Kea Webinar
DHCP introduction

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Welcome

• Welcome to part one of our webinar series "the KEA DHCP Server"
About this Webinar

• short history of DHCP
• DHCPv4
• DHCPv6
• References
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)

- initial DHCPv4 RFCs: 1993
- ISC DHCP Release 3.0: 1999
- first DHCPv6 RFC (3315): 2003
- DHCPv6 support in ISC DHCP: 2007
- KEA development starts: 2010
- KEA DHCP Version 1.0: 2015
- current DHCPv6 RFC (8415): 2018
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 (3/3)

- according to the RFC, a DHCP server must store the lease information to permanent storage before giving the IP address to a client
- this can be a performance bottleneck on a DHCP server
- we will discuss the various options in one of the following webinars
DHCP Clients, Relays and 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)
DHCP messages (1)
DHCP messages (2)
DHCP messages (3)
DHCP messages (4)
DHCP messages (5)
DHCPv4 client states
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 (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
• we will cover the BOOTP fields and DHCPv4 options in our next webinar
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 a IP address
Host reservation (2/3)
Host reservation (3/3)
Shared Subnet
Shared Subnet

- 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 continuous range of IPv4 addresses are available.
Shared Subnet

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

```
shared-subnet
subnet 192.168.1.0/24
  pool 192.168.0.50-192.168.0.80

subnet 10.2.4.0/24
  pool 10.2.4.150-10.2.4.188
```
Shared Subnet

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

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

- 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

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

DHCPv4 Client 192.168.1.76

DHCPv4 Client 192.168.1.03

DHCPv4 Client 100.64.0.10

DHCPv4 Client 100.64.0.20

DHCPv4 Client 192.168.1.55

DHCPv4 Client 192.168.1.65

shared-subnet

subnet 192.168.1.0/24 (clients)
pool 192.168.8.50-192.168.8.80

subnet 100.64.0.0/16 (modem)
pool 100.64.1.0-100.64.99.255

DHCPv4 Server
Shared Subnet

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

Subnet 1 (192.168.1.0/24) and Subnet 2 (100.64.0.0/16)
DHCPv6
DHCPv6

• from a birds-eye view, **DHCPv6** works the same way as DHCPv4
• in the details, it is all different
• **DHCPv6** is not an upgrade to DHCPv4, it is a protocol of its own
DHCPv6 IP based vs. DHCPv4 Layer2/Ethernet based (use of link-local addresses)

- DHCPv6 is solely a Layer 3 protocol
- a DHCPv6 client already has a working link-local IPv6 address (fe80::) when sending the first DHCPv6 request
- no "low-level kernel trickery" required
DHCPv6 protocol (port numbers, communication)

- DHCPv6 Servers and Relay-Agents listen on Port 547 (UDPv6)
- DHCPv6 clients listen on Port 546 (UDPv6)
DHCPv6 multicast usage and addresses

- DHCPv6 clients communicate using link-local multicast addresses
  - All-DHCP-Relay-Agents-and-Servers (ff02::1:2)
  - All-DHCP-Servers (ff05::1:3)
the role of router in DHCPv6

• DHCPv6 has been designed to provide it's service in cooperation with the local router(s)
• DHCPv6 must be enabled in the router configuration (M-Flag or O-Flag)
• The Default-Gateway Address will be retrieved from a router and **not** from the DHCPv6 Server
Router in DHCPv6 (1/2)
Router in DHCPv6 (1/2)
DHCPv6 address allocation vs. DHCPv4 address allocation

• DHCPv6 server must issue IP Addresses randomly from the available address pool
• some DHCPv4 server products issue IP Addresses continuously
• The DHCPv6 scheme makes it harder to guess an IP Address or scan a network segment
DHCPv6 allocation types: non-temporary, temporary, multiple addresses, prefix-delegation

• a DHCPv6 client can send different kind of IP address requests
  • **non-temporary**: an address that will always be given to this client if available. This is similar to an DHCPv4 address request.
  • **temporary**: an address that will always change on each request and has a low lease time. Used by the client for outgoing connections for privacy reasons
  • **multiple**: a client can request multiple IP addresses from the DHCPv6 server
  • **prefix delegation**: a client that is a router and also a DHCPv6 server itself can request one or more IPv6 prefix networks from an upstream DHCPv6 server
  • this allows for an hierarchical DHCPv6 configuration
DHCPv6 in combination with SLAAC

- IPv6 support Stateless Automatic Automatic Address Configuration aka **SLAAC**
- **SLAAC** can be used as an alternative to **DHCPv6**
- **SLAAC** and **DHCPv6** can be combined
DHCPv6 - stateless vs. stateful

