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CCNA: IP Addressing and IP Services

What is an IP Address?

An IP (version 4) address consists of 32-bits (divided in 4-octets) and usually written in dotted decimal format

Each octet consists of 8-bits or 1-byte

An IP address is necessary for an inter-networking device to communicate and exchange information with each other

An IP address is divided into two parts: Network and Host

Classes of IP Addresses

Class A: 0.0.0.0 to 127.255.255.255

Class B: 128.0.0.0 to 191.255.255.255

Class C: 192.0.0.0 to 223.255.255.255

Class D: 224.0.0.0 to 239.255.255.255

Class E is reserved and can not be assigned. Class D is reserved for multicast application. Only Class A, B and C are available to address assignment

Class A has 8-bits reserved for network, allowing for 28 networks and 224 hosts. The network mask for Class A networks is 255.0.0.0

Class B has 16-bits reserved for network, allowing 216 networks and 216 hosts. The network mask for Class B networks is 255.255.0.0

Class C has 24-bits reserved for network, allowing 224 networks and 28 hosts. The network mask for Class C networks is 255.255.255.0

Configuration Example: IPv4 address assignment

Router R1:
interface fastethernet0/0
ip address 192.168.1.1 255.255.255.0

Reserved Addresses

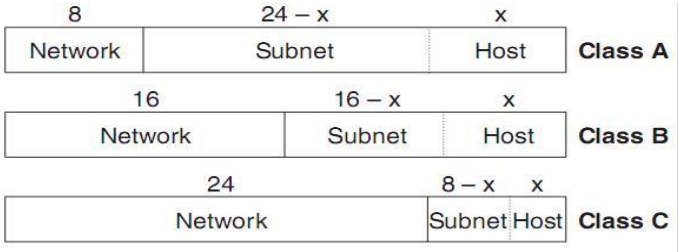
RFC 1918 define thes following reserved address spaces to be used in private network:
10.0.0 / 8
172.16.0.0 / 12
192.168.0.0 / 16

Apart from above mentioned addresses, 0.0.0.0 is used to assign and denote default routes. It cannot be assigned to a host. 127.0.0.0 is reserved for loopback and it is used for testing purposes

IP Subnetting

Subnetting allows sub-dividing the flat address spaces (Class A,B and C) into smaller networks called Subnets

A number of bits (according to the requirement) are taken from the host portion of an IP address to create the subnetworks. The following figure depicts the number of bits and address format when Subnetting is used



Example: Network 192.168.1.0 needs to be subnetted to allow room for 8 additional subnetworks. 192.168.1.0 is class C address, which implies the subnet mask is 255.255.255.0.

Step 1: How many bits to borrow to create the required subnets.
2n = number of subnets, where the exponent n is bits borrowed from the host portion.
Thus we need 3 bits create 8 subnets as 23 = 8 subnets.

Step 2: Calculate the new subnet mask
Previous subnet mask = 11111111. 11111111. 11111111.00000000 or 255.255.255.0
3 additional bits added, so the new subnet mask = 11111111. 11111111. 11111111.11100000 or 255.255.255.224

Step 2: Subnet Magic Number
subtract the last nonzero octet of the subnet mask from 256
256-224 = 32

Step 3 - List the subnet address, host range and the broadcast address.
The first subnet address will be 192.168.1.0/27 and the following subnets will be with increments of 32, the subnet Magic Number we calculated in the previous step.

