Kea DHCP and NetBox

Integrating with JSON/REST API

Carsten Strotmann, Michael Schwartzkopff and the ISC Team

All content © 2023 Internet Systems Consortium, Inc.

Welcome

Welcome to our Webinar on integrating external tools with Kea DHCP (using NetBox as the example)

All content © 2023 Internet Systems Consortium, Inc.

In this Webinar

- What is NetBox
- A quick tour of NetBox
- The NetBox API (REST/JSON/Python)
- Managing Kea DHCP Settings via NetBox custom fields
- Kea DHCP Subnet definitions, DHCP pools, DHCP reservations and options from within NetBox
- Exporting NetBox data into Kea DHCP
- Importing Kea DHCP data into NetBox

All content © 2023 Internet Systems Consortium, Inc.

Goal of this Webinar

- This webinar will show how an external application can be integrated with Kea DHCP via the provided API
- NetBox is used as an example, the same solutions discussed here can be applied to other DCIM or IPAM solutions (Open Source or closed source)
    - It should also be applicable to other types of applications (Ticket systems, Inventory databases, Configuration orchestration tools, cloud management solutions)

All content © 2023 Internet Systems Consortium, Inc.

Code used in this webinar

- The code created for this webinar is available under a permissive open source license (Apache License)
- The code is meant as an example, it is not supported by ISC or sys4 and it might not be suitable for production environments

All content © 2023 Internet Systems Consortium, Inc.
All content © 2023 Internet Systems Consortium, Inc.

What is NetBox

All content © 2023 Internet Systems Consortium, Inc.

What is NetBox

- NetBox is an Open Source Datacenter Inventory System and IP Address Management System
    - IP Subnets and IP-Address Ranges
    - VLANs
    - Devices and their IP-Addresses
    - Virtual Machines
    - Cabling and Power
- Website: https://netbox.dev
- Source : https://github.com/netbox-community/netbox

All content © 2023 Internet Systems Consortium, Inc.

What is NetBox

- NetBox is open source under the Apache 2 license
- It is build using Python (3.8+) and the Django Web Framework
- Other components:
    - PostgreSQL database (11+)
    - Redis (Key-Value Store, Version 4.0+)
    - HTTP Server (reverse Proxy with NGINX, Apache etc)
    - LDAP Environment (optional)

All content © 2023 Internet Systems Consortium, Inc.
All content © 2023 Internet Systems Consortium, Inc.

A quick tour of NetBox

Demo Time

All content © 2023 Internet Systems Consortium, Inc.

All content © 2023 Internet Systems Consortium, Inc.

The NetBox API (REST/JSON/Python)

All content © 2023 Internet Systems Consortium, Inc.

The NetBox API

- NetBox offers different ways to integrate with external applications
    - REST/JSON API (similar to Kea DHCP API - this is what we will use in this webinar)
    - GraphQL
    - Webhooks - triggers where NetBox will be able to inform external applications whenever an object in NetBox changes
    - NAPALM (https://github.com/napalm-automation/napalm): a Python library that implements a set of functions to interact with different router vendor devices using a unified API
    - Prometheus Monitoring Metrics

All content © 2023 Internet Systems Consortium, Inc.

Python Wrapper for NetBox

- `pynetbox` (https://github.com/netbox-community/pynetbox) is a Python wrapper around the NetBox API
- This python module eases the development of integration of external tools into NetBox
- As Python offers rich support for working with JSON based REST API, we have used the Python as the implementation language for our examples in this webinar
    - The same functions can be implemented in C/C++, Rust, Go, Ruby or other languages with support for JSON REST API

All content © 2023 Internet Systems Consortium, Inc.

Python Wrapper for NetBox Example

- Reading the subnet (aka "Prefix") definitions from NetBox

```
from pprint import pprint
import pynetbox
nb = pynetbox.api(
    'http://netbox.dane.onl',
    token='<secure-token>'
)

subnets = nb.ipam.prefixes.all()
for subnet in subnets:
    pprint(dict(subnet))
```

All content © 2023 Internet Systems Consortium, Inc.

Python Wrapper for Kea DHCP

- pykeadhcp - A python module used to interact the the Kea DHCP API daemons (dhcp4, dhcp6, ctrl-agent and ddns) https://github.com/BSpendlove/pykeadhcp

All content © 2023 Internet Systems Consortium, Inc.

Using the Python wrapper

- Changing the Kea DHCP4 configuration from Python

```
from pykeadhcp import Kea

# Connect to the Kea Agent endpoint
server = Kea(host="http://[::1]", port=9099)

# Fetch the DHCP4 Kea configuration
config = server.dhcp4.config_get()

# Print a configuration value
print( "Kea DHCP setting 'authoritative':", config['arguments']['Dhcp4']['authoritative'] )

# Change a configuration value
config['arguments']['Dhcp4']['authoritative'] = True

# Sending the new configuration to Kea DHCP4
response = server.dhcp4.config_set(config["arguments"])
assert response["result"] == 0

# Write the new configuration back to the config file
response = server.dhcp4.config_write("/etc/kea/kea-dhcp4.conf")
assert response["result"] == 0
```

All content © 2023 Internet Systems Consortium, Inc.

