Kea DHCP

Introduction

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- Basics of DHCPv4
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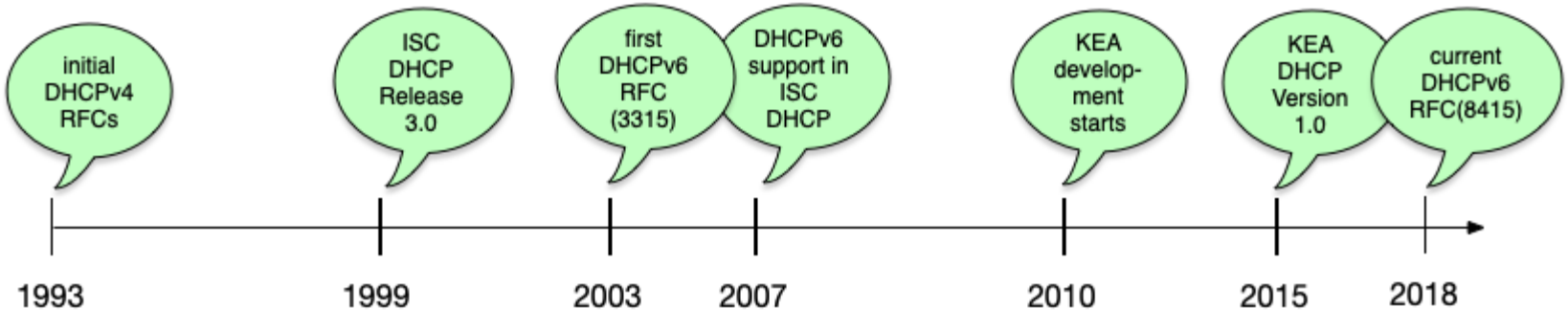
About DHCP

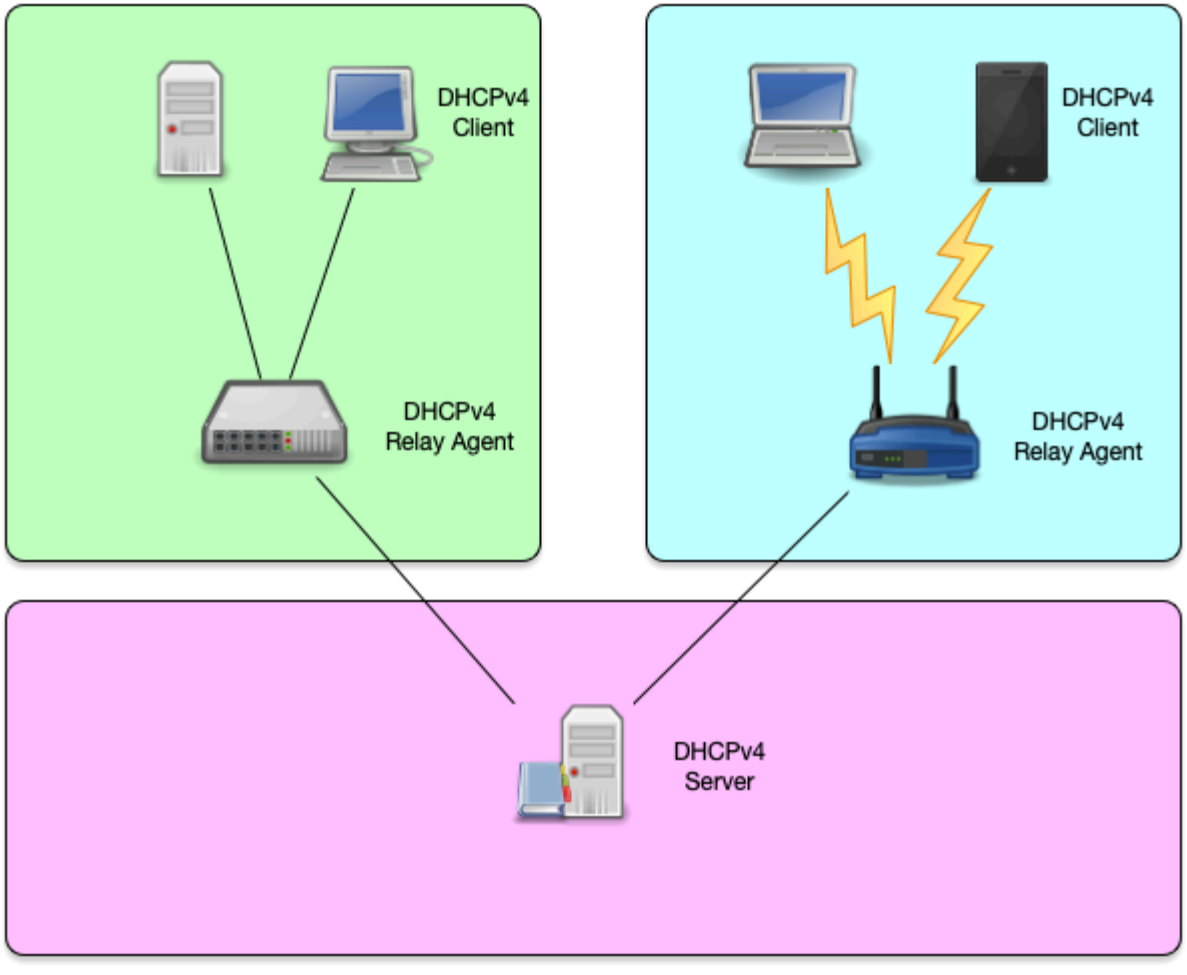
- DHCP is short for Dynamic Host Configuration Protocol
  - The Internet standard protocol to assign IP addresses and network related configuration to TCP/IP connected machines
  - For IPv4: RFC 2131
  - For IPv6: RFC 8415

Short history of DHCP (including ISC-DHCP and Kea)

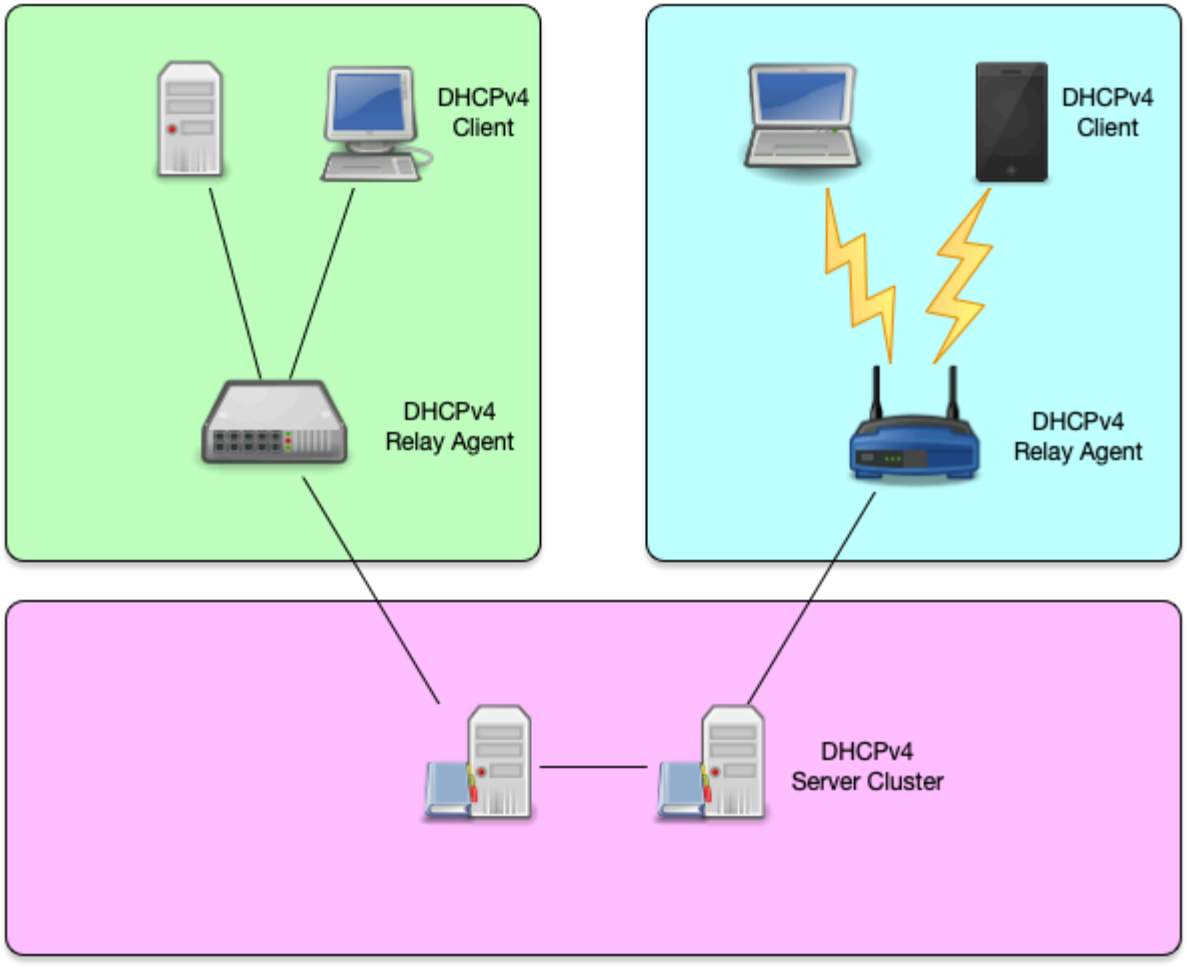


DHCPv4 overview

DHCPv4 overview (1/2)



DHCPv4 overview (2/2)



DHCPv4 protocol

- The DHCPv4 protocol uses UDP broadcast and (in some situations) unicast
    - The DHCPv4 server or relay agents listen on port 67
    - A DHCPv4 client listens on port 68 for messages from a server or relay agent
    - The initial request from a client requires layer 2 (Ethernet) communication

DHCPv4 Lease concept

DHCPv4 Lease (1/3)

- When using the DHCP protocol, a client can never keep an IP Address forever
    - Each IP Address given out by a DHCP server has a "lease" time
    - This is the time in seconds that the client is allowed to use the IP Address

DHCPv4 Lease (2/3)

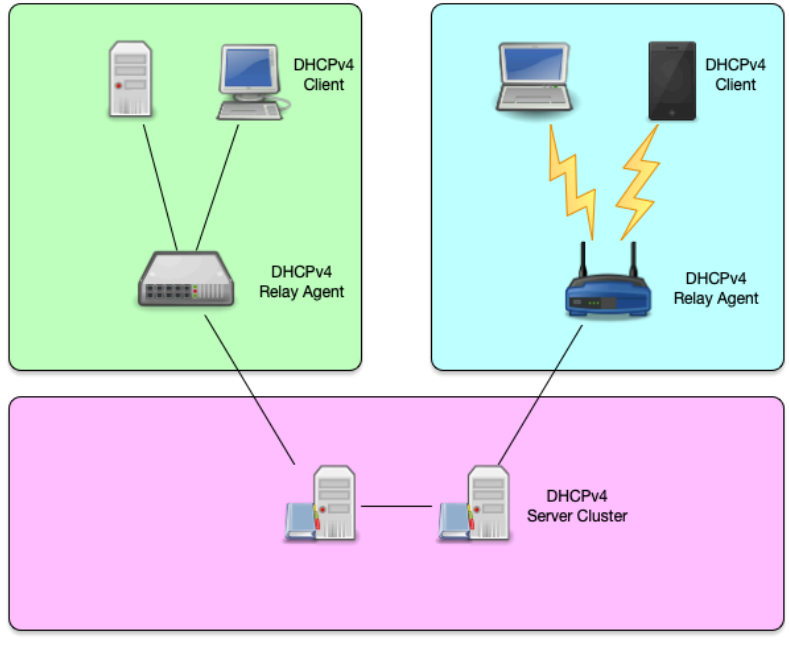
- The "lease" time is delivered in an DHCP option
  - It is a 32bit value
  - The maximum lease time is $FFFFFFFE (= 4294967294 seconds or ~136 years)
  - A lease time of $FFFFFFFF indicates an infinite lease

DHCPv4 Lease (3/3)

- According to the RFC, a DHCP server **must** store the lease information to permanent storage before confirming the IP address to a client
    - This can be a performance bottleneck on a DHCP server