Subnet Address	Host Range	Broadcast Address
192.168.1.0/27	192.168.1.1 -192.168.1.30	192.168.1.31
192.168.1.32/27	192.168.1.33 -192.168.1.62	192.168.1.63
192.168.1.64/27	192.168.1.65 -192.168.1.94	192.168.1.95
192.168.1.96/27	192.168.1.97 - 192.168.1.126	192.168.1.127
192.168.1.128/27	192.168.1.129 - 192.168.1.158	192.168.1.159
192.168.1.160/27	192.168.1.161 - 192.168.1.190	192.168.1.191
192.168.1.192/27	192.168.1.193 - 192.168.1.222	192.168.1.223
192.168.1.224/27	192.168.1.225 - 192.168.1.254	192.168.1.255

As shown in the table, once we have listed the subnet addresses, calculating the host range and broadcast address is relatively simple. The broadcast address will be the last address of the subnet and one less the preceding subnet address. The host range will start from the next address after the subnet address for example for the subnet 192.168.1.32/27 the host range will start at 192.168.1.33 and end at one less the broadcast address

Summary:
Subnets=2n
Where: n=number of bits required for Subnetting
Used to calculate the subnets
Host=2h-2
where h=remaining bits in host portion
Used to calculate usable host addresses

Variable Length Subnet Mask (VLSM)

VLSM occurs when an internetwork uses more than one mask in different subnets of a single Class A, B or C network. It allows more granular distribution of IP addressing and avoids address wastage. For example: On point-to-point links only two IP addresses are required and thus using subnet mask of /24 which is used throughout an internetwork is not a scalable solution.

For routing protocols to support VLSM, routing protocol must advertise the subnet number and the subnet mask. The routing protocol is assumed classless if VLSM is supported and vice versa

RIP version 2, EIGRP, and OSPF support VLSM and therefore are classless

Problems with VLSM: Overlapping subnets:
For example: Consider 172.16.4.1/23 and 172.16.5.1/24
The first, last and broadcast host for 172.16.4.1/23 are: 172.16.4.1, 172.16.5.254 and 172.16.5.255
The first, last and broadcast host for 172.16.5.1/23 are: 172.16.5.1, 172.16.5.254 and 172.16.5.255

Solution:
The only solution is re-number one of the overlapping VLSM subnets

Dynamic Host Configuration Protocol (DHCP)

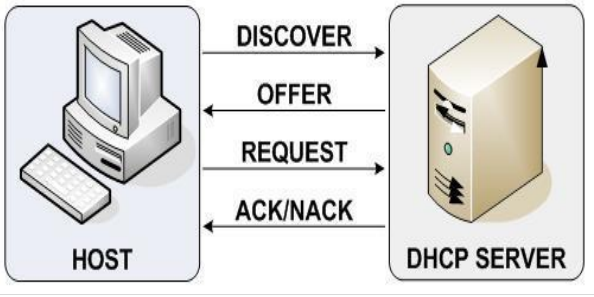
A host can be assigned an IP address in two ways:
1. Static configuration:
2. Dynamic configuration

DHCP is used to assign IP addresses dynamically. It is based on BOOTP procotol

Uses UDP as the delivery protocol. Server uses port number 67 and client uses port 68.

The following process occurs when a client request IP address from a DHCP server:
1. client broadcasts a DISCOVER message
2. DHCP server reply back with an OFFER message to the client
3. client then REQUEST the DHCP server for the IP address
4. DHCP server send either ACK or NACK; either an IP address is assigned or the request is denied

The address assignment process is depict in the following diagram



DHCP Client Configuration Example on Cisco IOS

```
Router R1:
interface fastethernet0/0
 ip address dhcp   <- Configures the interface as the DHCP client to dynamically obtain IP

interface fastethernet 0/1
ip address 192.168.1.1 255.255.255.0

ip dhcp pool POOLA
network 192.168.1.0 255.255.255.0
dns-server 192.168.1.100 192.168.1.101
default-router 192.168.1.1
domain-name ABC.COM
```

Domain Naming System (DNS)

DNS is used to resolve IP address to (easily remembered) names

Uses both TCP and UDP as the transport protocol with port number 53

Configuration Example: DNS Client Configuration

The name servers used belong to www.OpenDNS.com and are illustrated for education purpose only
The 208.67.220.220 is the primary name server and 208.67.222.222 is the secondary name server