Documentations

- Documentation of the NetBox REST API: https://docs.netbox.dev/en/stable/integrations/rest-api/
- Documentation of the Kea DHCP REST API: https://kea.readthedocs.io/en/latest/arm/ctrl-channel.html

All content © 2023 Internet Systems Consortium, Inc.
All content © 2023 Internet Systems Consortium, Inc.

Managing Kea DHCP Settings via NetBox custom fields

All content © 2023 Internet Systems Consortium, Inc.

NetBox custom fields

- NetBox currently does not naively support the storage of data for DHCP
- The user of a NetBox system can extend the NetBox data model with "custom fields"
- The custom fields can be attached to almost any of the NetBox native object types (Subnet, IP-Ranges, IP-Addresses etc)
- The NetBox custom fields offer a wide range of pre-defined data types (IP-Addresses, Text-Fields, Booleans [Yes/No or On/Off], Numbers, Date etc)

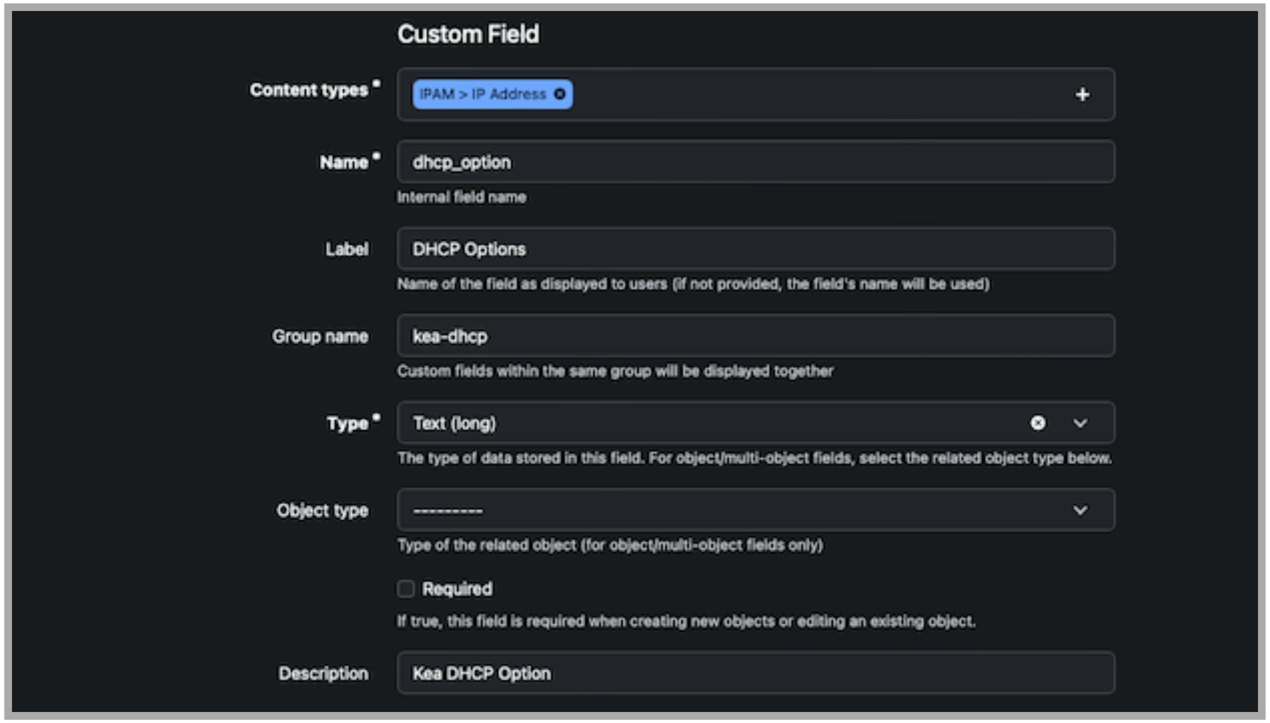
All content © 2023 Internet Systems Consortium, Inc.

NetBox custom fields

- We will create and use the custom field feature to store DHCP specific data (e.g. DHCP options, Lease-Times, Kea DHCP configuration) in NetBox
- The NetBox custom fields are available through the REST API and will be used to convert the data stored into a valid Kea DHCP configuration

All content © 2023 Internet Systems Consortium, Inc.