DHCP Clients, Relays and Server

- Because a client machine without IP address can only communicate on the local link, the base DHCPv4 protocol is "link-local" only
- DHCPv4 relay-agents can be used to forward DHCPv4 requests to centralised DHCPv4 server
    - DHCP relay-agents are often found in network equipment (e.g. router)
    - Dedicated "software based" relay-agents are available

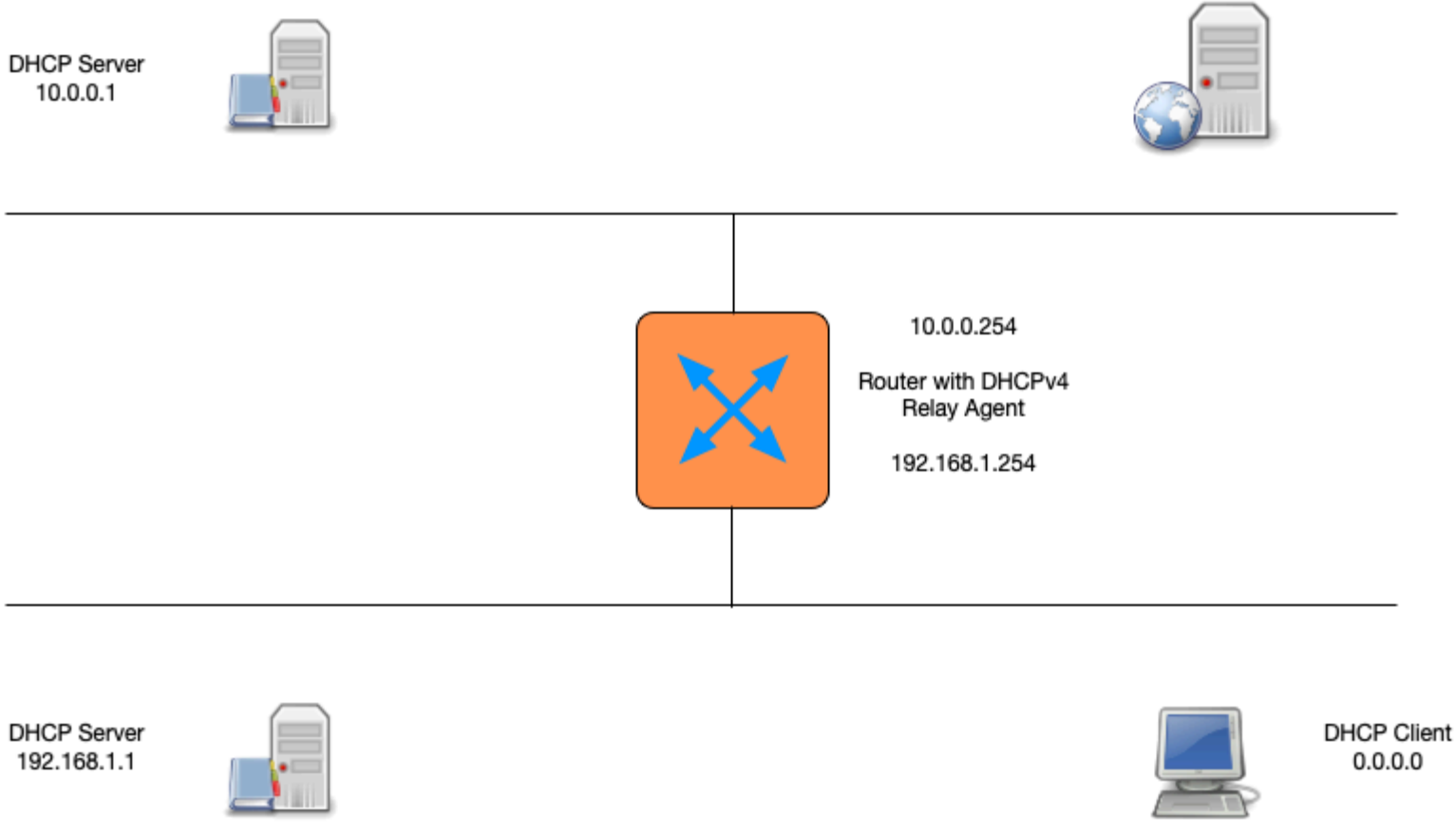


DHCP messages and client server communication

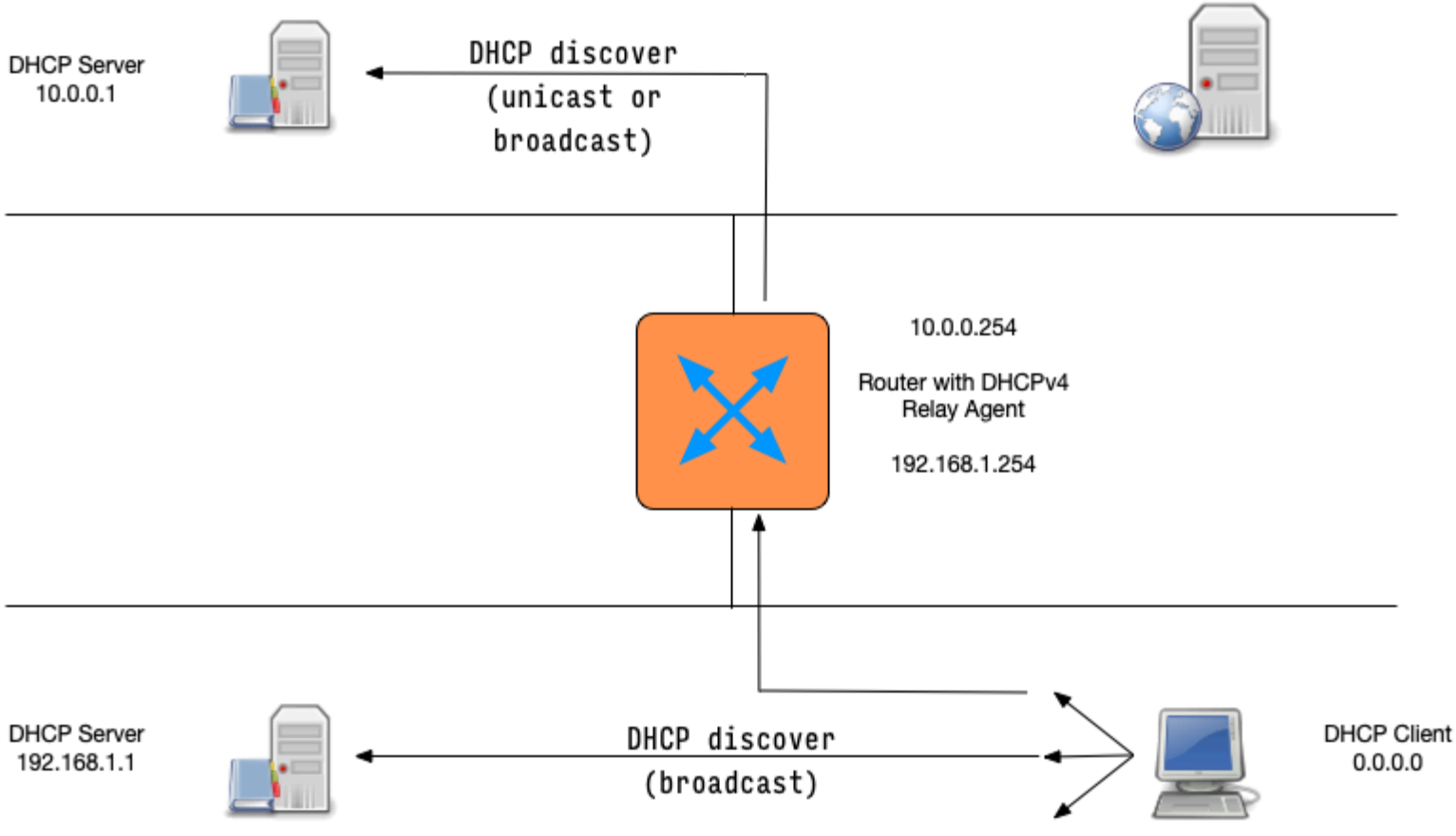
- **DHCPDISCOVER** (client asks: is there a DHCP server that can give me an address)
- **DHCPOFFER** (DHCP server offers an address to the client)
- **DHCPREQUEST** (client requests the IP address offered by the server)
- **DHCPACK** (server marks the IP address as *leased* and confirms that transaction)

This communication is sometimes called **DORA** (Discover - Offer - Request - Ack)

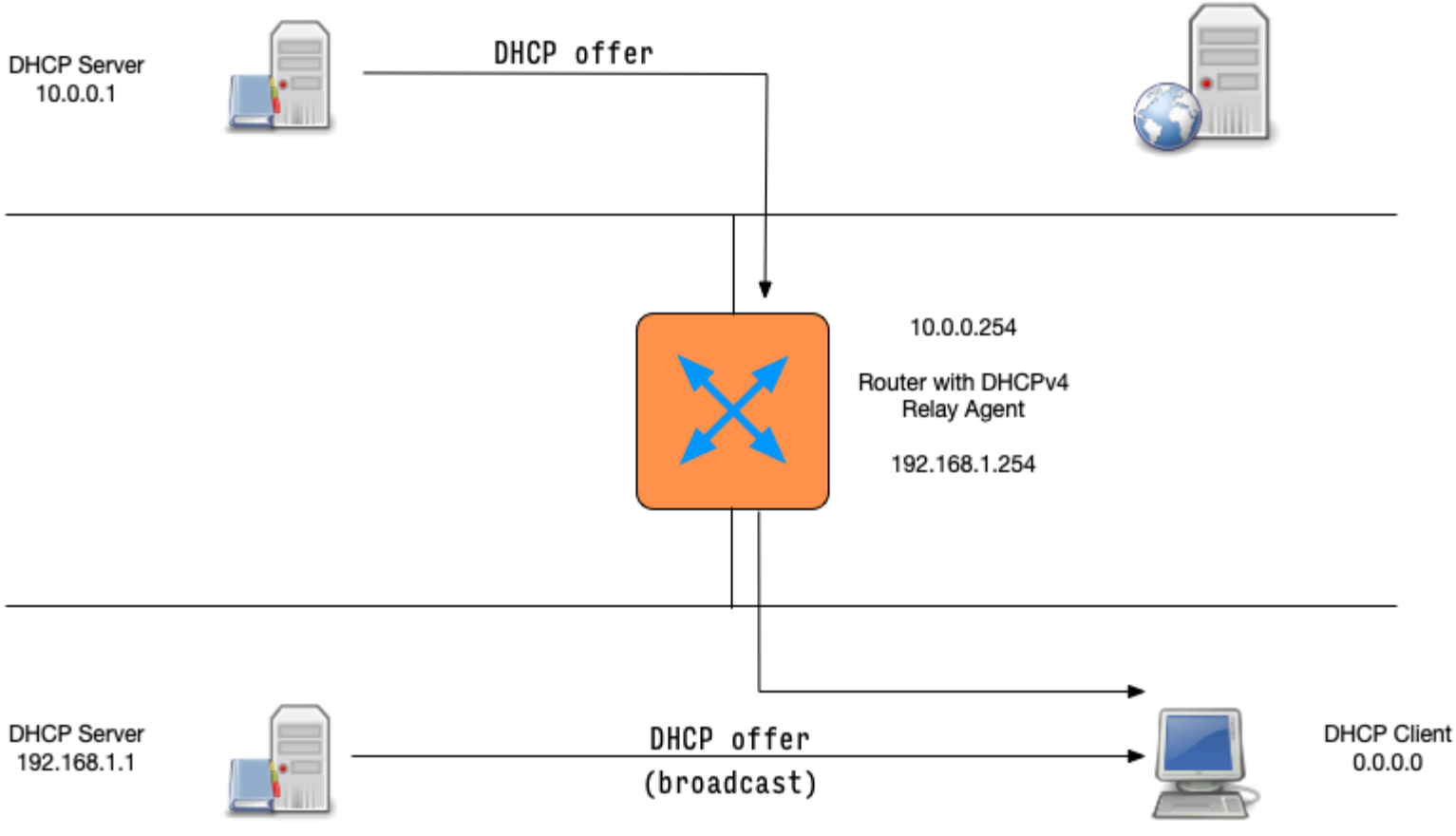
DHCP messages (1)



