SH Dr. Soufiane Hourri

École Supérieure de Technologie de Safi · Cadi Ayyad University
Computer Science Department · 2026-2027

NETWORK ADMINISTRATION · DUT S3 · PRACTICAL SESSION 02

DHCP: srv1 gives addresses to the lab

In Masterclass 02 you saw how DHCP works. Today you make it work. srv1 becomes a Kea DHCP server, client1 receives its address automatically, and you watch every DORA message pass. Then you play with leases, give client1 a reserved address, and serve a second network.

BY THE END OF THE SESSION YOU WILL HAVE

- A Kea DHCP server on srv1 for `labnet` (192.168.50.0/24)
- client1 configured by DHCP, then with the reserved address `192.168.50.20`
- A second network `labnet2` (192.168.60.0/24) with a new VM, client2, also served by srv1
- Real captures of DORA and of a lease renewal, and a lease file you can read

BEFORE YOU COME

- srv1 and client1 from Practical 01, with their snapshots
- Your notes from Masterclass 02 (DORA, leases, Kea)
- Enough RAM for three VMs at once: give client1 and client2 1536 MB each if your laptop has 8 GB (Settings ▸ System, VM powered off)

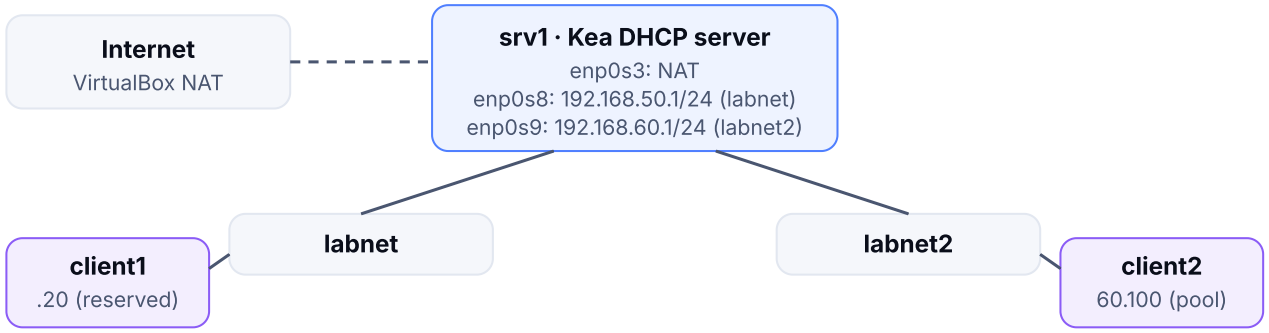
Duration 4 hours, in class, including a 15-minute break. Work alone, except in Part 7 (pairs). Help your neighbour when you finish a part.

Deliverable The answers to the **questions** (violet boxes), the output of each **checkpoint** (green boxes) and your troubleshooting table, in one PDF report. Show each checkpoint to the teacher during the session. The submission deadline is announced in class.

Conventions `$` means "type this command" (do not type the `$`). Grey text after `#` is a comment. Work in the VirtualBox window of each VM. It helps to place srv1 and client1 side by side on the screen.

Time	Part	Content
0:00	0	Starting point: check srv1 and client1
0:10	1	client1 asks for an address, and nobody answers
0:35	2	Install and configure Kea on srv1
1:20	3	Watch DORA and read the lease
1:50		**Break (15 min)**
2:05	4	Lease timers: renewal, server failure, expiry
2:30	5	A reservation for client1
2:55	6	A second network, labnet2, with client2
3:25	7	Troubleshooting challenge in pairs
3:45		Final configuration, snapshots, what to hand in

THE LAB AT THE END OF TODAY



Interface names are the usual ones in VirtualBox. Always check the real names with `ip -br address` and use them in every command and in the Kea configuration.

Part 0 Starting point

10 min

Start srv1 and client1 and log in on both. Check that you are where Practical 01 ended:

BASH · SRV1

```
$ ip -br address
$ ping -c 3 fedoraproject.org
```

BASH · CLIENT1

```
$ ip -br address
$ nmcli connection show
$ ping -c 3 192.168.50.1
```

Expected: srv1 has `192.168.50.1/24` on enp0s8 and reaches the Internet; client1 has `192.168.50.10/24` on enp0s3 (connection `labnet`) and pings srv1. If something is missing, restore your snapshots **srv1 network ok** and **client1 network ok**, or finish Parts 5 and 6 of Practical 01 first. Then take a snapshot of both VMs named **before dhcp**.

Part 1 client1 asks, nobody answers

25 min

Before installing anything, watch what a DHCP client does on a network without a DHCP server. On srv1, start a capture on the labnet card:

BASH · SRV1

```
$ sudo tcpdump -i enp0s8 -n -v port 67 or port 68
  # leave it running; Ctrl+C stops it
```

On client1, switch the `labnet` connection from a fixed address to DHCP. `ipv4.method auto` means "use DHCP"; the empty `ipv4.addresses ""` removes the fixed address.