Creating custom fields for DHCP options in NetBox

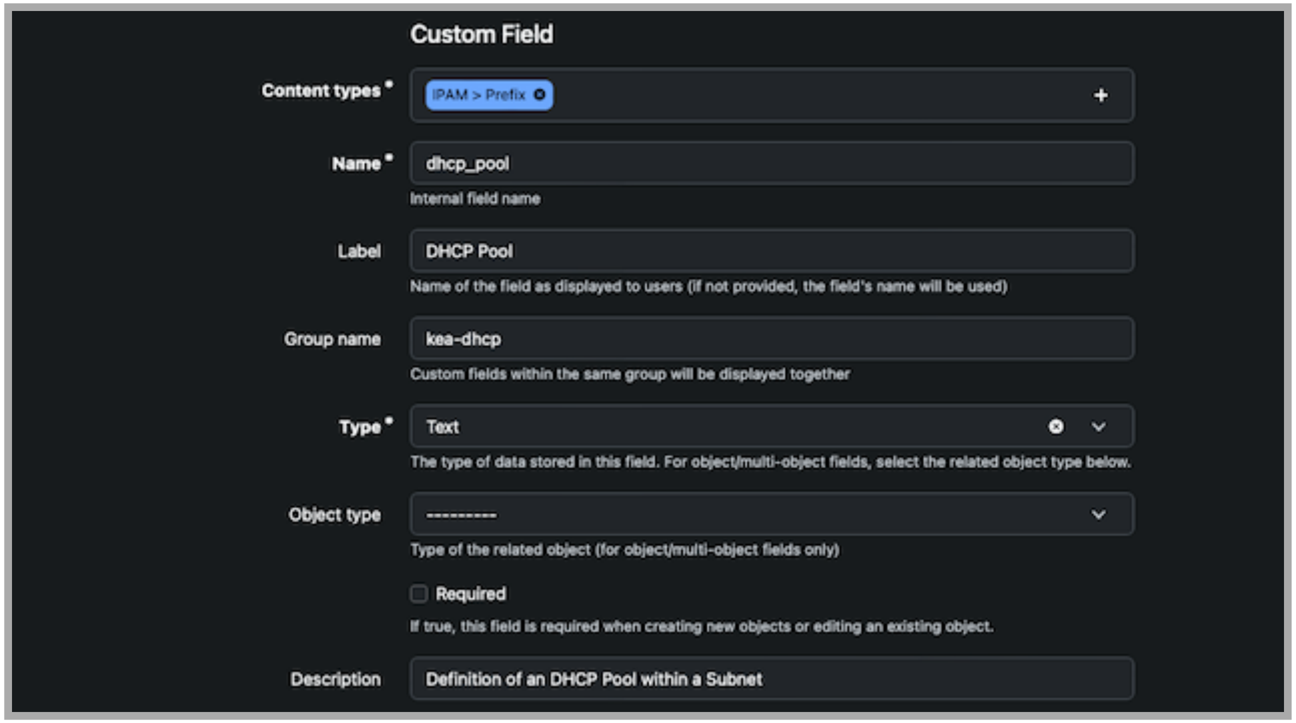


Custom Field

Content types *	IPAM > IP Address
Name *	dhcp_option Internal field name
Label	DHCP Options Name of the field as displayed to users (if not provided, the field's name will be used)
Group name	kea-dhcp Custom fields within the same group will be displayed together
Type *	Text (long) The type of data stored in this field. For object/multi-object fields, select the related object type below.
Object type	--------- Type of the related object (for object/multi-object fields only)
	☐ Required If true, this field is required when creating new objects or editing an existing object.
Description	Kea DHCP Option

All content © 2023 Internet Systems Consortium, Inc.

Creating custom fields for DHCP dynamic pools in NetBox



Custom Field

Content types * IPAM > Prefix

Name * dhcp_pool
Internal field name

Label DHCP Pool
Name of the field as displayed to users (if not provided, the field's name will be used)

Group name kea-dhcp
Custom fields within the same group will be displayed together

Type * Text
The type of data stored in this field. For object/multi-object fields, select the related object type below.