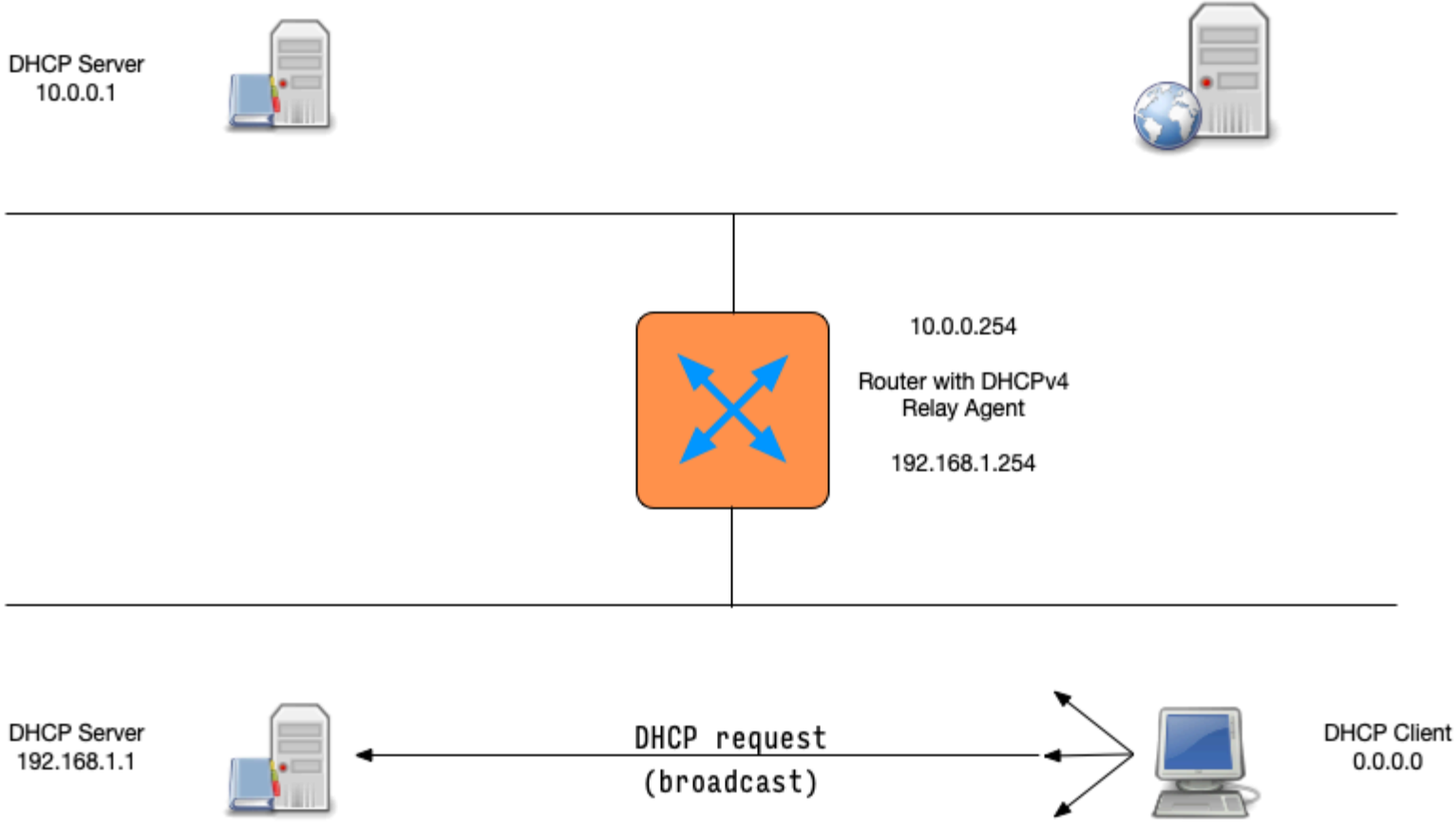
DHCP messages (2)



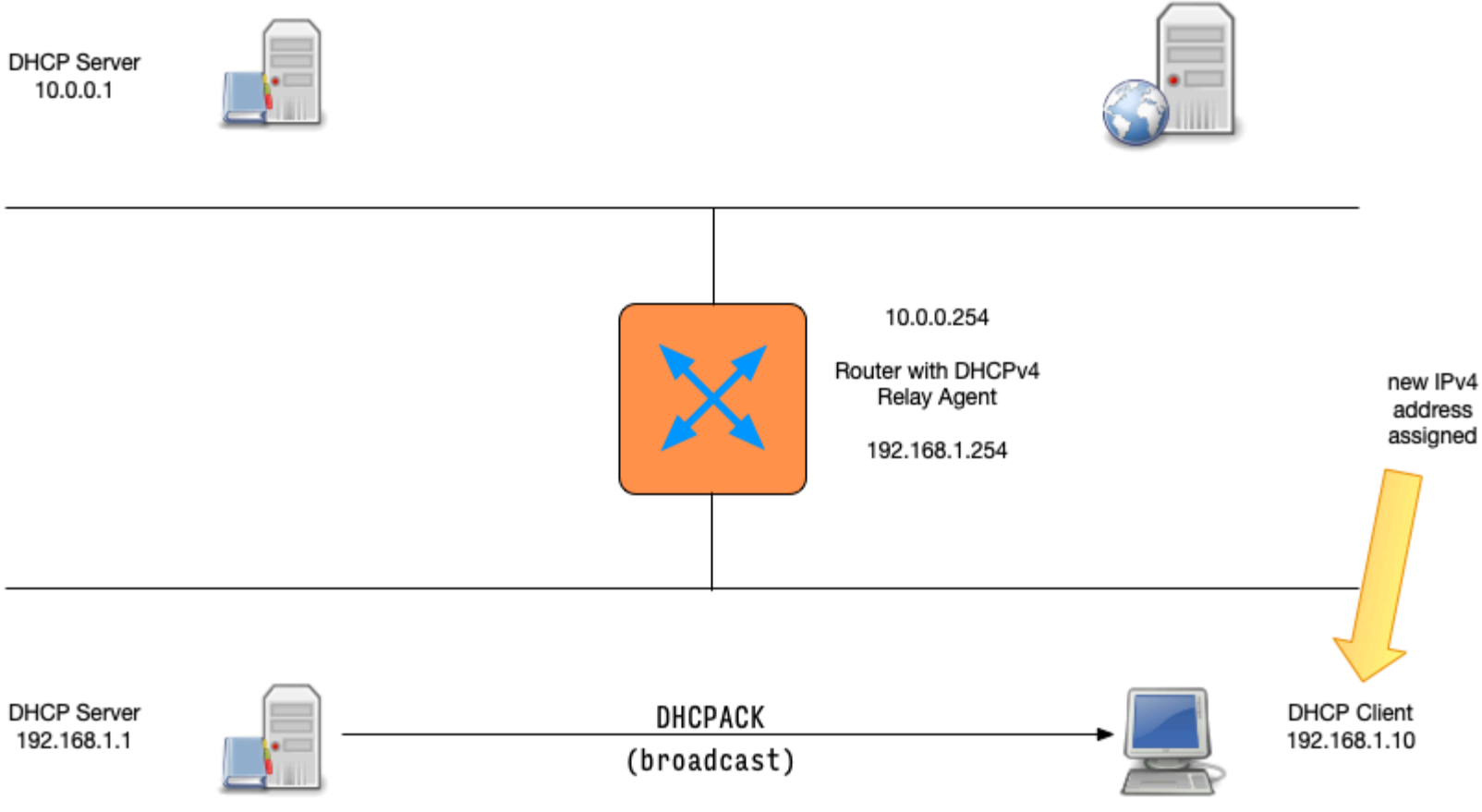
DHCP messages (3)



DHCP messages (4)



DHCP messages (5)

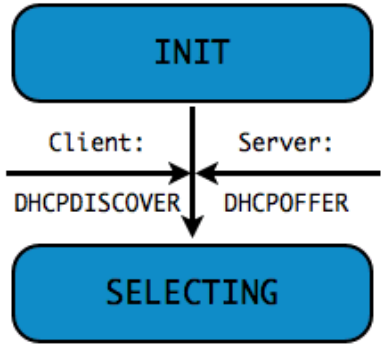


DHCPv4 client states

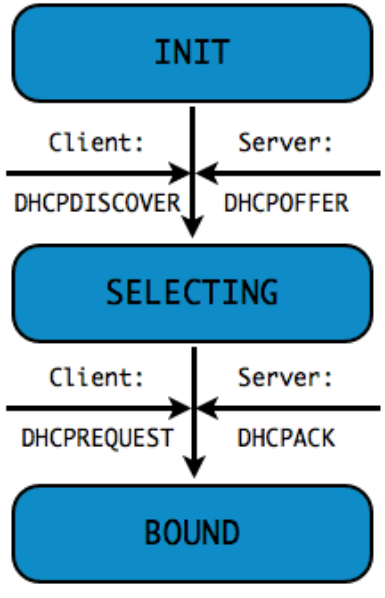
- A DHCP Client goes through a defined number of "states" when requesting or renewing a lease
    - `INIT-REBOOT`, `INIT`, `SELECTING`, `BOUND`, `RENEWING`, `REBINDING`

without IPv4 address (1/10)

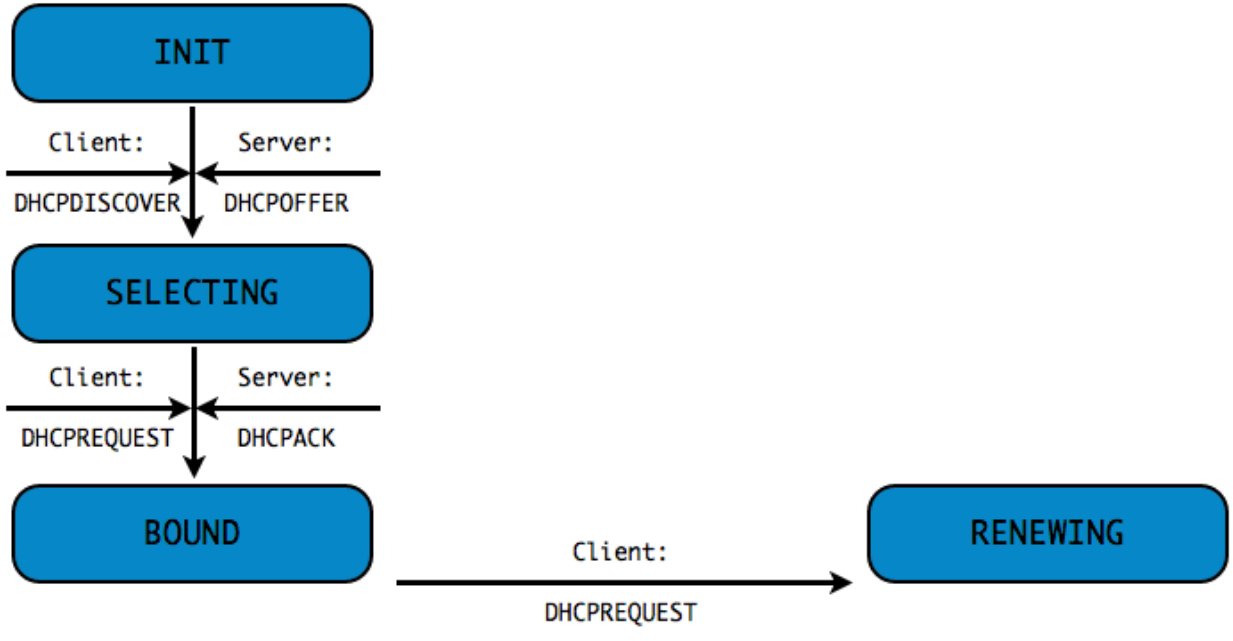
without IPv4 address (2/10)



