

IPv4 Classful and Classless Subnetting: Design Philosophy, Limitations, and Modern Practice

Course: Robotics Design and Internet of Things (CS346)

1 Introduction

IPv4 addressing was originally designed using a **classful architecture**, where fixed network boundaries defined how addresses were allocated and routed. While simple, this approach proved inefficient and unscalable as the Internet grew.

To overcome these limitations, **classless addressing** and **CIDR (Classless Inter-Domain Routing)** were introduced, enabling flexible subnetting, efficient address utilization, and scalable routing.

This document explains:

- Why classful addressing existed
- How it works at bit level
- Why it failed
- How classless subnetting solves real-world problems

2 IPv4 Classful Addressing

2.1 What is Classful Addressing?

In classful addressing, IPv4 addresses are divided into classes based on the leading bits of the first octet. Each class has a fixed network and host portion.

2.2 IPv4 Address Classes

| Class | Leading Bits | First Octet Range | Network Bits | Host Bits |
|-------|--------------|-------------------|--------------|-----------|
| A | 0 | 1–126 | 8 | 24 |
| B | 10 | 128–191 | 16 | 16 |
| C | 110 | 192–223 | 24 | 8 |
| D | 1110 | 224–239 | Multicast | – |
| E | 1111 | 240–255 | Experimental | – |

| Class | Subnet Mask | CIDR Notation |
|-------|---------------|---------------|
| A | 255.0.0.0 | /8 |
| B | 255.255.0.0 | /16 |
| C | 255.255.255.0 | /24 |

2.3 Default Subnet Masks

2.4 Why Classful Addressing Was Simple

- Routers inferred subnet mask from IP alone
- No need to exchange mask information
- Low processing overhead (important in early routers)

2.5 Why Classful Addressing Failed

2.5.1 Massive Address Wastage

- Class A: 16 million hosts per network
- Class B: 65,536 hosts per network
- Class C: Only 254 hosts

Organizations were forced to choose between:

- Too large (Class B)
- Too small (Class C)

2.5.2 Routing Table Explosion

Each classful network required a separate routing entry, causing routers to maintain extremely large routing tables.

2.5.3 No Support for VLSM

Classful addressing does not support Variable Length Subnet Masking, meaning all subnets must be of equal size.

3 Subnetting in Classful Networks

Subnetting was introduced as a workaround.

3.1 Subnetting Concept

Borrow bits from the host portion to create subnets.

Example (Class C):

- Network: 192.168.1.0/24
- Borrow 2 bits
- New mask: /26
- Subnets: 4

3.2 Limitations of Classful Subnetting

- Subnet mask not carried in routing updates
- Requires manual configuration
- Breaks across routers unless mask is known

4 Classless Addressing and CIDR

4.1 What is Classless Addressing?

Classless addressing removes the concept of fixed classes. Any IPv4 address can have any subnet mask.

IP Address + Prefix Length = CIDR

Example:

192.168.10.0/27

4.2 Why CIDR Was Introduced

- Efficient address allocation
- Support for Variable Length Subnet Masking (VLSM)
- Route aggregation (supernetting)
- Reduced routing table size

5 Variable Length Subnet Masking (VLSM)

5.1 Concept

Different subnets can have different sizes based on actual host requirements.

Example:

- Admin network: 50 hosts → /26
- Sensor network: 10 hosts → /28
- Point-to-point link: 2 hosts → /30

5.2 Real-World IoT Example

In a smart campus:

- Camera network requires large subnets
- Sensor networks require small subnets
- Gateways require point-to-point links

VLSM avoids wasting addresses.

6 CIDR and Route Aggregation

6.1 Supernetting

Multiple contiguous networks can be summarized into a single route.

Example:

- 192.168.0.0/24
- 192.168.1.0/24
- 192.168.2.0/24
- 192.168.3.0/24

Aggregated as:

192.168.0.0/22

6.2 Impact on Internet Routing

- Smaller routing tables
- Faster route lookup
- Scalable Internet growth

7 Classful vs Classless: Technical Comparison

| Aspect | Classful | Classless (CIDR) |
|---------------------|----------|------------------|
| Subnet mask | Fixed | Variable |
| VLSM support | No | Yes |
| Address efficiency | Poor | High |
| Routing scalability | Poor | Excellent |
| Modern usage | Obsolete | Universal |

8 Exam-Oriented Key Observations

- Classful routing is obsolete but important historically
- CIDR is mandatory in modern IP networks
- VLSM is impossible without classless routing
- Route aggregation is key to Internet scalability

9 Conclusion

Classful addressing provided simplicity during the early Internet era but failed to scale due to address wastage and routing inefficiencies. Classless addressing, through CIDR and VLSM, solved these issues by allowing flexible subnet sizes and route aggregation. Today, all modern IP networks rely on classless addressing principles.