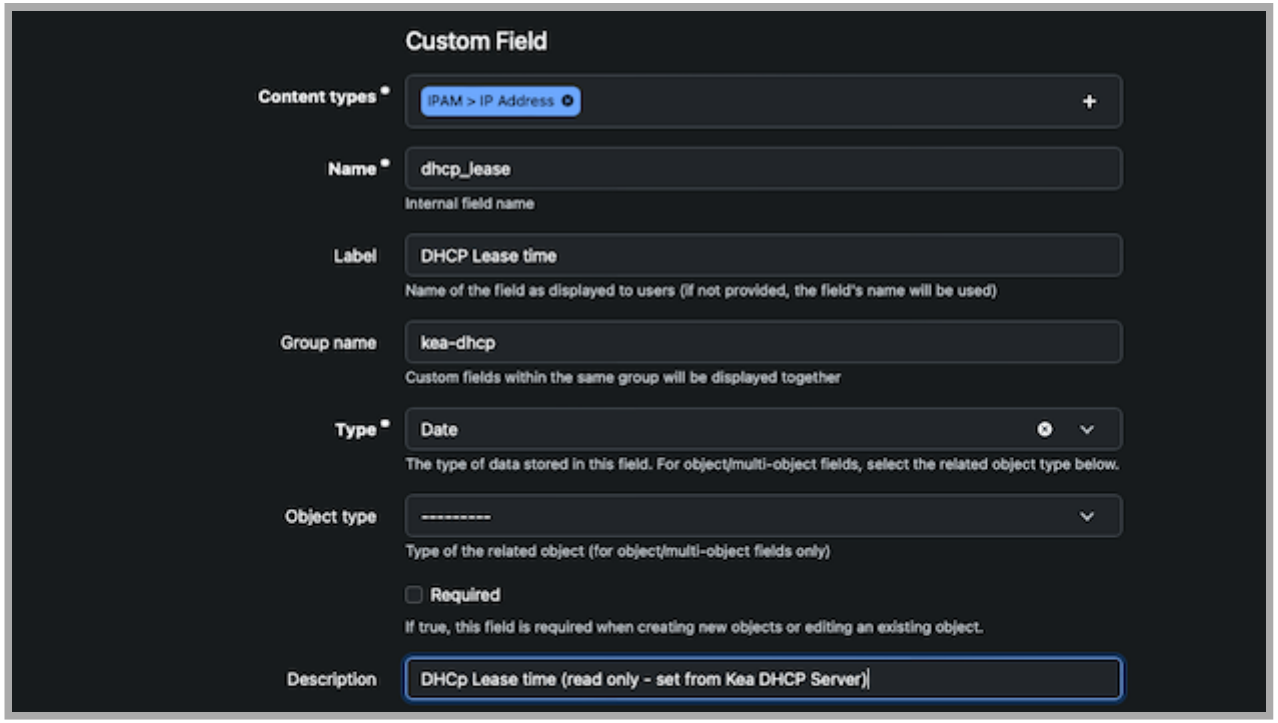
Object type ---------
Type of the related object (for object/multi-object fields only)

☐ Required
If true, this field is required when creating new objects or editing an existing object.

Description Definition of an DHCP Pool within a Subnet

All content © 2023 Internet Systems Consortium, Inc.

Creating custom fields for IP-Address lease time data


Custom Field

Content types *	IPAM > IP Address
Name *	dhcp_lease Internal field name
Label	DHCP Lease time Name of the field as displayed to users (if not provided, the field's name will be used)
Group name	kea-dhcp Custom fields within the same group will be displayed together
Type *	Date The type of data stored in this field. For object/multi-object fields, select the related object type below.
Object type	--------- Type of the related object (for object/multi-object fields only)
	☐ Required If true, this field is required when creating new objects or editing an existing object.
Description	DHCp Lease time (read only - set from Kea DHCP Server)

All content © 2023 Internet Systems Consortium, Inc.
All content © 2023 Internet Systems Consortium, Inc.

Kea DHCP Subnet definitions, DHCP pools, DHCP reservations and options from within NetBox

All content © 2023 Internet Systems Consortium, Inc.

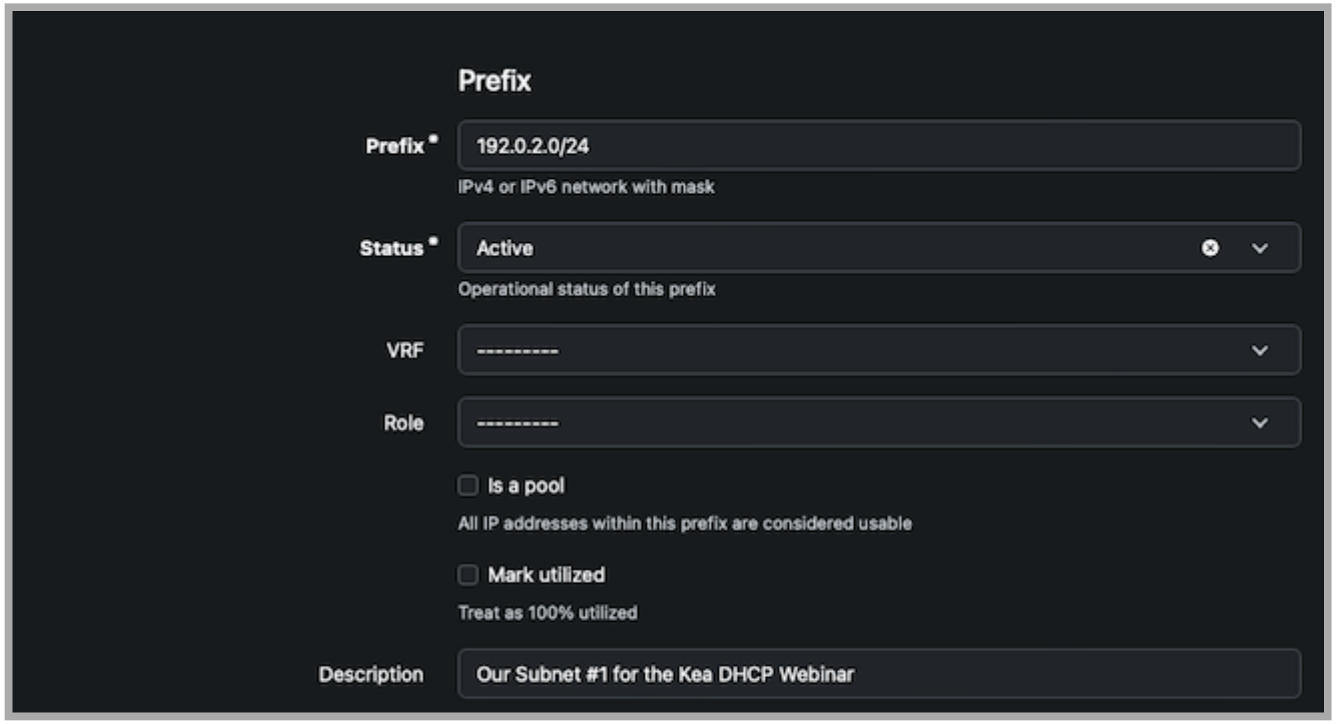
Matching NetBox data objects with Kea DHCP configuration blocks