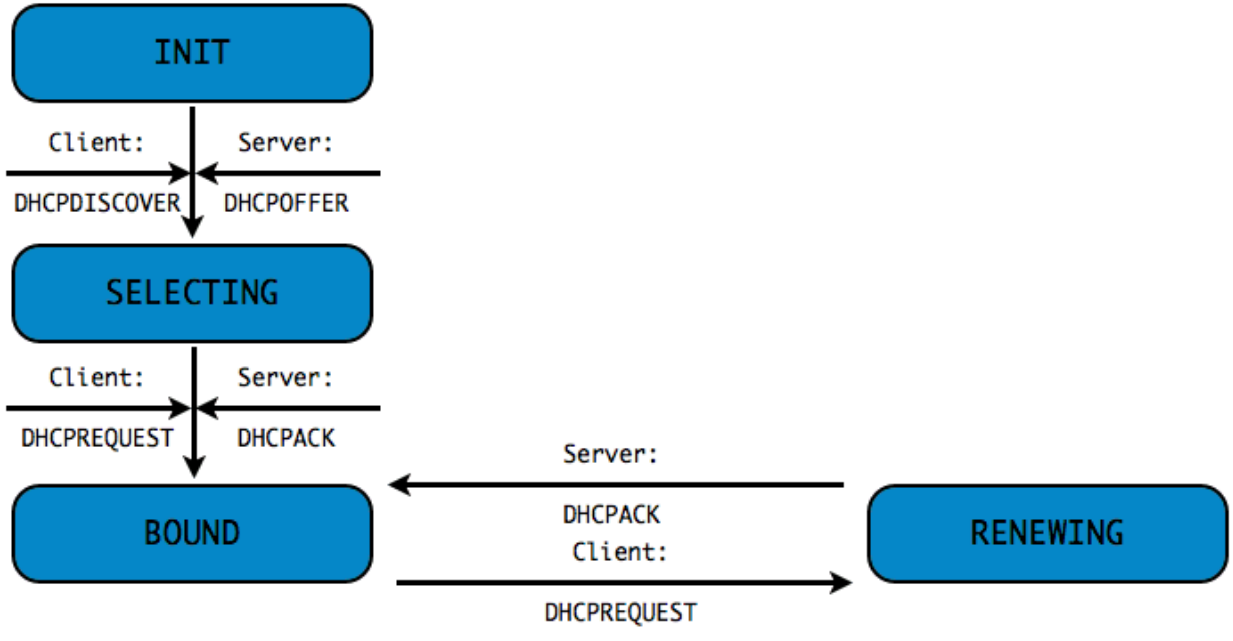
without IPv4 address (3/10)



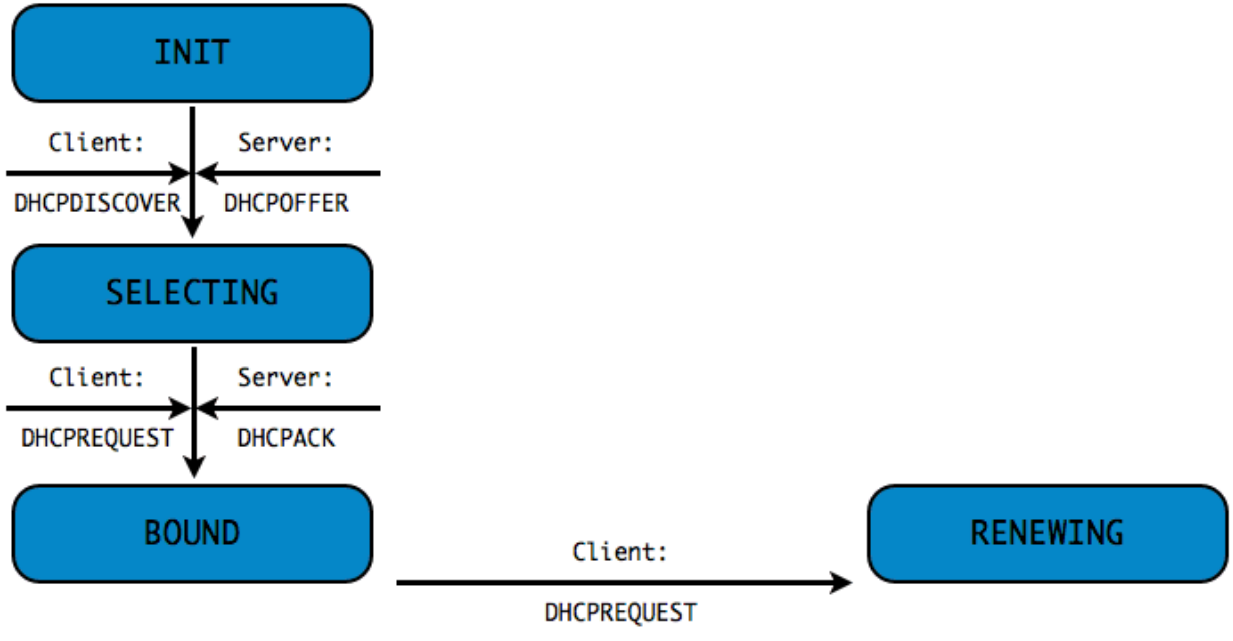
without IPv4 address (4/10)



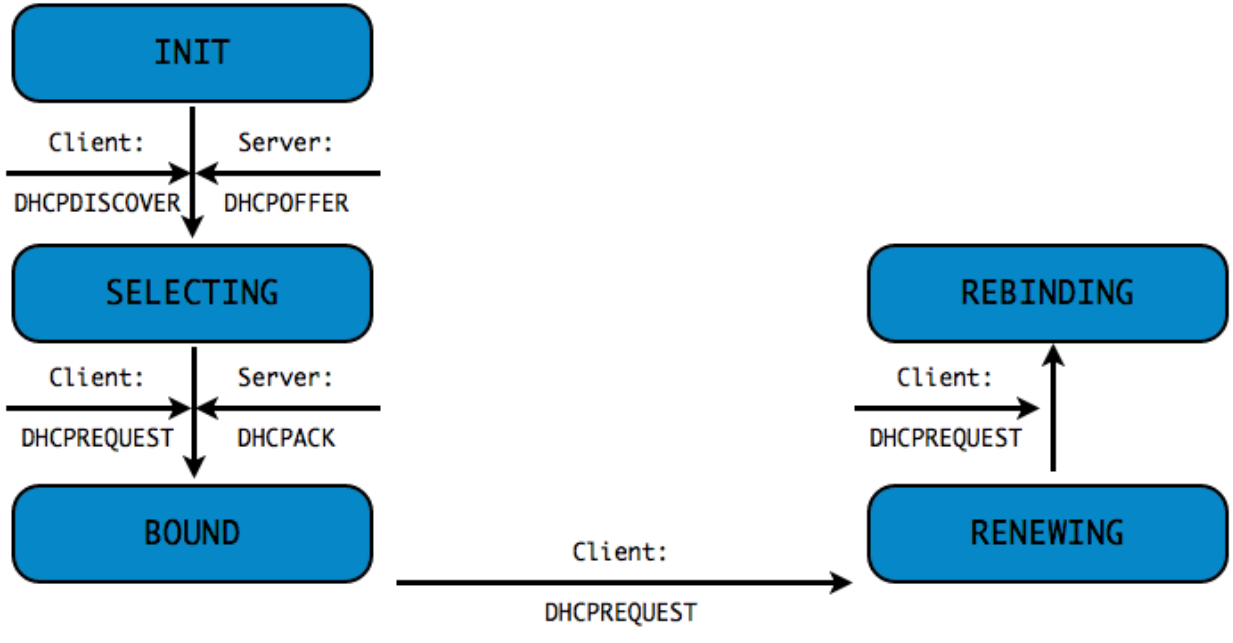
without IPv4 address (5/10)



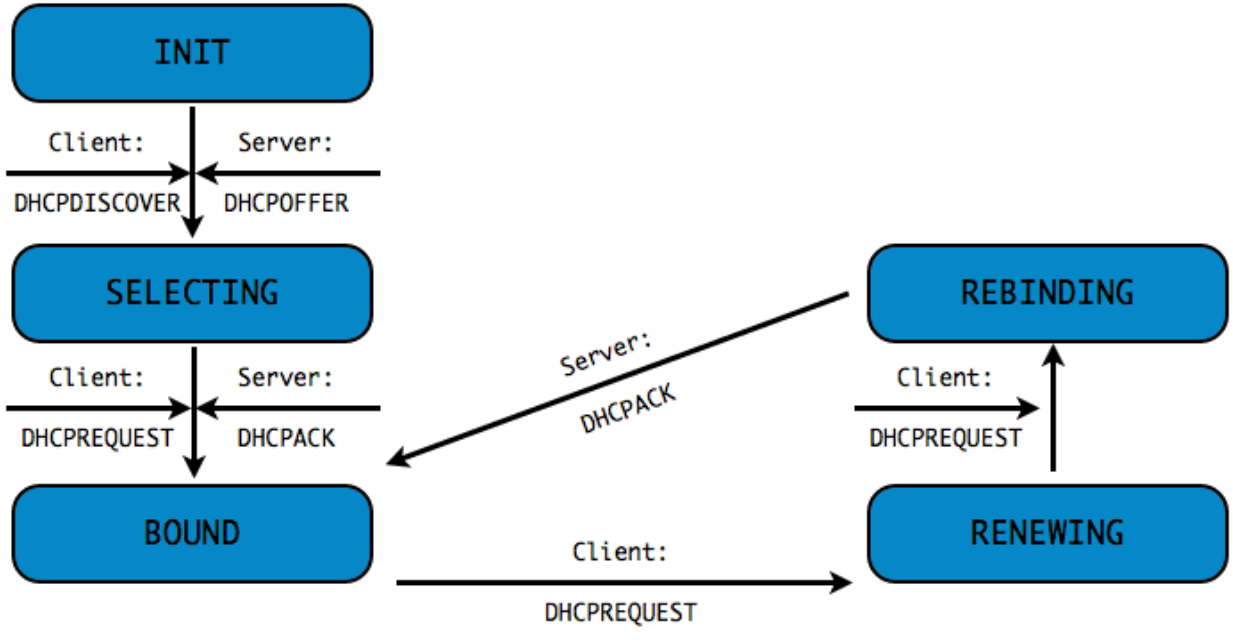
without IPv4 address (6/10)



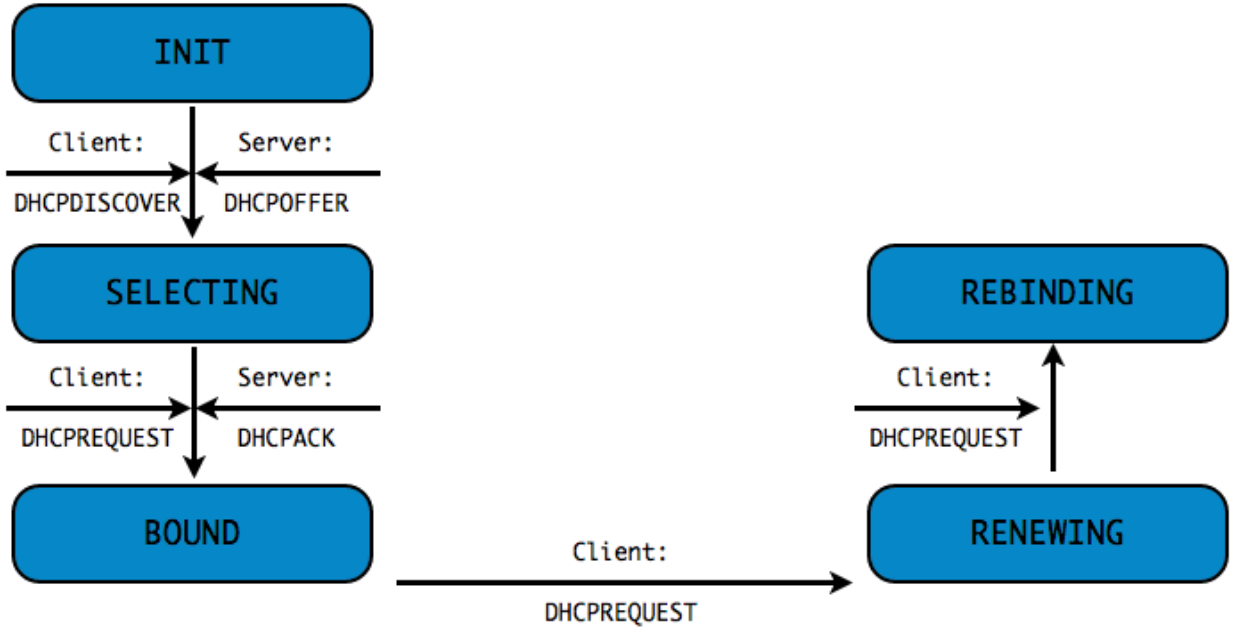
without IPv4 address (7/10)



