Dynamic Host Configuration Protocol (DHCP)

1 Introduction

What is DHCP?

The **Dynamic Host Configuration Protocol (DHCP)** is a client–server network protocol that automatically assigns IP addresses and other essential network configuration parameters to hosts when they join a network.
DHCP enables **plug-and-play networking** by eliminating the need for manual IP configuration.

Before communication, a host must know:

- Its **IP address**
- **Subnet mask**
- **Default gateway**
- **DNS server address**

Manually configuring these values for every device is inefficient and error-prone. DHCP automates this entire process.

2 Why DHCP is Needed

Problems Without DHCP

- IP address conflicts
- High administrative overhead
- Configuration mistakes
- Poor scalability

Common Use Cases

- Devices frequently joining/leaving (phones, laptops, IoT)
- Large campus and enterprise networks
- Home and public Wi-Fi networks

Key Idea

DHCP allows networks to scale to thousands of devices with minimal manual effort.

3 DHCP Architecture

Main Components

- **DHCP Client**: Device requesting configuration
- **DHCP Server**: Assigns IPs and manages address pool
- **DHCP Relay Agent**: Forwards DHCP messages across subnets

Why Relay Agent is Required

DHCP uses **broadcast messages**, which routers do not forward. A relay agent forwards these messages so DHCP can work across multiple subnets.

4 DHCP Address Allocation Methods

- **Dynamic Allocation**: Temporary IP via lease (most common)
- **Automatic Allocation**: Permanent IP (rare)
- **Manual Allocation (Reservation)**: IP mapped to MAC address

Manual allocation is often used for:

- Servers
- Printers
- Network devices

5 DHCP in a Multi-Subnet Network

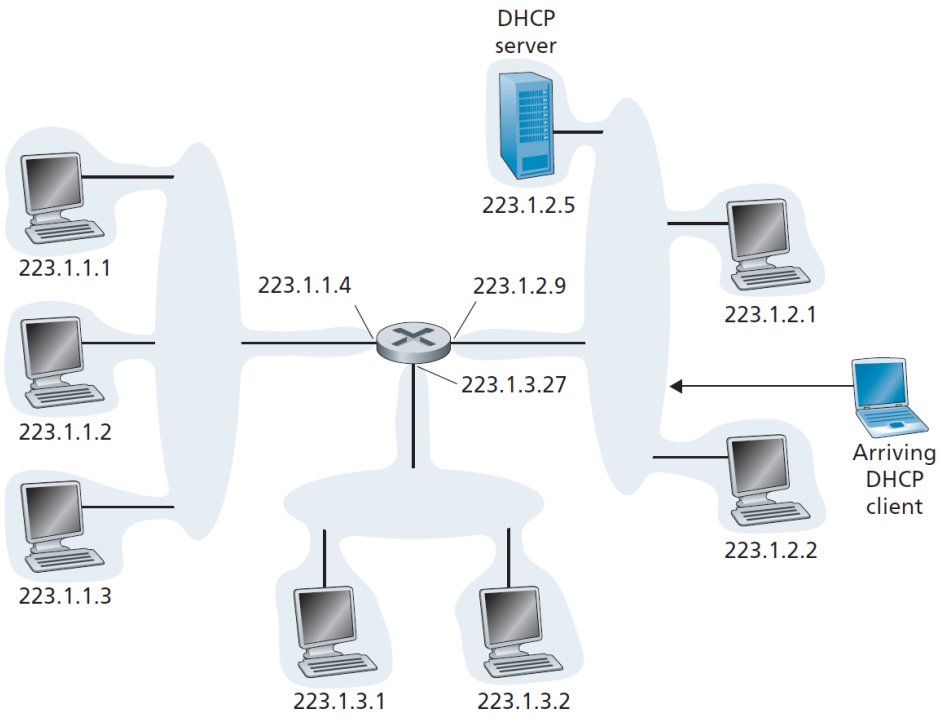

Figure 1: DHCP client, server, and relay agent across multiple subnets

Without a relay agent, DHCP would fail outside the local subnet.

6 DHCP Operation: The Four-Step DORA Process

DORA Overview

Discover → Offer → Request → ACK

6.1 1. DHCP Discover (Client → Broadcast)

- Client has no IP address
- Sends broadcast to `255.255.255.255`

Source IP: 0.0.0.0 Destination IP: 255.255.255.255

Message meaning: *"Is there any DHCP server available?"*

6.2 2. DHCP Offer (Server → Broadcast)

Each server responds with:

- Offered IP address
- Subnet mask
- Lease time
- Server identifier

Broadcast is used because the client still lacks an IP.

6.3 3. DHCP Request (Client → Broadcast)

The client:

- Chooses one offer
- Broadcasts acceptance

This informs all servers which offer was selected.

6.4 4. DHCP ACK (Server → Broadcast)

Final confirmation including:

- Assigned IP
- Gateway and DNS
- Lease duration

Result

After receiving DHCPACK, the host becomes a valid network member.

