**IP ADDRESSING**

**IP ADDRESS (Internet Protocol Address)**

* If you want to download a file from the internet then your computer should have an address so that other computers in internet can find and locate your computer. In internet terms this address is called IP Address.
* IP address opens up communication and gives your devices ability to connect to the internet.
* So, if a device wants to communicate with any other device, it needs an IP address.
* The address is made up of 32 binary bits or 4 bytes in length, which can be divisible into a network portion and host portion with the help of a subnet mask.
* The value in each octet ranges from 0 to 255 decimal, or 00000000 - 11111111 binary.

**How Devices Obtain IP Addresses**

* The router is responsible for assigning IP addresses to devices within a network, typically through the Dynamic Host Configuration Protocol (DHCP).
* Every time a device connects to the router, it gives IP address to the device. So, router gives IP addresses to the devices.
* The devices connected to the router has the same IP address format as the router. And the router does this using subnet mask.
* The IP address have a network ID and a host ID.
* With network portion, the devices on the same network have the same network so if a device wants to send a message to another device and if the network portion of the other device is same then it can directly send the message to the device.
* If a device wants to communication with a device which is in another network, then it will communicate with the help of default gateway or router.
* In a network, two IP addresses are always reserved that no device can use. For example: IP-192.168.1.204 Subnet Mask-255.255.255.0. Then in this network, the first IP address i.e. 192.168.1.0 is known as network address and it is reserved and cannot be used and the last IP address that is 192.168.1.255, it is known as broadcast address.

**IP Address Classes and Reserved Addresses:**

* **IP address classes are a method of categorizing IP addresses based on their range and intended use, providing a structured approach to allocating addresses within a network.**
* **The primary classes are Class A, B, C, D and E.**
* **Class A addresses are designed for very large networks, allowing for up to 16 million hosts, making them suitable for major organizations and ISPs.**
* **Class B addresses support medium-sized networks with up to 65,000 hosts, ideal for universities and large businesses.**
* **Class C addresses are typically used for small networks, accommodating up to 254 hosts, making them common in small offices and home networks.**
* **Class D addresses are reserved for multicast groups, allowing a single packet to be sent to multiple hosts simultaneously, useful in streaming media and conferencing applications.**
* **Class E addresses are reserved for experimental purposes and research, often used in advanced networking protocols.**
* **Understanding these classes are crucial for network design and management, allowing network administrators to allocate IP addresses according to the specific needs of their networks.**
* **The range** between **126.0.0.0 and 128.0.0.0 includes IP addresses which are part of Class A but are primarily reserved for loopback addresses, allowing applications to communicate with the host without requiring an external network. The most commonly used address in this range is 127.0.0.1, often referred to as localhost.**

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| **Class A** | **1.0.0.0 -126.0.0.0** |
| **Class B** | **128.0.0.0 - 191.255.255.255** |
| **Class C** | **192.0.0.0-223.255.255.255** |
| **Class D** | **224.0.0.0-239.255.255.255** |
| **Class E** | **240.0.0.0-255.255.255.255** |

**Types of IP Addressing: IPv4 and IPv6**

1. IPv4:

* IPv4 stands for internet protocol version 4.
* The IPv4 address is made up of 32 binary bits or 4 bytes in length, which can be divisible into a network portion and host portion with the help of a subnet mask.
* The 32 binary bits are broken into four octets. Each octet is 8 bits long. Each octet is converted into decimal and separated by a period (dot). This notation is called dotted-decimal notation.
* The value in each octet ranges from 0 to 255 decimal, or 00000000 - 11111111 binary.
* Nearly 4.3 billion devices can be addressed and connected with IPv4 address. Since we have an extraordinary number of devices today, we need more addresses. So, we are moving towards IPv6 address which is 128 bits in length.

1. IPv6:

* IPv6 stands for Internet Protocol version 6.
* IPv6 is a group of 8 hexadecimal numbers separated by colons.
* The IPv6 address is made up of 128 binary bits. Since a unique sequence of 1s and 0s is given to each computer connected to the internet. So, with IPv6 a total of 2 to the power 128 devices can be connected to the internet.