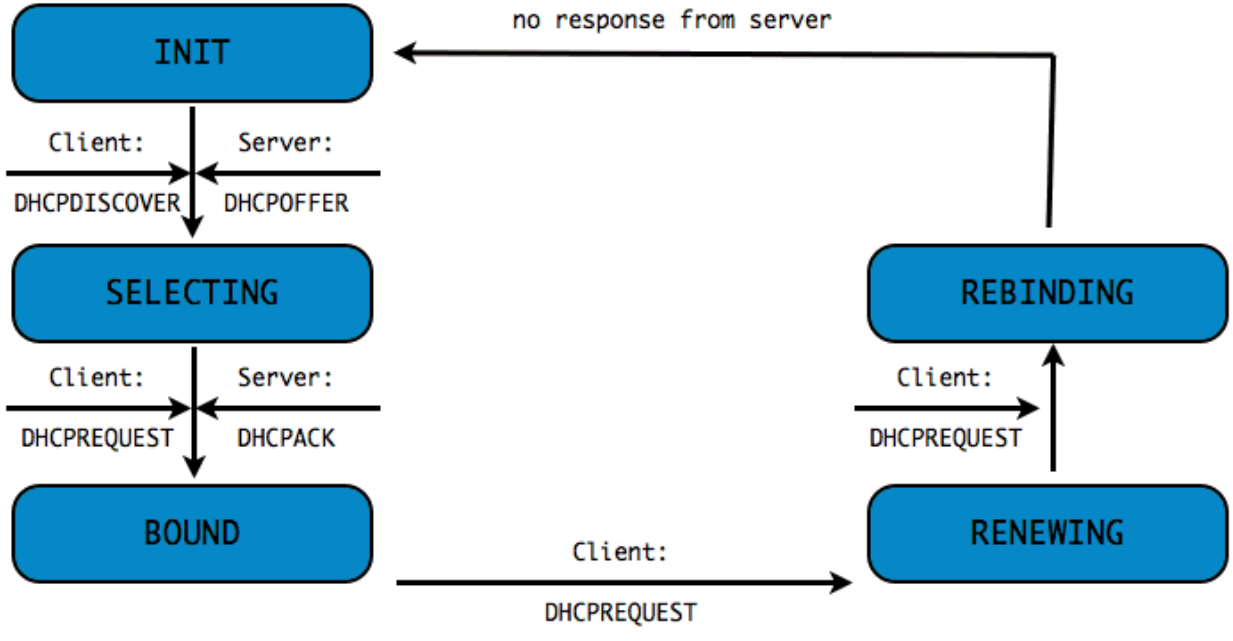
without IPv4 address (8/10)



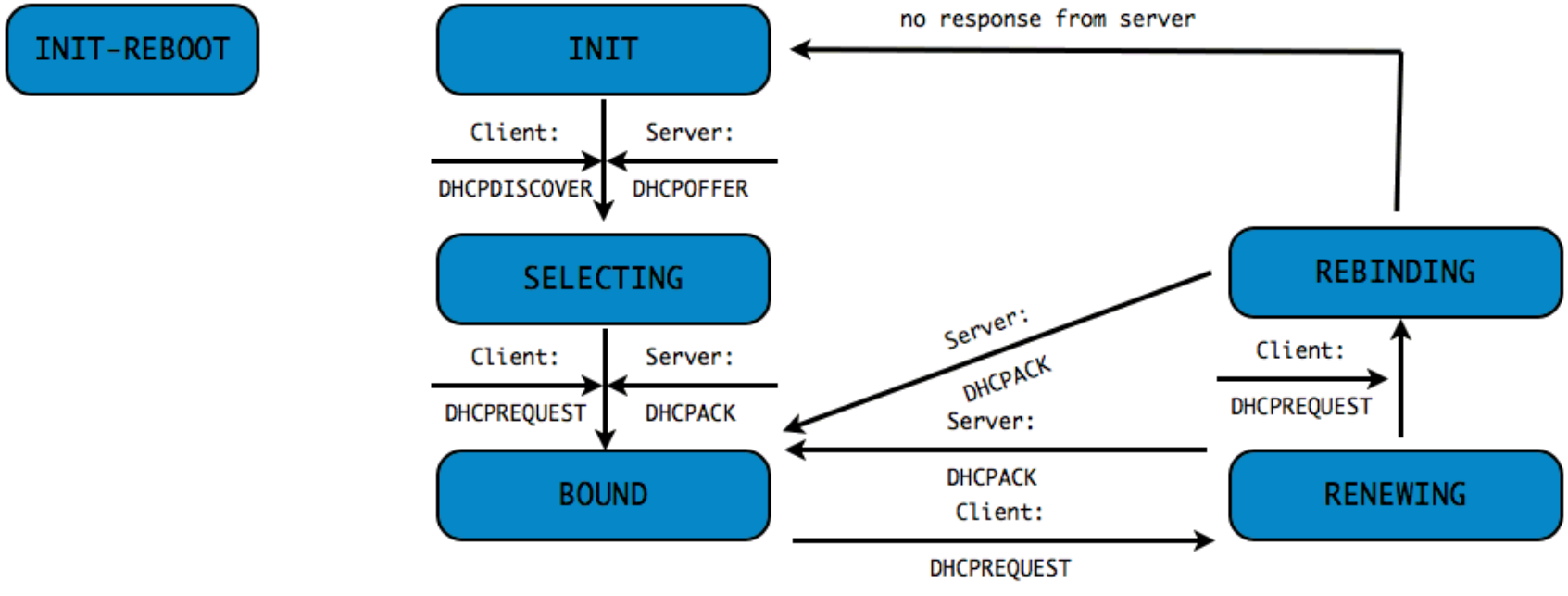
without IPv4 address (9/10)



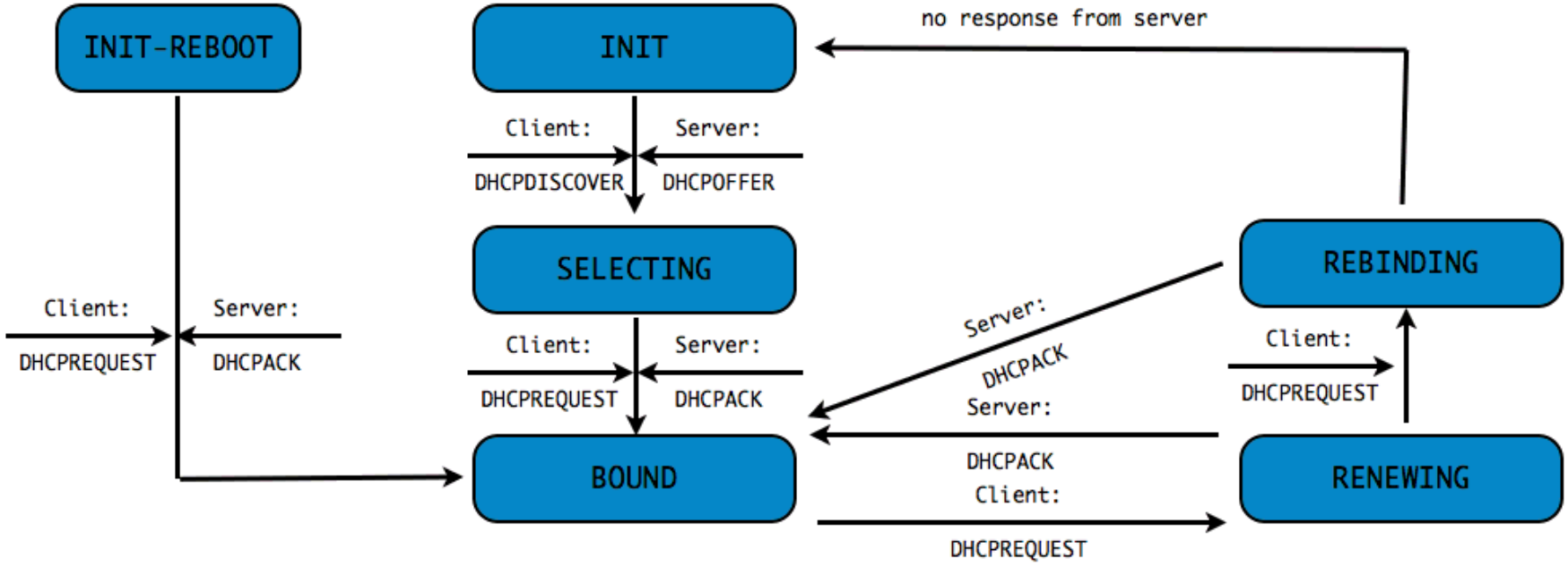
without IPv4 address (10/10)



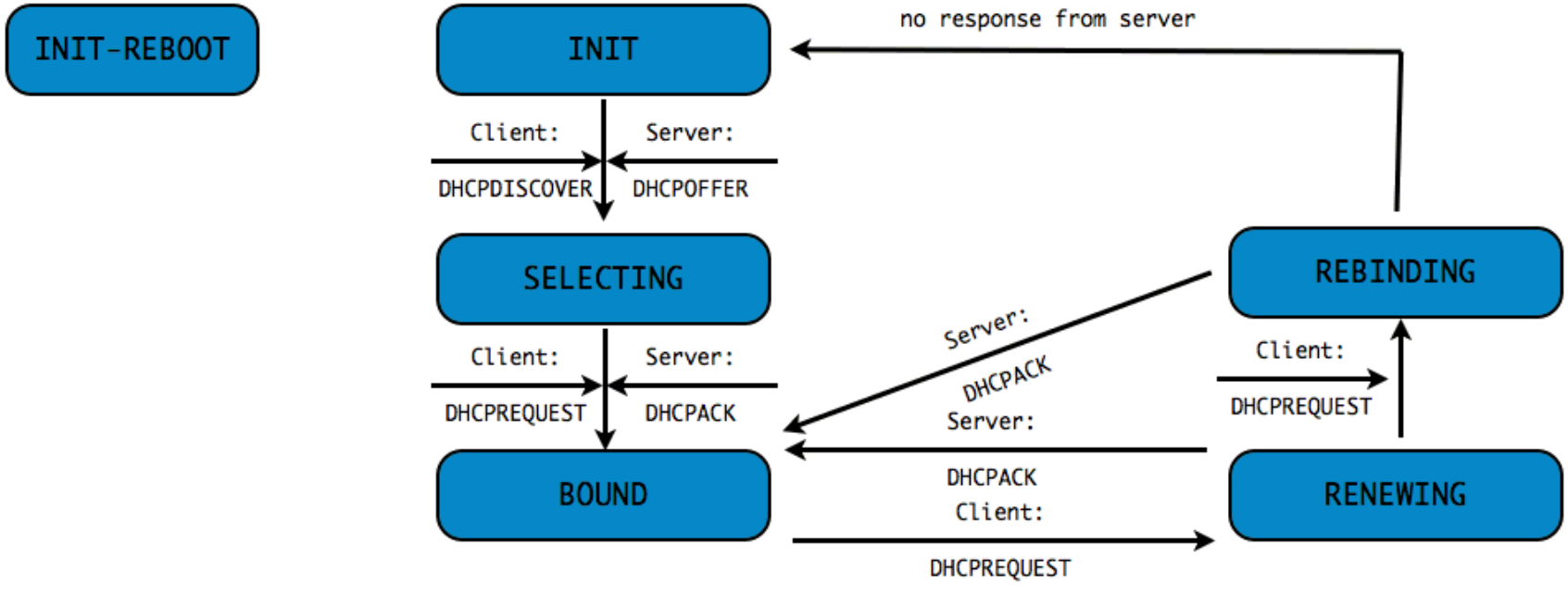
with IPv4 address (1/4)



