🚀R&D DOCUMENT ON IP ADDRESSING AND SUBNETTING

TITLE :

Analysis of the fundamentals of various types of Networking components for enterprise systems.

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PURPOSE :

To research and document IP addressing and subnetting concepts in IPv4 and IPv6, enabling efficient network design and host allocation.

📌TOPICS TO BE COVERED IN THIS DOCUMENT:

- Introduction to IP addressing
- IPv4 Addressing
- IPv4 Subnetting
- CIDR and CIDR ranging
- Calculating subnets and hosts in IPv4 Addressing
- IPv6 Addressing
- IPv6 Subnetting
- IPv6 CIDR
- Comparison between IPv4 and IPv6 Addressing
- Examples in all versions of Addressing

INTRODUCTION TO IP ADDRESSING

An IP address is used to uniquely identify devices on a network. It is a unique number that is assigned to every device on a network that uses IP for communication. They are essential for the internet to function as they allow the devices to send and receive data by providing a way to find the destination device on the network.

IP Addressing is this process of assigning IP Address to devices in order to allow them to communicate effectively.

IPv4 ADDRESSING

- Structure of IPv4 = 32 -bit number written in decimal dotted format - e.g. : 192.168.0.1
- This type of addressing is divided into 4 octets (8-bit blocks).
- Each octet contains 0-255 characters.

ADDRESS CLASSES:

Class	Starting bits	Range	Usage
A	0	1.0.0.0 - 126.0.0.0	Large networks
B	10	128.0.0.0 - 191.255.0.0	Medium networks
C	110	192.0.0.0 - 239.255.255.0	Small networks
D	1110	224.0.0.0 - 239.255.255.255	Multicasting
E	1111	240.0.0.0 - 255.255.255.255	Reserved

Private IP Ranges:

Class A: 10.0.0.0 - 10.255.255.255
Class B: 172.16.0.0 - 172.31.255.255
Class C: 168.168.0.0 - 192.168.255.255

IPV4 SUBNETTING

Subnetting divides one large network into smaller logical networks. It helps in efficient IP utilization and improved security and routing.

Terminologies :
- Network Address - This is the first address in subnet. It is not assignable to the host.
- Broadcast Address - Last address in the subnet.
- Usable Hosts - Total address = 2 (for network and broadcast).

Subnet Mask:

Defines the boundary between network and host portion. Example : 255.255.255.0 means /24 (24 bits for network , and 8 for host).

CIDR AND CIDR RANGING

CIDR (Classless Inter-Domain Routing) allows flexible subnetting by writing IPs as IP/prefix.It is expressed as IP Address followed by slash and number of network bits (e.g. - 192.168.1.0/24).

CIDR BLOCK SIZES

CIDR	SUBNET MASK	# of IPs	USABLE HOSTS
/30	255.255.255.252	4	2
/29	255.255.255.248	8	6
/28	255.255.255.240	16	14
/27	255.255.255.224	32	30
/26	255.255.255.192	64	62
/25	255.255.255.128	128	126
/24	255.255.255.0	256	254

CALCULATING SUBNETS AND HOSTS IN IPV4 ADDRESSING

Formulae:

- For calculating total hosts = $2^{borrowed\ bits}$
- For calculating usable hosts = $2^{host\ bits} - 2$ (network and broadcast addresses excluded)
- Host bits = 32 - subnet prefix

Subnet Mask :

A subnet mask defines which portion of the IP is for the networ and which is for hosts.
Example : Subnet mask 255.255.255.192 corresponds to /26.
Subnet mask length = number of 1s in binary format.

IP - 192.168.1.0/26

- Subnet Mask: 255.255.255.192
- Hash Bits: 32-26 = 6
- Total Hosts: 2^6 = 64
- Usable Hosts: 64-2 = 62
- Subnets from /24 -> /26: subnets of 64 addresses each.

IPv6 ADDRESSING

IPv6 is a 128-bit address. Written in hexadecimal, colon separated (e.g. - 2001:04db8:85a3:0000:0000:8a2e:0370:7334). It consists of vast address space of 2^128 bit addresses.

IPv6 ADDRESS TYPES

TYPE	DESCRIPTION
Unicast	One- to- one communication
Multicast	One - to - many
Anycast	One - to - nearest

Some of the common abbreviation rules for IPv6 addressing includes removing leading zeroes (for example - 01ab -> 1ab) and Replacing consecutive zero blocks with :: once.

IPv6 SUBNETTING AND CIDR

- CIDR is also used in IPv6 (e.g. /64, /56, /48).
- Common subnet : /64 which is the standard subnet size.
- No broadcast address is provided here - replaced by multicast in IPv6.

For example:
2001:db8:abcd:0012::/64 - subnet of 2^64 addresses.

COMPARISON - IPv4 AND IPv6 ADDRESSING

Feature	IPv4	IPv6
Address length	32 bits	128 bits
Format	Decimal (e.g. 192.0.2.1)	Hexadecimal (e.g. 2001:db8::1)
Address Space	~4.3 billion	~3.4*10^38
NAT required	Yes	No
Broadcast	Yes	No (uses multicast)
Security	Optional	Mandatory

EXAMPLES

->CREATING 4 SUBNETS FROM 192.168.10.0/24
Convert /24 to /26 - 4 subnets possible
Subnets -
192.168.10.0/26 - 62 hosts
192.168.10.64/26 - 62 hosts
192.168.10.128/26 - 62 hosts
192.168.10.192/26 - 62 hosts

Create /64 subnets from given IPv6 address - 2001:db8::/48
First: 2001:db8:0:0::/64
Second : 2001:db8:0:1::/64
Third: 2001:db8:0:2::/64