7 DHCP Message Exchange Diagram

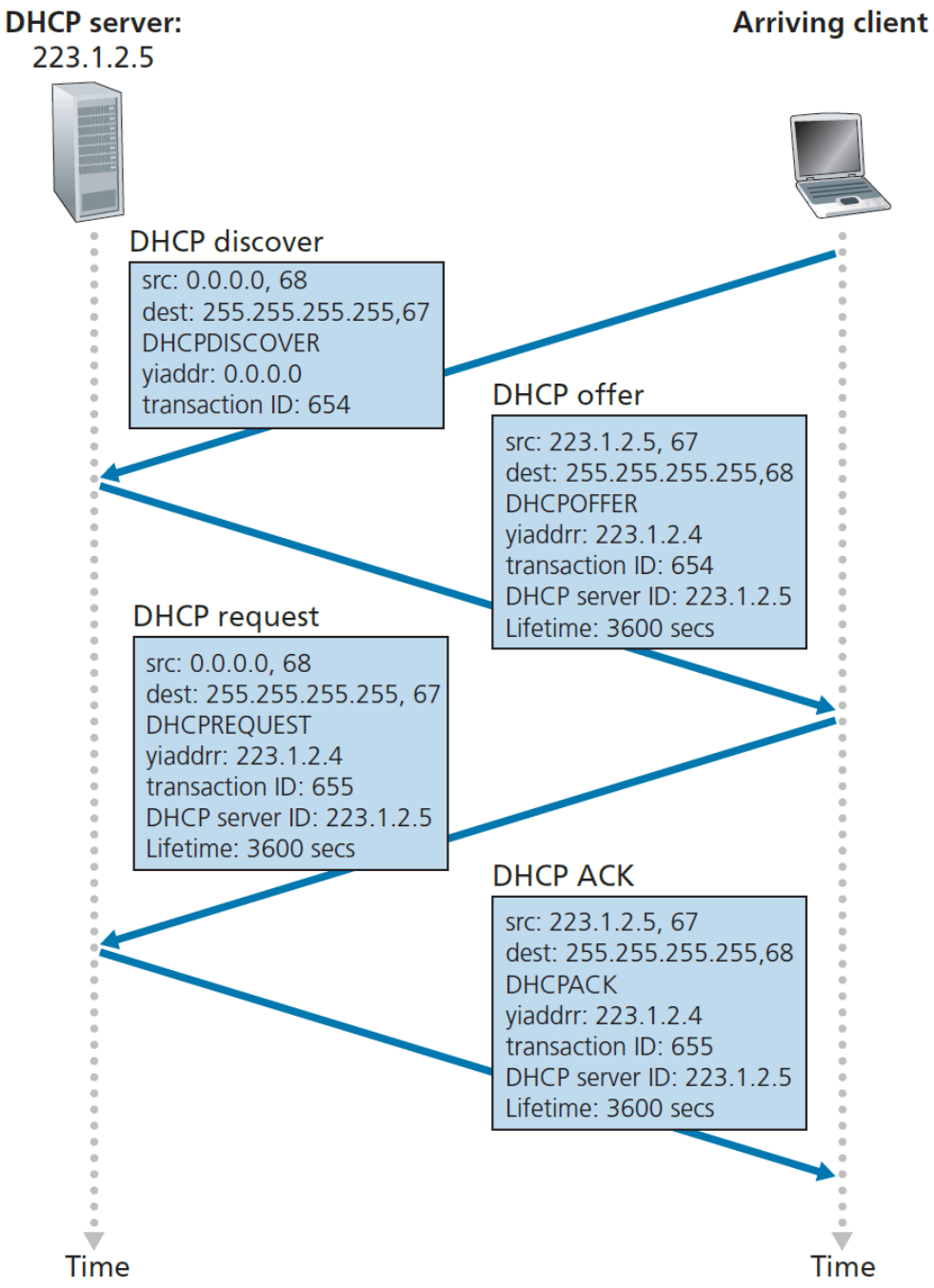

Figure 2: DHCP four-step handshake

8 DHCP Lease Mechanism

- IP addresses are assigned temporarily

- Client renews lease before expiration

If renewal fails:

- Lease expires
- Client must restart DORA process

Purpose of Leasing

Leases ensure efficient IP address reuse and prevent exhaustion.

9 Transport Layer and Ports

- Uses **UDP**
- Client port: **68**
- Server port: **67**

UDP is used due to low overhead and broadcast capability.

10 DHCP Limitations

Main Limitation

When a host moves to a new subnet, it receives a new IP address. This breaks ongoing TCP connections.

Therefore, DHCP alone is insufficient for:

- Mobile IP
- Cellular networks

11 Advantages and Disadvantages

Advantages

- Automatic configuration
- Reduces human error
- Scalable and efficient

Disadvantages

- Server dependency
- Vulnerable to rogue DHCP attacks

12 Where DHCP is Used

- Home networks
- Enterprise LANs
- University campuses
- Wireless and ISP networks

13 Summary

Key Takeaways

- DHCP automates IP configuration
- Uses DORA handshake
- Supports large-scale networks
- Essential for modern Internet operation

DHCP is the foundation of modern, scalable IP networking.