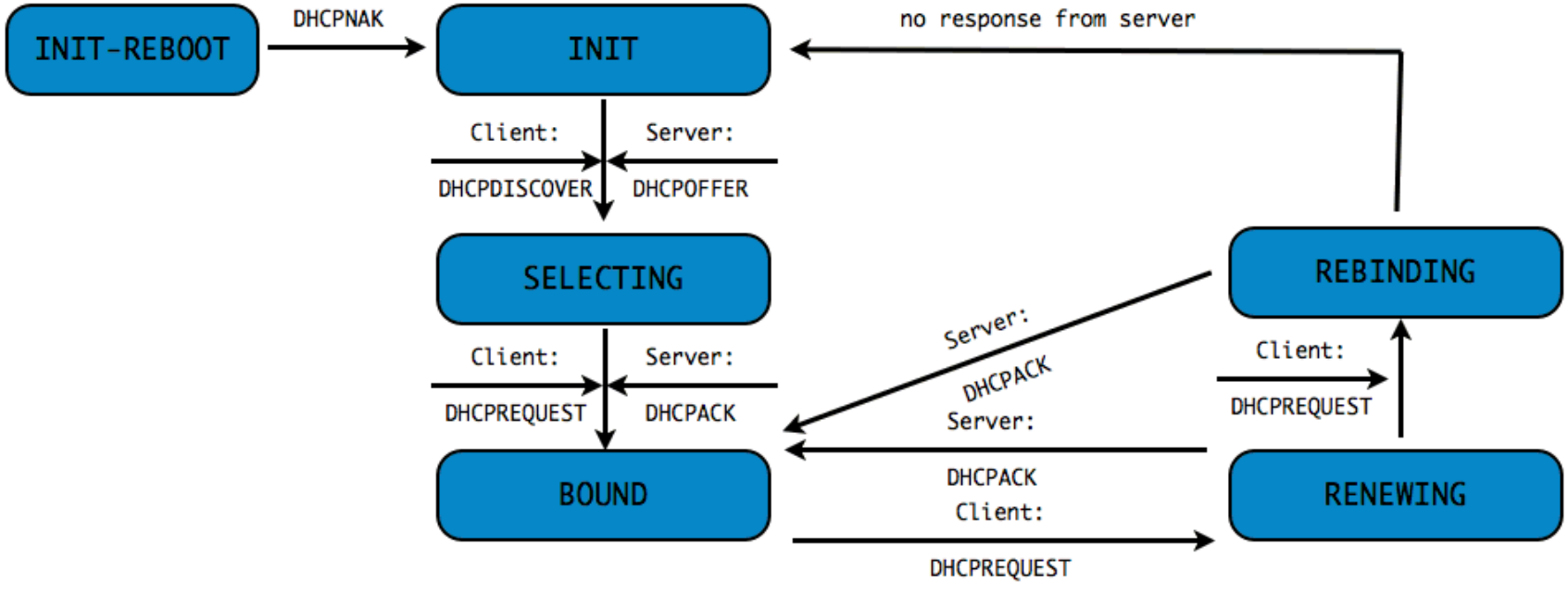
with IPv4 address (2/4)



with IPv4 address (3/4)



with IPv4 address (4/4)



Distributing network configuration with DHCP

BOOTP fields and DHCPv4 Options

- In addition to an IP address, DHCPv4 can be used to network configuration to a client
    - BOOTP configuration fields like `next-server` or `boot-file-name`
    - DHCPv4 options like `domain-name-servers` or `domain-search`

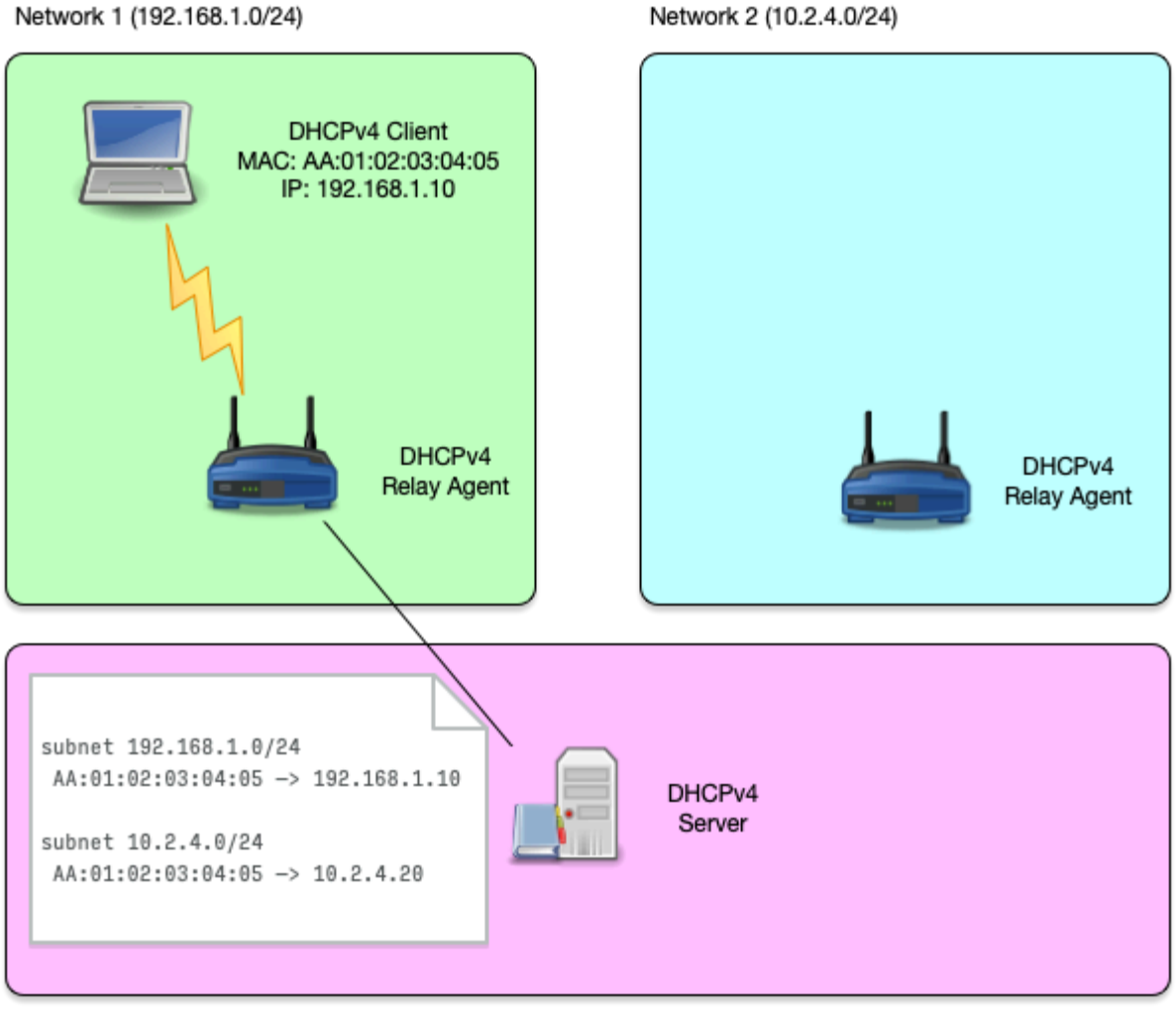
Host reservations

Host reservation (1/3)

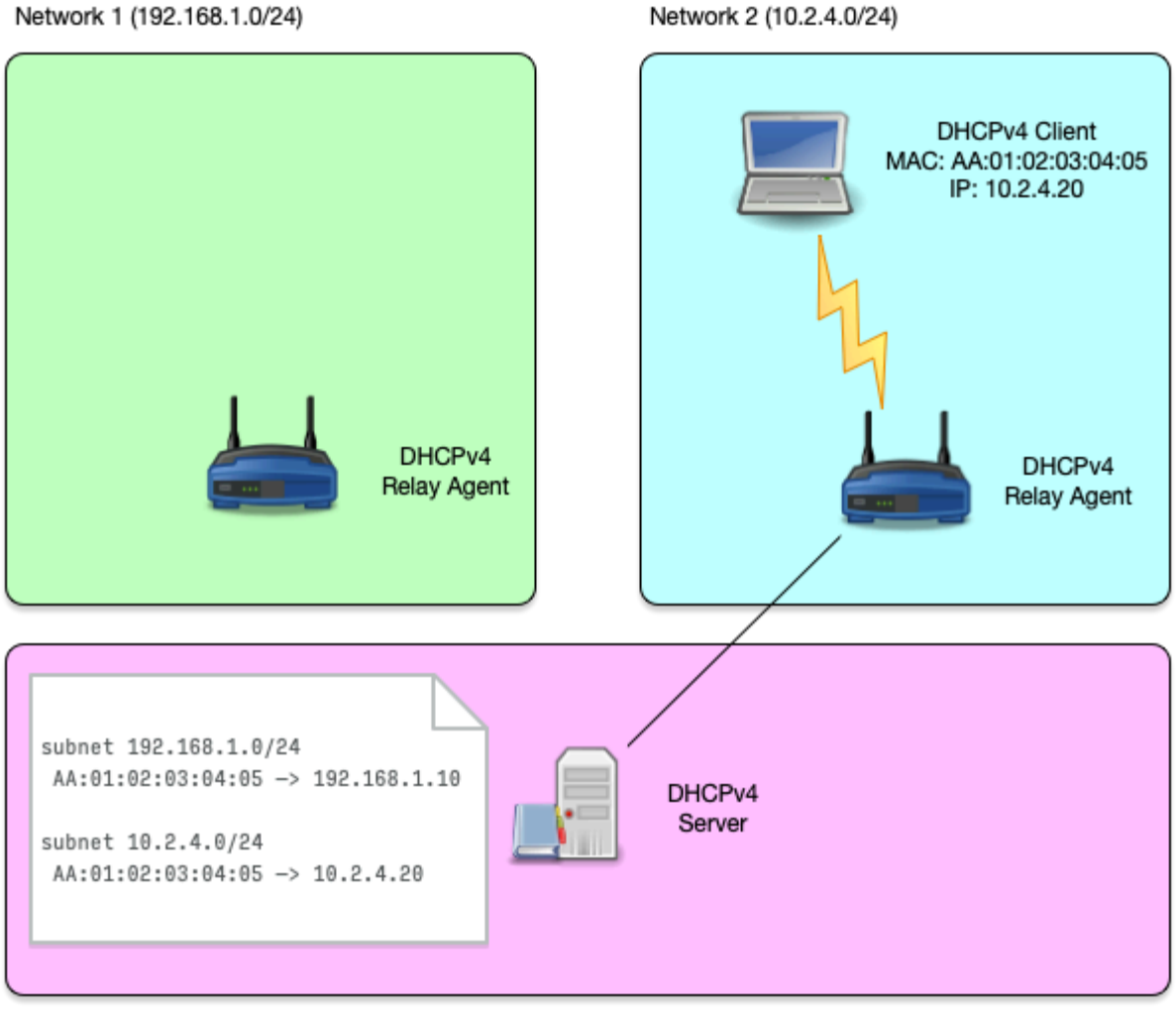
- Sometimes a DHCP IP address should always be given to the same DHCP client machine
    - For example if that machine receives incoming connections (web-server, printer, database)
    - Or if firewall rules define a security policy based on the IP address

- A **host reservation** binds a DHCP client via a client identifier (Ethernet MAC address) to an IP address

Host reservation (2/3)


Network 1 (192.168.1.0/24)
Network 2 (10.2.4.0/24)
DHCPv4 Client
MAC: AA:01:02:03:04:05
IP: 192.168.1.10
DHCPv4
Relay Agent
DHCPv4
Relay Agent
subnet 192.168.1.0/24
AA:01:02:03:04:05 -> 192.168.1.10
subnet 10.2.4.0/24
AA:01:02:03:04:05 -> 10.2.4.20
DHCPv4
Server

Host reservation (3/3)


Network 1 (192.168.1.0/24)
Network 2 (10.2.4.0/24)
DHCPv4 Client
MAC: AA:01:02:03:04:05
IP: 10.2.4.20
DHCPv4
Relay Agent
DHCPv4
Relay Agent
subnet 192.168.1.0/24
AA:01:02:03:04:05 -> 192.168.1.10
subnet 10.2.4.0/24
AA:01:02:03:04:05 -> 10.2.4.20
DHCPv4
Server

