Research & Development Document

Topic: IP Addressing and Subnetting (IPv4 & IPv6)
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1. Introduction

IP addressing and subnetting are fundamental to computer networking. Every networked device requires a unique IP address to communicate effectively. Subnetting allows logical segmentation of IP networks for better performance, security, and manageability. This document outlines the key principles and practices of IP addressing and subnetting, including detailed IPv4 and IPv6 analysis.

2. Prerequisites

- Basic understanding of networking concepts
- Familiarity with binary and decimal number systems
- Basic knowledge of routers and hosts

3. Requirements

- Capability to identify and apply IP address classes
- Ability to calculate subnets using CIDR notation
- Understanding of usable and reserved IP addresses
- Familiar with router configuration syntax

4. Additional Information

- IPv4 is gradually being replaced by IPv6 due to address exhaustion
- CIDR enables flexible subnetting by eliminating classful dependency
- IPv6 addresses are hexadecimal and 128 bits long, eliminating the need for NAT

5. Understand IP Addresses

5.1 IPv4 Format:

- 32-bit numeric address (e.g., 192.168.1.1)
- Divided into four octets

5.2 IPv6 Format:

- 128-bit address (e.g., 2001:db8::1)
- Uses hexadecimal notation and :: for zero compression

6. Network Masks

- Network masks determine the boundary between network and host portions
- Example: 255.255.255.0 for /24 in IPv4

7. Understand Subnetting

Subnetting divides a network into smaller logical networks.

Advantages:

- Efficient IP address allocation
- Enhanced security
- Simplified network management

Subnet Formulae:

- Total Subnets = 2^n (where n = borrowed bits)
- Usable Hosts = $2^{\text{host bits}} - 2$

8. Examples

IPv4 Example:

- IP: 192.168.10.0/28
- Subnet Mask: 255.255.255.240
- Total Hosts: 16
- Usable Hosts: 14

IPv6 Example:

- Prefix: 2001:db8:abcd::/64
- Subnets Possible (from /48): 2^16 = 65536 subnets

9. Special Subnets

9.1 Loopback

Used for testing and diagnostics.

9.2 Link-local

Automatically assigned if DHCP fails.

9.3 APIPA, Multicast, and Broadcast

- APIPA: 169.254.0.0/16
- Multicast: 224.0.0.0/4
- Broadcast: 255.255.255.255

10. 31-bit Subnets

- Used for point-to-point links
- Subnet mask: 255.255.255.254

11. 32-bit Subnets

- Subnet mask: 255.255.255.255
- Identifies a single host
- Often used in routing tables and loopback interfaces

12. Related Information

- **RFC 1918** – Private IPv4 addressing
- **RFC 4291** – IPv6 addressing architecture
- **CIDR Notation** – RFC 4632
- **Tools:** IP Calculator, Subnet Planner, Wireshark for verification

13. Conclusion

Knowledge of IP addressing and subnetting is critical for network planning, administration, and security. With IPv4 address depletion continues , IPv6 offers a scalable solution. Effective use of subnetting methods, CIDR, and host calculation assists organizations in designing effective, secure, and economical networks.