machines using different protocols

IPv4 Subnetting Classful

- The oldest form of allocating IP addresses in IPv4 protocol is with **classful** subnetting
- This is when IP addresses are divided into 5 different categories, A through E
- **Class A** is a public addressing system that sends one-to-one communication between the destination and the source
  - This has a subnet mask of 255.0.0.0 and has a range from 0.0.0.0 – 127.255.255.255
  - 0.x.x.x is reserved for the default network and 127.x.x.x is reserved for the loopback, so the range is actually 1.0.0.0 – 126.255.255.255
- **Class B** is a public addressing system where the first two numbers signify the network, while the last two numbers signify the host
  - This has a subnet address of 255.255.0.0 and has a range from 128.0.0.0 to 191.255.255.255
- **Class C** is a public addressing system where the first three numbers signify the network and the last number signifies the host
  - This has a subnet mask of 255.255.255.0 and has a range from 192.0.0.0 to 223.255.255.255
- **Class D**
  - The range of these IP addresses is 224.0.0.0 – 239.255.255.255
  - Used for multicast addresses
- **Class E**
  - This has the range of 240.0.0.0 – 255.255.255.255
  - Saved for scientific research and future use

CIDR

- **CIDR notation** (Classless Inter-Domain Routing) is known as a variable length subnet mask
  - Subnets are given in blocks, with the most common being /0, /8, /16, /24, and /32

CIDR Block	CIDR Range	Total Number of IP Addresses
0.0.0.0/0	0.0.0.0 – 255.255.255.255	4,294,967,296
0.0.0.0/8	0.0.0.0 – 0.255.255.255	16,777,216
0.0.0.0/16	0.0.0.0 – 0.0.255.255	65,536
0.0.0.0/24	0.0.0.0 – 0.0.0.255	256
0.0.0.0/32	0.0.0.0 – 0.0.0.0	1

- The /0 to /32, refers to the 32-bits that make up an entire IP address and how many can change

IPv6 Concepts

- **Tunneling**
  - Allows for two networks/devices that use IPv6 to communicate over a network using IPv4
- **Dual stack**
  - When a device uses both IPv4 and IPv6 protocol
  - Allows for a network to start upgrading to IPv6 without having to do all the devices at once
- **Shorthand notation**
  - Allows an IPv6 address to be shortened
  - The IPv6 address 2004:0fb8:3c4d:0015:0000:0000:1b2f:1a2b can be shortened/collapsed to 2004:fb8:3c4d:15:::1b2f:1a2b
- **Router advertisement**
  - The router sends messages to an IPv6 network to all the nodes on the network
  - Provides updates to the network in which the hosts can learn the prefixes and parameters of that network
- **Stateless address autoconfiguration (SLAAC)**
  - Automatic IPv6 address allocation like APIPA
  - No server holding/keeping track of what device has what IP address
  - SLAAC uses the MAC address to help create unique IP Addresses that should not be used by other devices