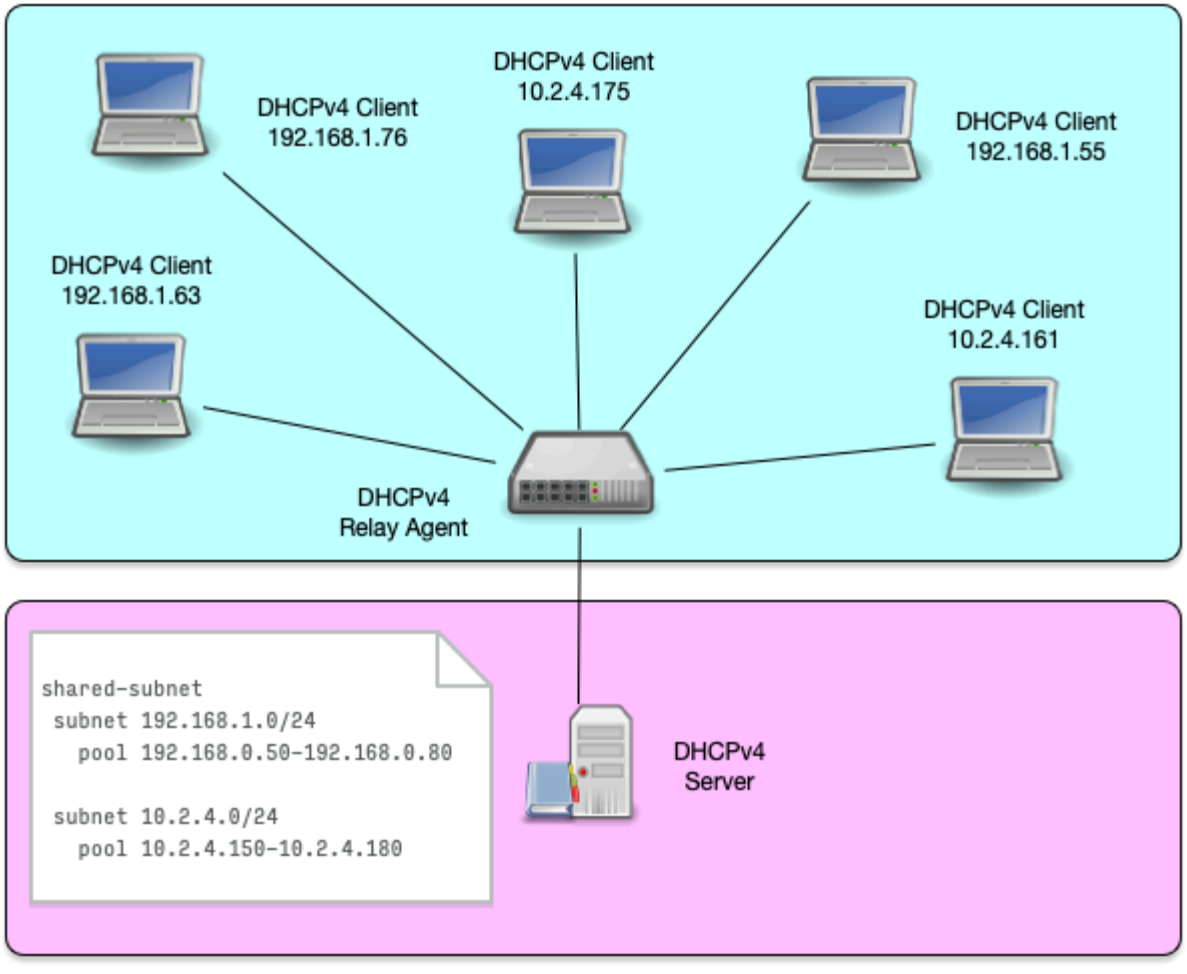
Shared Subnet

Shared Subnet (1/8)

- A **shared subnet** is a physical network with more than one DHCPv4 managed subnet inside
- Shared subnet are sometimes created if a larger number of IP addresses are needed in a network, but because of IPv4 address shortage no contiguous range of IPv4 addresses are available

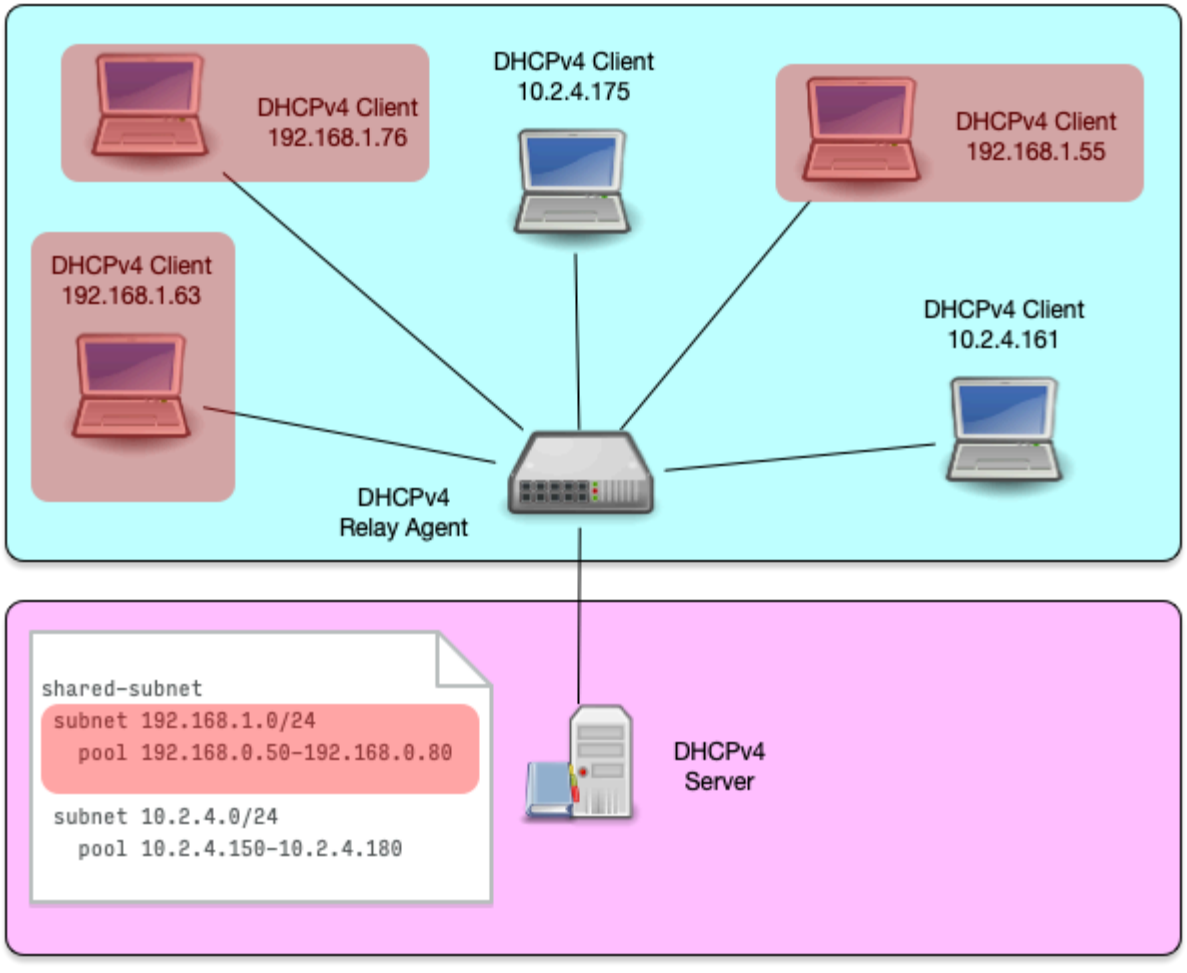
Shared Subnet (2/8)

Subnet 1 (192.168.1.0/24) and Subnet 2 (10.2.4.0/24)



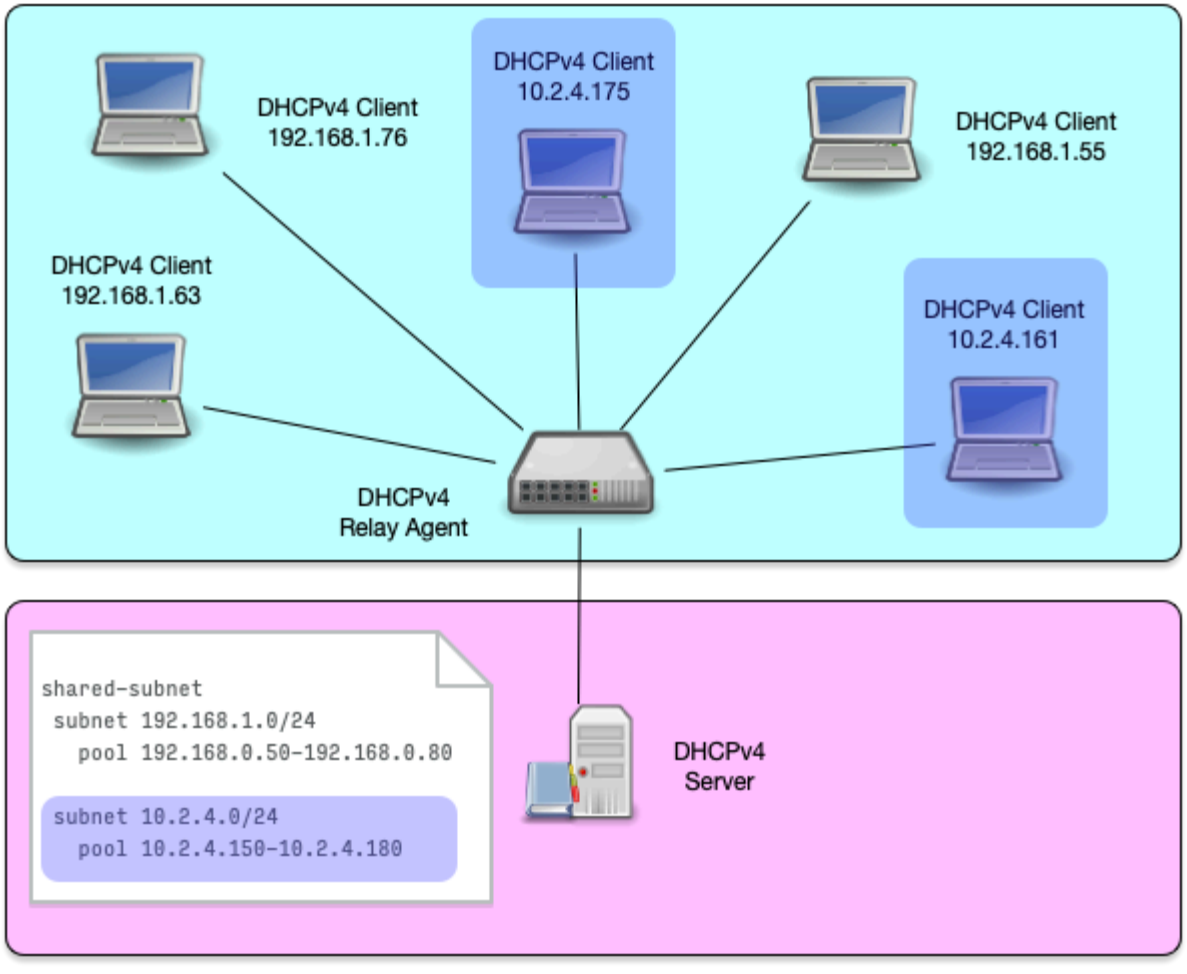
Shared Subnet (3/8)

Subnet 1 (192.168.1.0/24) and Subnet 2 (10.2.4.0/24)



Shared Subnet (4/8)

Subnet 1 (192.168.1.0/24) and Subnet 2 (10.2.4.0/24)

