Lesson 1: IP Addressing

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Overview

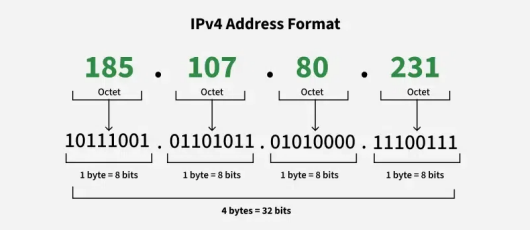
1. Overview of IPv4 (Internet Protocol version 4)
   - IP Protocol
   - IPv4 Address Structure and Classe
2. Advanced Subnetting Techniques
   - Calculating Subnets
   - Variable Length Subnet Masking (VLSM)
   - Classless Inter-Domain Routing (CIDR)
3. Overview of IPv6

Keys of the IP Protocol

- Provides logical addressing and packet delivery across networks.
- Ensures routing of packets through interconnected networks (best effort delivery).
- Logical addressing using IPv4 (32-bit) or IPv6 (128-bit).
- Connectionless: No dedicated connection required.
- Unreliable: No guarantees for delivery, order, or integrity.
- Fragmentation: Handles large packets by breaking them into smaller fragments.
- Determines the best path for packet delivery using routing tables.
- Supports dynamic and static routing mechanisms.

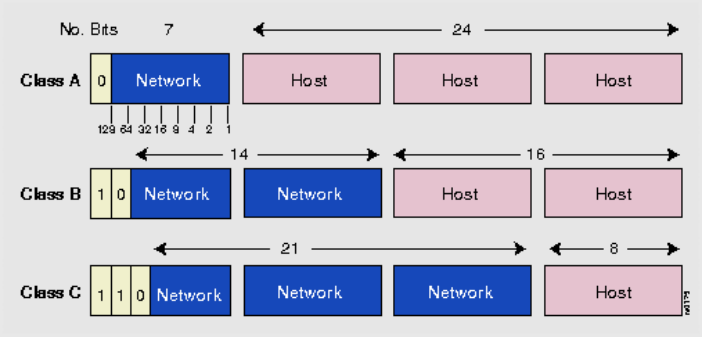
IPv4 Addressing

- Address Length: 32-bit
- Address Format: Dotted decimal notation (e.g., 192.168.1.100)
- Address Space: Limited, leading to a global shortage.
- Security: Limited built-in security features.



IPv4 Address Structure and Classes

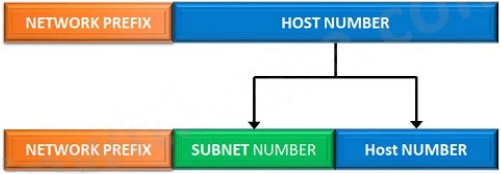
- an IPv4 address consists of two main parts
  - Network Part: Identifies the specific network.
  - Host Part: Identifies the specific device within the network.



- Subnet Mask: Determines which part is for the network and which for the host.

What is Subnetting?

- Dividing a network into smaller subnetworks.
- Purpose: Efficient IP allocation, improved network management, and enhanced security.



Calculating Subnets

- Identify the number of required subnets or hosts.
- Borrow bits and calculate the new subnet mask.
- Determine the increment or block size.
- Calculate network IDs, broadcast addresses, and valid host ranges.

Scenario: You are the network administrator for a small company. The company has the following departments and requirements:

- **Management**: 30 hosts
- **Sales**: 15 hosts
- **IT**: 20 hosts
- **HR**: 10 hosts
- **Finance**: 15 hosts

The company has been allocated the IP address block `192.168.1.0/24`. Design an FLSM (Fixed-Length Subnet Mask) plan to accommodate all departments.

Variable Length Subnet Masking (VLSM)

- VLSM allows the creation of subnets with different sizes, optimizing IP address usage by assigning subnet masks based on actual requirements.
- Avoid wastage of IP addresses.
- Enhance flexibility in network design.

Steps for Applying VLSM

1. Analyze Requirements :
   - List the number of hosts needed for each subnet.
   - Example:
     - Subnet A: 50 hosts
     - Subnet B: 25 hosts
     - Subnet C: 10 hosts
2. Assign the Largest Subnet First:
   - Start with the largest host requirement to ensure sufficient IPs.
3. Determine Subnet Masks:
   - Calculate the required subnet mask for each subnet using the formula : 2^{n-2}.
4. Allocate IP Ranges:
   - Use block sizes to assign non-overlapping ranges.
5. Repeat for Smaller Subnets:
   - Continue assigning IPs based on decreasing host needs.