- In the following slides we offer some ideas how NetBox objects can be mapped into Kea DHCP and back
- There is no universal truth in these mappings, and some mappings are a matter of taste
- There are other ways to do this, and depending on the network and the use of NetBox, you will need to adapt these mappings to your needs

All content © 2023 Internet Systems Consortium, Inc.

Kea DHCP Subnets

- We will use the NetBox build in "Prefix" object to create Kea DHCP subnet definitions



Prefix

Prefix *: 192.0.2.0/24
IPv4 or IPv6 network with mask

Status *: Active
Operational status of this prefix

VRF: ---------

Role: ---------

☐ Is a pool
All IP addresses within this prefix are considered usable

☐ Mark utilized
Treat as 100% utilized

Description: Our Subnet #1 for the Kea DHCP Webinar

All content © 2023 Internet Systems Consortium, Inc.

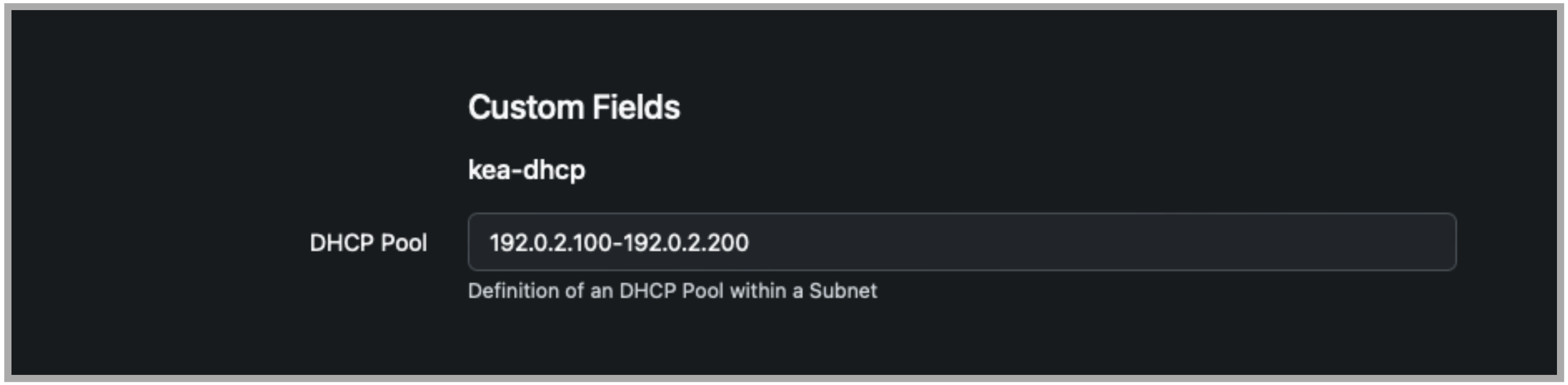
Kea DHCP Subnets

```
# remove existing kea subnet configuration
del (kea_config['arguments']['Dhcp4']["subnet4"])

# Array of Kea Subnets
kea_subnets = []

# Fetch all subnets from NetBox
subnets = nb.ipam.prefixes.all()

# Iterate over all subnet from NetBox
for subnet in subnets:
 subnet_name  = subnet["prefix"]
 dhcp_options = subnet["custom_fields"]["dhcp_option"]
 dhcp_pool    = subnet["custom_fields"]["dhcp_pool"]

 # Create new Array of Subnets for Kea
 kea_subnet = {}
 print("Adding Subnet:", subnet_name)
 kea_subnet["subnet"] = subnet_name
[...]
```

All content © 2023 Internet Systems Consortium, Inc.

Kea DHCP Pools

- We use a NetBox custom fields "dhcp_pool" to define dynamic DHCP Pools within the Kea DHCP Subnet definitions



Custom Fields

kea-dhcp

DHCP Pool: 192.0.2.100-192.0.2.200

Definition of an DHCP Pool within a Subnet

All content © 2023 Internet Systems Consortium, Inc.