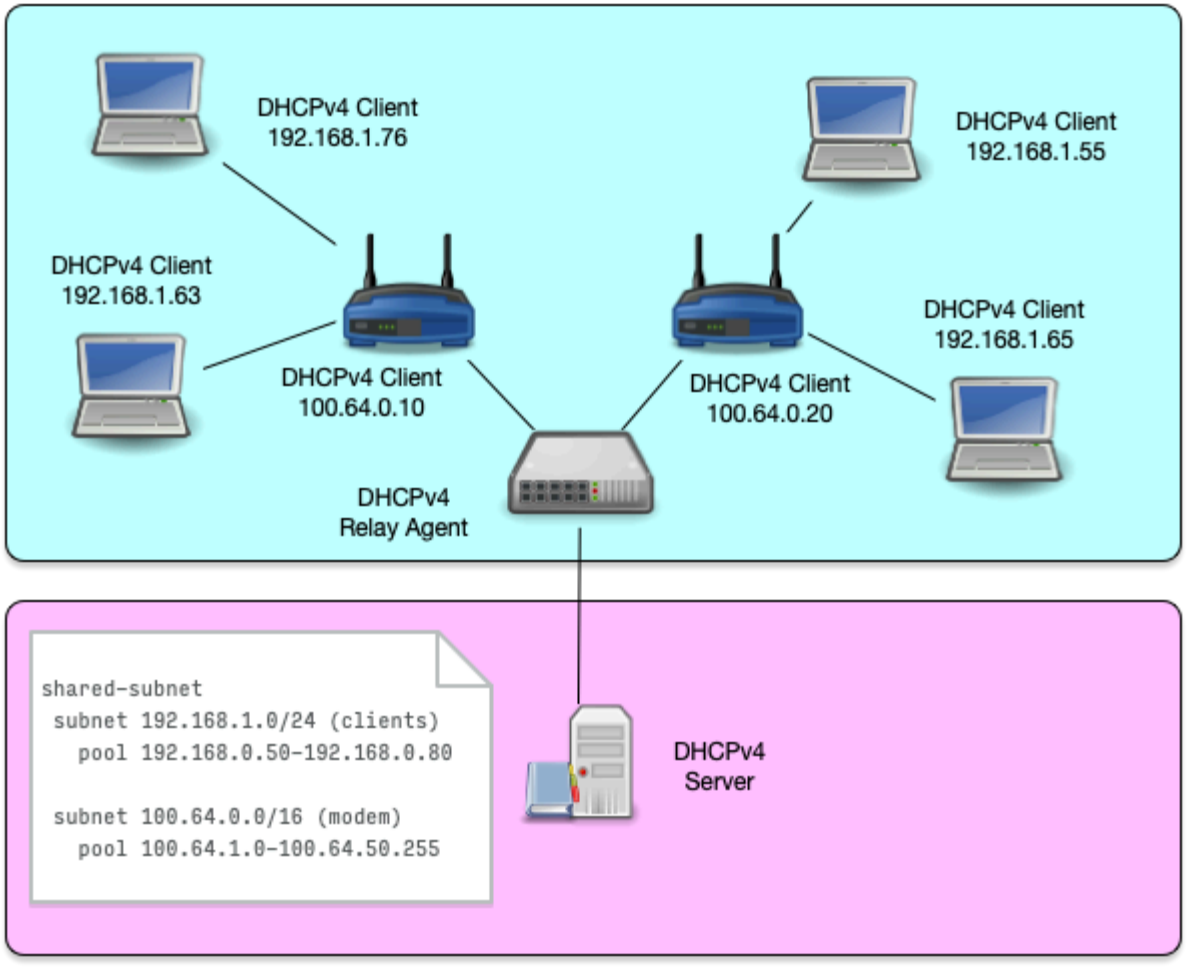


Shared Subnet (5/8)

- Another use case of **shared subnets** is a network where addresses from different IPv4 subnets (and possibly different network configuration) should be given to different network devices
    - Cable modems and end user devices
    - Printer, desktop and mobile devices
    - POS terminals and retail infrastructure devices (digital price tags)

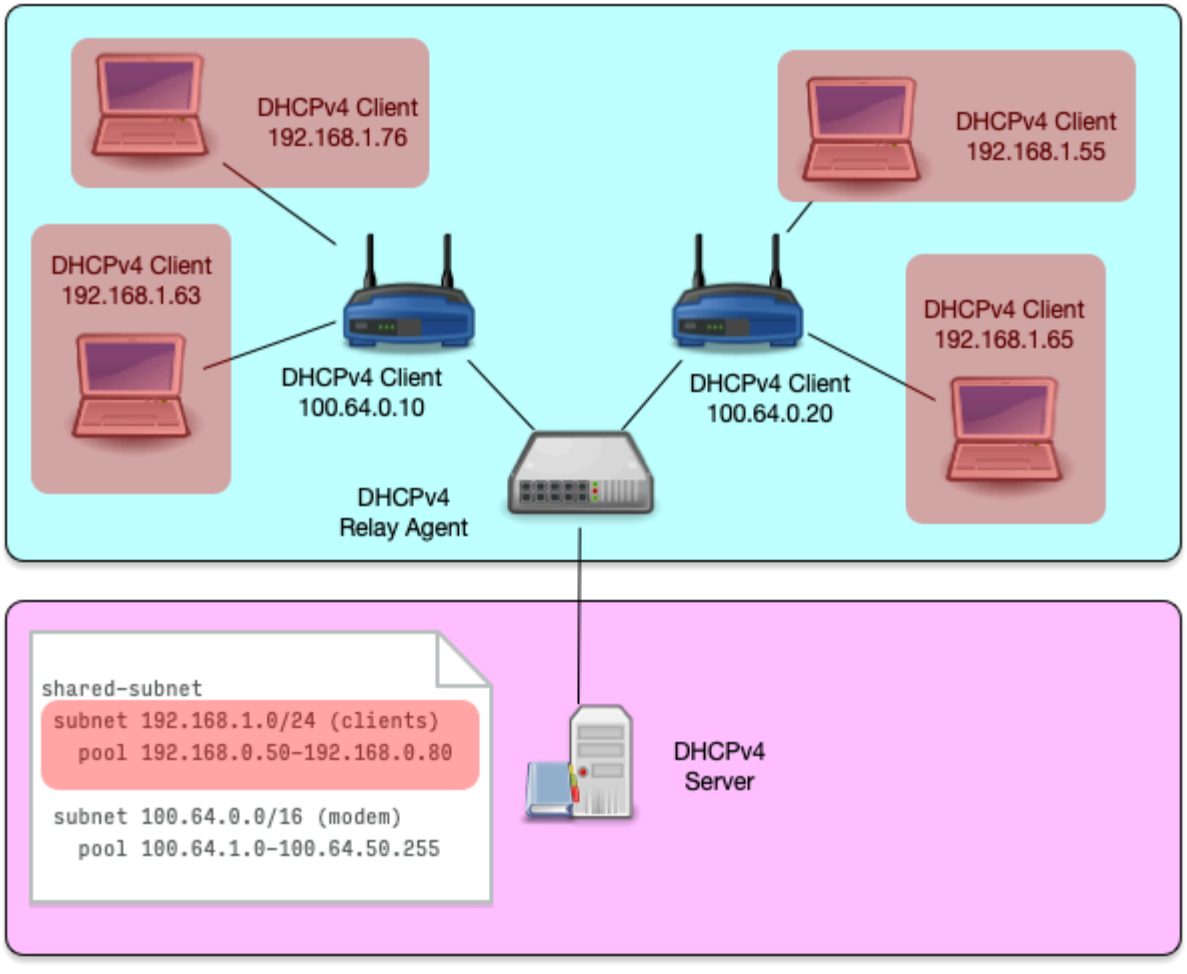
Shared Subnet (6/8)

Subnet 1 (192.168.1.0/24) and Subnet 2 (100.64.0.0/16)



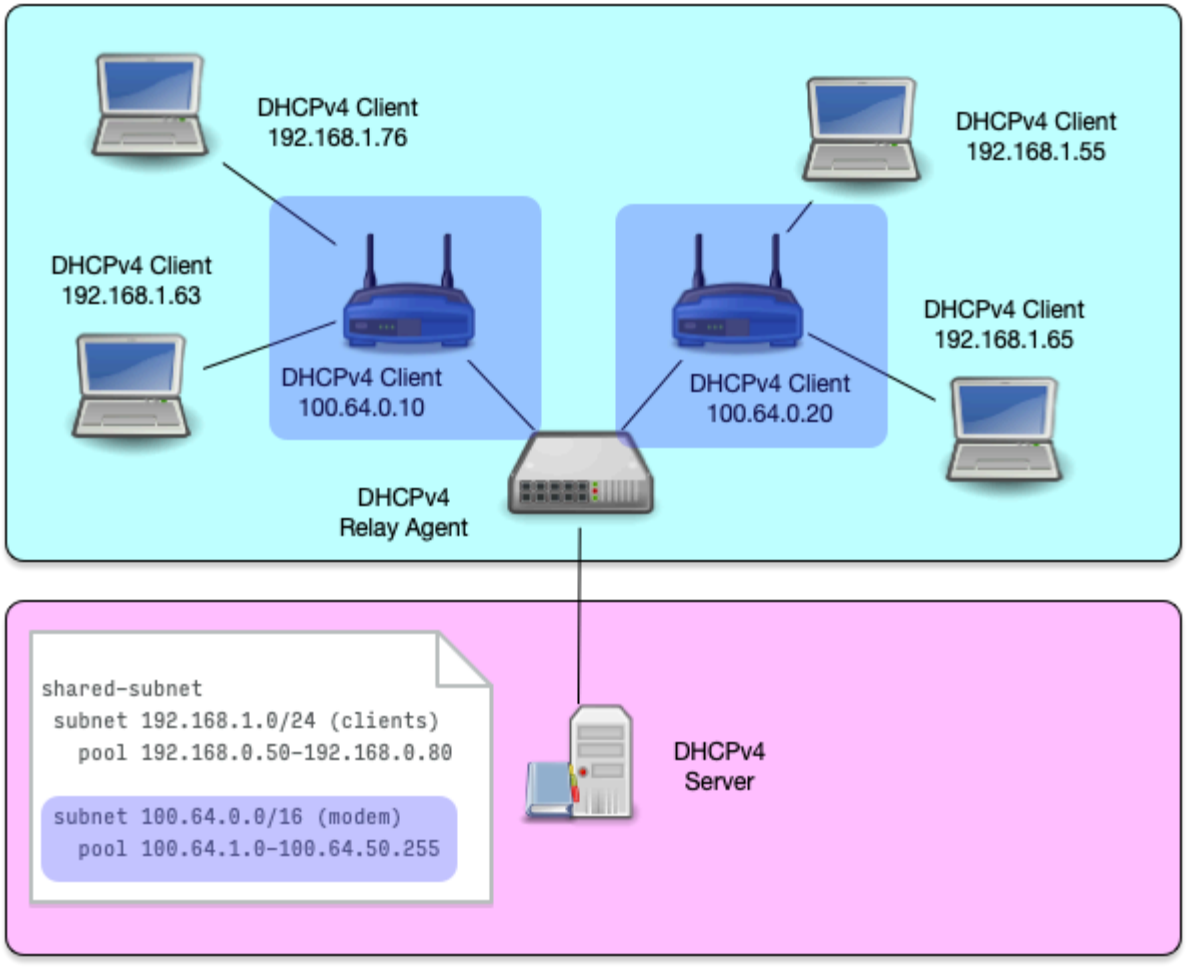
Shared Subnet (7/8)

Subnet 1 (192.168.1.0/24) and Subnet 2 (100.64.0.0/16)



Shared Subnet (8/8)

Subnet 1 (192.168.1.0/24) and Subnet 2 (100.64.0.0/16)



References: RFCs, Books, recommended Webpages

Internet Standards

- DHCPv4
  - RFC 2131 - DHCPv4 Dynamic Host Configuration Protocol
  - RFC 2132 - DHCP Options and BOOTP Vendor Extensions
  - RFC 3396 - Encoding Long Options in the Dynamic Host Configuration Protocol (DHCPv4)
  - RFC 4361 - Node-specific Client Identifiers for Dynamic Host Configuration Protocol Version Four (DHCPv4)
  - RFC 6842 - Client Identifier Option in DHCP Server Replies
- DHCPv6
  - RFC 8415 - Dynamic Host Configuration Protocol for IPv6 (DHCPv6)

Books

- The DHCP Handbook - Understanding, Deploying, and Managing Automated Configuration Services (Ralph Droms, Ted Lemon) 1999
- IP Address Management - Principles and Practice (Timothy Rooney) 2011
- The TCP/IP Guide - A Comprehensive, Illustrated Internet Protocols Reference (Charles M. Kozierok) 2005
- Windows Server 2019 Inside Out (Orin Thomas)

Websites

- ISC Kea Documentation - https://kea.readthedocs.io/en/latest/
- ISC Knowledgebase - https://kb.isc.org/
- The TCP Guide - http://www.tcpipguide.com/
- Microsoft - Dynamic Host Configuration Protocol (DHCP) https://docs.microsoft.com/en-us/windows-server/networking/technologies/dhcp/dhcp-top