Practical Lab

Scenario: You are the network administrator for a small company. The company has the following departments and requirements:

- **Management**: 30 hosts
- **Sales**: 60 hosts (increased from 50)
- **IT**: 20 hosts
- **HR**: 10 hosts
- **Finance**: 15 hosts

The company has been allocated the IP address block `192.168.1.0/24`. Design an VLSM (Variable-Length Subnet Mask) plan to accommodate all departments.

Solution

Subnet	Number of Machines	Mask	Network Address	First Address	Last Address	Broadcast Address
Sales	60	/26	192.168.1.0	192.168.1.1	192.168.1.62	192.168.1.63
Management	30	/27	192.168.1.64	192.168.1.65	192.168.1.94	192.168.1.95
IT	20	/27	192.168.1.96	192.168.1.97	192.168.1.126	192.168.1.127
Finance	15	/27	192.168.1.128	192.168.1.129	192.168.1.158	192.168.1.159
HR	10	/28	192.168.1.160	192.168.1.161	192.168.1.174	192.168.1.175

Table: Subnet Allocation for Company Departments

Classless Inter-Domain Routing (CIDR)

- CIDR is a method for IP address allocation and route aggregation introduced to replace the class-based system. It allows more efficient use of IP addresses.
- Overcome limitations of classful addressing.
- Aggregate multiple networks into a single route.

CIDR Notation and Prefix Length

- CIDR Notation
  - Combines the network address and prefix length (e.g., 192.168.1.0/24).
  - Prefix length indicates the number of bits used for the network portion.
- Subnet Mask Mapping

CIDR	Subnet Mask	Hosts per Subnet
/24	255.255.255.0	254
/25	255.255.255.128	126
/26	255.255.255.192	62
/27	255.255.255.224	30
/28	255.255.255.240	14
/29	255.255.255.248	6
/30	255.255.255.252	2

- The smaller the prefix length, the larger the host range.

CIDR in Action

- An ISP needs to allocate IPs for four networks:
  - Network 1: 192.168.1.0/25 (126 hosts)
  - Network 2: 192.168.1.128/26 (62 hosts)
  - Network 3: 192.168.1.192/27 (30 hosts)
  - Network 4: 192.168.1.224/28 (14 hosts)
- These networks can be aggregated into a single block:
  - CIDR Block: 192.168.1.0/24
  - Reduces the number of routes in the routing table from 4 to 1.

Internet Protocol version 6

- Address Length: 128-bit
- Address Format: Hexadecimal with colon separators (e.g., 2001:db8:0:1234::1)
- Address Space: Vastly larger, capable of supporting the growing number of connected devices.
- Security: Enhanced security features, including native support for IPsec.

IPv6 Address Writing Conventions

- **Format:** 8 groups of 4 hex digits, separated by colons (':')
  Example: `2001:0db8:85a3:0000:0000:8a2e:0370:7334`
- **Omit Leading Zeros:**
  Example: `2001:db8:85a3:0:0:8a2e:370:7334`
- **Compress Zeros:** Use `::` for consecutive zero groups (once per address)
  Example: `2001:db8:85a3::8a2e:370:7334`
- **IPv4 Embedded:** Use dotted-decimal for the last 32 bits
  Example: `::ffff:192.168.1.1`
- **Special Addresses:**
  Loopback: `::1`
  Unspecified: `::`
- **Network Prefix:** Use CIDR notation
  Example: `2001:db8:85a3::/48`
- **Case:** Use lowercase (conventionally).

Key Differences

Table: Key Differences between IPv4 and IPv6

Feature	IPv4	IPv6
Address Length	32-bit	128-bit
Address Space	Limited	Vast
Security	Limited	Enhanced
Header Format	More complex	Simpler
Autoconfiguration	Not supported	Supported

Why IPv6?

- Running Out of Addresses: IPv4's address space is nearly exhausted, hindering the growth of the internet.
- Improved Security: IPv6 incorporates security features like IPsec, enhancing data confidentiality and integrity.
- Simplified Header: IPv6 has a simpler header format, improving routing efficiency. Autoconfiguration: IPv6 supports autoconfiguration, simplifying network setup.

Transition to IPv6

The transition to IPv6 is ongoing, with many organizations and individuals adopting it. However, IPv4 continues to be widely used, and coexistence between the two protocols is crucial during the transition period.