• There are two different ways to get an IPv6 address for a IPv6 enabled device
  • Stateless configuration
  • Stateful configuration
DHCPv6 - stateless vs. stateful

- **Stateless** configuration
  - The IPv6 address will be determined without a DHCP Server (IPv6 auto-configuration = SLAAC)

- **Stateful** configuration
  - The IPv6 address will be received from a DHCPv6 Server
  - In both cases additional configuration parameters (DNS Server etc) can be retrieved by DHCPv6
DHCPv6 advertise message
DHCPv6 advertise (via relay)
DHCPv6 request
DHCPv6 reply
DHCPv6 client assigns a new IPv6 address
Identity Association (IA)

• An Identity Association (IA) is a construct through which a server and a client can identify, group, and manage a set of related IPv6 addresses (or delegated prefixes)
• Each IA consists of an IAID (Identity Association ID) and associated configuration information
• if a client has more than one network interface, every interface will be associated with one distinct IAID
Identity Association (IA)

- DHCPv6 clients can receive temporary and non-temporary addresses
  - temporary addresses are used for communication with outside, untrusted networks (like the Internet)
  - temporary addresses cannot be used to track a client, they are created randomly and change often
  - non-temporary addresses are stable and can be used to track a client machine (non-temporary addresses are used in trusted, internal networks)
- temporary and non-temporary (stable) IPv6 addresses are managed with the help of IAIDs
DHCPv6 client states

Init
DHCPv6 client states

- Init
  - Client: SOLICIT
  - Server: ADVERTISE

- Selecting
DHCPv6 client states

- **Init**
  - Client: SOLICIT
  - Server: ADVERTISE

- **Selecting**
  - Client: REQUEST
  - Server: REPLY

- **Bound**
DHCPv6 client states

- **Init**
  - Client: SOLICIT
  - Server: ADVERTISE

- **Selecting**
  - Client: REQUEST
  - Server: REPLY

- **Bound**

- **Renewing**
  - Client: RENEW
DHCPv6 client states

- **Init**
  - Client: SOLICIT
  - Server: ADVERTISE

- **Selecting**
  - Client: REQUEST
  - Server: REPLY

- **Bound**
  - Server: REPLY
  - Client: RENEW

- **Renewing**
DHCPv6 client states

- **Init**
  - Client: SOLICIT
  - Server: ADVERTISE

- **Selecting**
  - Client: REQUEST
  - Server: REPLY

- **Bound**
  - Client: RENEW

- **Rebinding**
  - Client: REBIND

- **Renewing**
DHCPv6 client states

Init

Selecting

Bound

Rebinding

Renewing

Client: SOLICIT  Server: ADVERTISE

Client: REQUEST  Server: REPLY

Server: REPLY

Client: REBIND

Client: RENEW
DHCPv6 client states

- **Init**
  - Client: SOLICIT
  - Server: ADVERTISE
  - No response from any server

- **Selecting**
  - Client: REQUEST
  - Server: REPLY

- **Bound**
  - Client: RENEW

- **Rebinding**
  - Client: REBIND

- **Renewing**
DHCPv6 rapid commit

- **rapid commit** speeds up the process of joining a network
- with "rapid commit" there is no information for the DHCPv6 server if the client is using the advertised IPv6 address
- the DHCPv6 server must reserve the IPv6 address for the full lease time
- this (temporary) squandering of IPv6 addresses is usually not a problem because of the large size of IPv6 subnets (/64 prefixes)
DHCPv6 rapid commit

[Diagram showing the process of DHCPv6 rapid commit]
DHCPv6 rapid commit
DHCPv6 rapid commit

DHCPv6 server has stored the lease even if not used by the client.

2001:db8:200::1
Router with DHCPv6 Relay Agent
2001:db8:100::1
fe80::1bac:ff:fe2:18

new IPv6 address assigned

DHCPv6 server has stored the lease used by the client.

DHCP Server
2001:db8:100::546
fe80::ac0:bb:12ff:fe60:550b

DHCP Client
2001:db8:100::abca:cafe:1
fe80::226:bbff:fe05:1a4f

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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
Next Webinars

• 30th September - Kea DHCP - Installation and configuration
• 14th October - Kea DHCP - Lease allocation, client classification, and option assignment
• 28th October - Kea DHCP - High Availability and Database Backends
• 18th November - Kea DHCP - Monitoring, Logging, and Stork
• 2nd December - Kea DHCP - Migrating to Kea from ISC DHCP
Questions and Answers