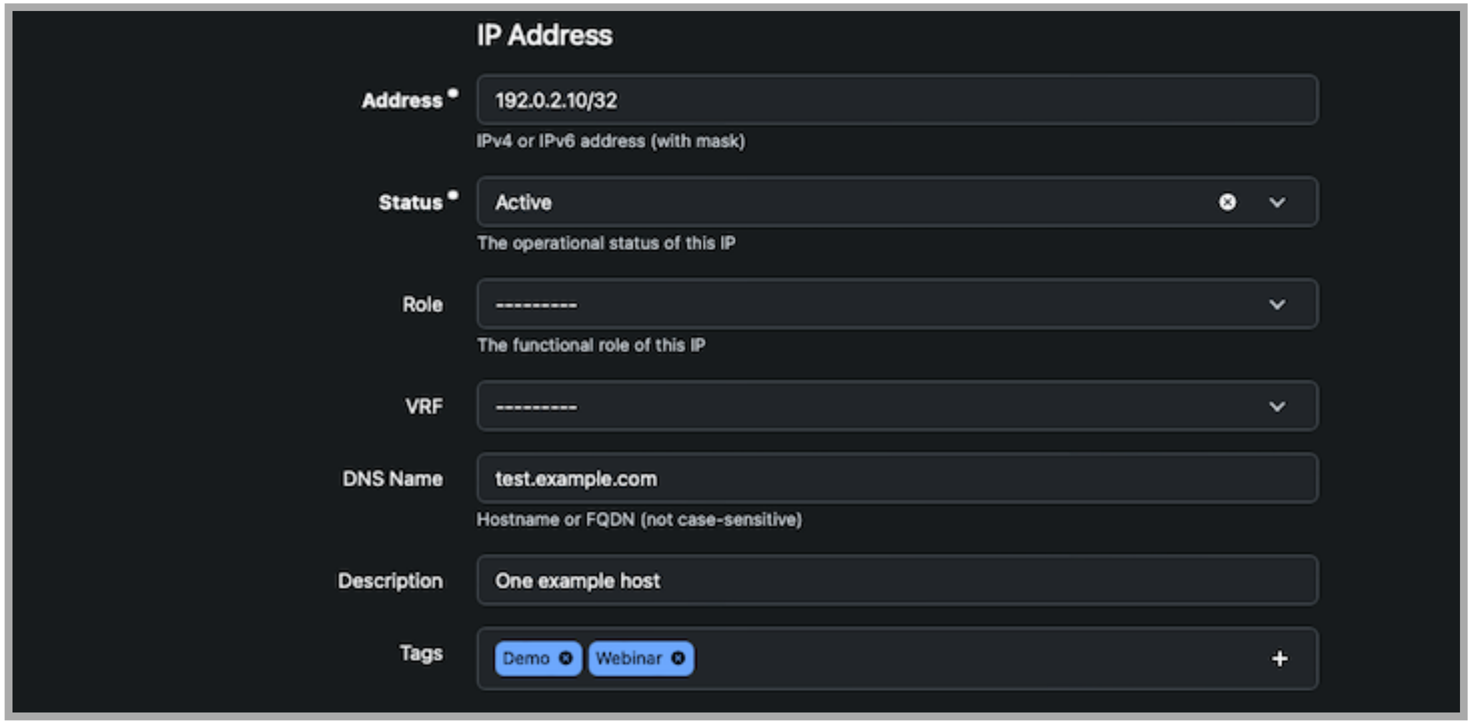
Kea DHCP Pools

```
# Iterate over all subnet from NetBox
for subnet in subnets:
 [...]
 kea_subnet["subnet"] = subnet_name

 # If the custom fields "dhcp_pool" is filled
 if dhcp_pool != None:
  print("  with DHCP Pool:", dhcp_pool)
  subnet_pools = []

  # Append a new Kea DHCP Pool structure
  pool = {}
  pool["pool"] = dhcp_pool

  # Append the new Pool to the Pools-Array
  subnet_pools.append(pool)

  # Add the Pools Array to the Kea Subnet config
  kea_subnet["pools"] = subnet_pools
[...]
```

All content © 2023 Internet Systems Consortium, Inc.

Kea Host Reservations

- We use the NetBox build in "IP Address" object together with custom fields to store DHCP options for Kea DHCP reservations



IP Address

Address *	192.0.2.10/32
	IPv4 or IPv6 address (with mask)
Status *	Active
	The operational status of this IP
Role	---------
	The functional role of this IP
VRF	---------
DNS Name	test.example.com
	Hostname or FQDN (not case-sensitive)
Description	One example host
Tags	Demo, Webinar

All content © 2023 Internet Systems Consortium, Inc.