**Understanding Subnet Masks in Detail:**

* Every IP address has a subnet mask.
* Subnet mask gives information about the network.
* For example: We have a device whose IP address is 192.168.32.5 and it’s subnet mask is 255.255.255.0. Subnet mask tells us how big the network is, how many IP addresses are there in the network, and more. The IP address 192.168.32.5 in binary is 11000000.10101000.00000101 and the subnet mask in binary is 11111111.11111111.11111111.00000000.
* The 1s in the subnet mask tell us which part of the IP address are the network bits. The network bits are the part of the IP address that don’t change and tells us which network we are on. 0s of the subnet mask tells us which part of the IP address are the host bits and also tells us how many hosts there are on the network. There are 8 zero bits in the subnet mask so the number of hosts on the network is equal to 2 to the power of 8 that is 256 but 2 IP address are reserved so number of hosts is equal to 254.
* If we need more IP addresses then we need more host bits which we can borrow from the network side which gives us more hosts and this is subnetting.

**What is Subnetting?**

* Subnetting is the process of dividing a larger network into smaller, more manageable subnetworks or subnets. By breaking down a network, subnetting helps organize and efficiently allocate IP addresses, preventing wastage of IP resources.
* It enhances network performance by reducing traffic congestion and improves security by isolating different parts of a network. Subnetting also allows network administrators to better manage and control access within different areas in a network making it easier to troubleshoot and maintain.
* Each subnet operates independently, yet remains part of a larger network, ensuring efficient communication between devices.

**Subnetting Calculation and Usable Hosts:**

* For subnetting, we need the original IP address and the subnet mask.
* Suppose we have the IP address 192.168.1.0 and subnet mask 255.255.255.0.
* To begin, we convert the subnet mask into binary that is 11111111.11111111.11111111.00000000. It contains 8 zeros and 24 one’s. The number of zero’s determines the number of possible hosts.
* Possible addresses = 2^n = 2^8 = 256.
* Usable addresses = 256 -2 = 254 because the first address in this range is reserved for the network ID which identifies the subnet itself and the last address is reserved for the broadcast address, used to send data to all devices in the subnet.
* The number of subnets can be calculated by using the formula 2^m, where m is the number of bits borrowed from host portion to create subnets.

**CIDR Notation and Address Interpretation:**

* Reading and interpreting subnetting requires identifying key elements like the network address, broadcast address and the range of usable IP addresses. A common way to represent this is through CIDR (Classless Inter-Domain Routing notation) which combines the IP address with a suffix that indicates the number of network bits in the subnet mask.
* For example: An IP address of 192.168.10.15/24 tells us that the first 24 bits belongs to the network portion, leaving 8 bits for host. To determine the network address, you set all host bits to zero giving you 192.168.10.0 in this case. The broadcast address is the address where all host bits are set to one. In this example, it is 192.168.10.255. The range of usable address is 192.168.10.1-192.168.10.254.
* CIDR notation helps quickly identify how the network is segmented making it easier to organize and allocate IP addresses efficiently.

**Creating Subnets in Subnet mask:**

* Dividing the current network 192.168.1.0/24 into four smaller networks, where the subnet mask is 255.255.255.0.
* **Step -1:** First, we convert the subnet mask in binary which is 11111111.11111111.11111111.00000000. The 1’s are the network bits which determines the network ID and 0’s are the host bits which determine the number of possible hosts on this network. Since, we need more network we will manipulate the subnet mask. When we need more networks, we need more network bits.
* **Step-2:** Then, we will determine how many bits are needed to create 4 subnets using the formula 2^n≥required subnets. Here, 2^2 = 4 so we will borrow 2 bits from the host portion.
* After borrowing 2 bits, subnet mask will be 11111111.11111111.11111111.11000000. So, the new subnet mask will be 255.255.255.192.
* **Step-3:** Then we will calculate the subnet increment (Block Size). Block Size = 2^ (Number of host bits left) = 2^6=64. So, subnets will increment by 64 in the fourth octet.
* **Step-4:** List the 4 subnets:

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| **Subnet** | **Network Address** | **First Host** | **Last Host** | **Broadcast Address** |
| 1 | 192.168.1.0/26 | 192.168.1.1 | 192.168.1.62 | 192.168.1.63 |
| 2 | 192.168.1.64/26 | 192.168.1.65 | 192.168.1.126 | 192.168.1.127 |
| 3 | 192.168.1.128/26 | 192.168.1.129 | 192.168.1.190 | 192.168.1.191 |
| 4 | 192.168.1.192/26 | 192.168.1.193 | 192.168.1.254 | 192.168.1.255 |