Kea Host Reservations

```
[...]
# remove existing kea (global) reservations from the configuration
if 'reservations' in kea_config['arguments']['Dhcp4']:
 del (kea_config['arguments']['Dhcp4']['reservations'])

# Array of Kea DHCP reservations
kea_reservations = []

# Iterating over all IP-Addresses from NetBox
for ip_address in ip_addresses:
 address      = ip_address["address"]
 # remove prefix notation from ip-address
 if "/" in address:
  address = address.split("/")[0]
 hw_address   = ip_address["custom_fields"]["hw_address"]
 dhcp_options = ip_address["custom_fields"]["dhcp_option"]
 hostname     = ip_address["dns_name"]

 reservation = { "hw-address": hw_address, "hostname": hostname, "ip-address": address }

 [ ... process DHCP options ... ]

 # add new reservation to configuration
 print("Adding reservation: ", address)
 kea_reservations.append(reservation)

# Add the reservations to the Kea configuration
kea_config['arguments']['Dhcp4']['reservations'] = kea_reservations
[...]
```

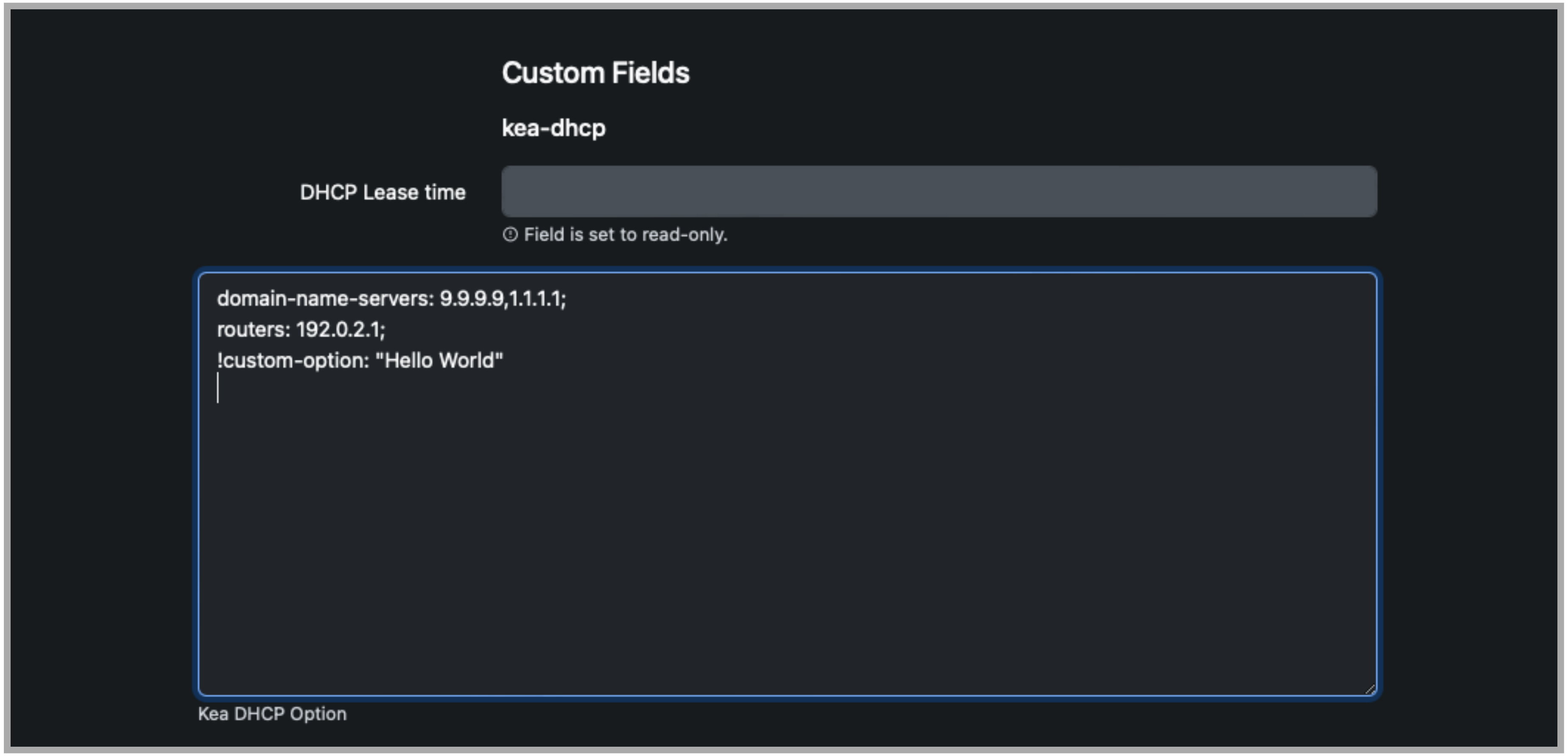
All content © 2023 Internet Systems Consortium, Inc.

Kea DHCP Options

- DHCP Options are stored in custom fields along with IP-Addresses (Reservations), IP-Ranges (Pools) or Prefixes (Subnets)
- We choose to store DHCP options as a text field with a simple structure of `[!]option-name|option-code: option-value-csv`. The optional `!` in front of a option marks a *must send* option
- Example 1: `domain-name-servers: 9.9.9.9, 1.1.1.1`
- Example 2: `!15: example.com`
- Example 3: `!routers: 192.0.2.1`

All content © 2023 Internet Systems Consortium, Inc.

Kea DHCP Options



Custom Fields

kea-dhcp

DHCP Lease time

Field is set to read-only.

```
domain-name-servers: 9.9.9.9,1.1.1.1;
routers: 192.0.2.1;
!custom-option: "Hello World"
```

Kea DHCP Option

All content © 2023 Internet Systems Consortium, Inc.

Kea DHCP Options

```
# Iterate over all subnet from NetBox
for subnet in subnets:
 [...]
 # Add the DHCP options
 if dhcp_options != None:
  # Remove line-breaks
  dhcp_options = ' '.join(dhcp_options.splitlines())
  # Split options into array
  options = dhcp_options.split(";")
  kea_options = []
  for option in options:
    kea_option = {}
    option = option.strip()
    if len(option) > 1:
     always_send = (option[0] == "!")
     if always_send:
      option = option[1:]
     print("  with DHCP Option:", option)
     option = option.split(":")
     kea_option["name"] = option[0]
     kea_option["data"] = option[1]
     kea_option["always-send"] = always_send

     # Add new Kea-Option to the options array
     kea_options.append(kea_option)

  # Add the Options Array to the Kea Subnet config
  kea_subnet["option-data"] = kea_options
[...]
```

All content © 2023 Internet Systems Consortium, Inc.
All content © 2023 Internet Systems Consortium, Inc.

Exporting NetBox data into Kea DHCP

All content © 2023 Internet Systems Consortium, Inc.

Exporting NetBox data into Kea DHCP

- Our example Python integration periodically reads the DHCP configuration data from NetBox, reads the current Kea DHCP configuration and writes back the changed Kea DHCP server configuration into the Kea DHCP server
- It would be possible to use the NetBox webhooks to trigger dynamic reconfiguration of Kea DHCP whenever the data in NetBox changes

All content © 2023 Internet Systems Consortium, Inc.
All content © 2023 Internet Systems Consortium, Inc.

Importing Kea DHCP data into NetBox

All content © 2023 Internet Systems Consortium, Inc.

Importing Kea DHCP lease times into NetBox

- After the new Kea DHCP server configuration has been applied, the example Python script reads the current leases from Kea DHCP using the *lease commands* hook API and writes the data back into IP-Address objects in NetBox
    - The `lease_cmds` hook in Kea DHCP is used to export the lease information
    - The custom field "lease time" is used to store the current lease time

All content © 2023 Internet Systems Consortium, Inc.

Python example code to import leases from Kea DHCP to netbox

```
# Read current leases from Kea DHCP
print("Updating lease information from Kea DHCP into NetBox")
kea_leases = server.dhcp4.lease4_get_all([1])
kea_leases = kea_leases["arguments"]["leases"]
for lease in kea_leases:
 leasetime = lease["cltt"]
 lease_cltt = datetime.utcfromtimestamp(leasetime).strftime('%Y-%m-%d %H:%M:%S')
 print("  Lease for " + lease["ip-address"] +": valid until "+ lease_cltt + " UTC")
 try:
   nb_ip_address = nb.ipam.ip_addresses.get(address=lease["ip-address"])
   if nb_ip_address == None:
    nb_ip_address.address = nb.ipam.ip_addresses.create(
        address=lease["ip-address"],
        description="Added from Kea DHCP"
    )
    nb_ip_address.custom_fields["dhcp_lease"]=lease_cltt
    nb_ip_address.save()
   else:
    nb_ip_address.address=lease["ip-address"]
    nb_ip_address.custom_fields["dhcp_lease"]=lease_cltt
    nb_ip_address.save()

 except pynetbox.lib.query.RequestError as e:
  print(e.error)
```

All content © 2023 Internet Systems Consortium, Inc.

The example code in action

- Demo time

All content © 2023 Internet Systems Consortium, Inc.
All content © 2023 Internet Systems Consortium, Inc.

Resources

- Blog Post: netbox integration with KEA DHCP Server https://www.sys4.de/blog/netbox-kea-dhcp.en/
- Source repository with example code from this webinar https://github.com/cstrotm/kea-dhcp-netbox-webinar
- Kea Lease commands hook https://kea.readthedocs.io/en/kea-2.2.0/arm/hooks.html?highlight=lease_cmds#lease-cmds-lease-commands-for-easier-lease-management

All content © 2023 Internet Systems Consortium, Inc.
All content © 2023 Internet Systems Consortium, Inc.

Resources

- Pynetbox Blog Series: Pynetbox - NetBox Python API client part 1 - getting info https://ttl255.com/pynetbox-netbox-python-api-client-p1-getting-info/
- The NetBox community mailing list: https://netboxlabs-23319422.hs-sites.com/join-the-netbox-community
- JSON-View commandline JSON viewer https://github.com/doorOfChoice/json-view

All content © 2023 Internet Systems Consortium, Inc.
All content © 2023 Internet Systems Consortium, Inc.

Upcoming ISC Webinar

- 16 May - Migrating to Kea from ISC DHCP
- 07 Jun - Using the new dynamic templates in Kea

All content © 2023 Internet Systems Consortium, Inc.
All content © 2023 Internet Systems Consortium, Inc.

Questions / Answers

All content © 2023 Internet Systems Consortium, Inc.
All content © 2023 Internet Systems Consortium, Inc.