BASH · CLIENT1

```
$ sudo nmcli connection modify labnet ipv4.method auto ipv4.addresses ""
$ sudo nmcli connection up labnet
  # waits, then fails after about 45 seconds: nobody answers
$ ip -br address show enp0s3
```

Look at srv1's window while client1 waits.

QUESTIONS 1 TO 4

1. Which DHCP message type do you see (option 53)? Give its source and destination IP addresses and ports, and explain each of the four values.
2. How many times does client1 send this message before giving up, and roughly how many seconds apart?
3. The capture shows `xid`. Is it the same in every message, or does it change? What is it used for?
4. What does `ip -br address show enp0s3` show on client1 after the failure? What would a Windows PC show in the same situation?

Stop the capture with Ctrl+C. client1 stays without an address until Part 3.

Part 2 Install and configure Kea on srv1

45 min

2.1 Install and open the configuration file

BASH · SRV1

```
$ sudo dnf install kea
$ sudo cp /etc/kea/kea-dhcp4.conf /etc/kea/kea-dhcp4.conf.orig
$ sudo nano /etc/kea/kea-dhcp4.conf
  # delete everything (Ctrl+K deletes a line) and type the file below
```

2.2 Write the configuration

Type this file exactly (the grey numbers are line numbers, do not type them). JSON is strict: every opening `{` or `[` is closed, items are separated by commas, and there is no comma after the last item of a list.

JSON · /ETC/KEA/KEA-DHCP4.CONF

```
 1  {
 2    "Dhcp4": {
 3      "interfaces-config": { "interfaces": [ "enp0s8" ] },
 4      "lease-database": { "type": "memfile", "persist": true },
 5      "valid-lifetime": 3600,
 6      "subnet4": [
 7        {
 8          "id": 1,
 9          "subnet": "192.168.50.0/24",
10          "pools": [ { "pool": "192.168.50.100 - 192.168.50.199" } ],
11          "option-data": [
12            { "name": "routers", "data": "192.168.50.254" },
13            { "name": "domain-name-servers", "data": "192.168.50.2" },
14            { "name": "domain-name", "data": "lab.internal" }
15          ]
16        }
17      ]
18    }
19  }
```

Lines	Meaning
3	Listen **only** on enp0s8 (labnet). Never on enp0s3: that is the NAT side.
4	Store leases in a file, `/var/lib/kea/kea-leases4.csv`, so they survive a restart
5	Lease time: 3600 seconds
8 to 10	The subnet, its unique id, and the pool from the address plan (.100 to .199)
11 to 15	Options sent to clients: gateway (option 3), DNS server (option 6), domain name (option 15). The mask (option 1) is derived from `/24`.

The gateway .254 and the DNS server .2 do not exist yet. Clients will receive these values now and use them when those machines are built.

2.3 Check, open, start

BASH · SRV1

```
$ sudo kea-dhcp4 -t /etc/kea/kea-dhcp4.conf
  # nothing printed = syntax correct
$ sudo firewall-cmd --permanent --add-service=dhcp
$ sudo firewall-cmd --reload
$ sudo systemctl enable --now kea-dhcp4
$ systemctl status kea-dhcp4
$ sudo journalctl -u kea-dhcp4 --since today
```

ABOUT THE FIREWALL RULE

Kea receives the broadcasts of directly connected clients through **raw sockets**, which pass beside the Linux firewall. On labnet, DHCP would work even without the `dhcp` rule. The rule is still the correct configuration: it is needed for requests forwarded by a relay agent from another network (Masterclass 02, chapter 5), which arrive as ordinary UDP packets. (Kea Administrator Reference Manual, Interface Configuration.)

If `kea-dhcp4 -t` prints an error, read the line and column numbers it gives. A missing comma is reported on the line **after** the mistake.

CHECKPOINT 1

- ☐ `kea-dhcp4 -t` prints nothing.
- ☐ `systemctl status kea-dhcp4` shows `active (running)` and `enabled`.

QUESTIONS 5 AND 6

5. What would happen on the campus if line 3 listed both enp0s3 and enp0s8, and srv1's first card were bridged instead of NAT?
6. Kea is enabled and started. Which command proves that it will start again after a reboot, and what does it print?

Part 3 Watch DORA and read the lease

30 min

Start the capture on srv1 again, then ask for an address on client1:

BASH · SRV1 · WINDOW 1

```
$ sudo tcpdump -i enp0s8 -n -v port 67 or port 68
```

BASH · CLIENT1

```
$ sudo nmcli connection up labnet
$ ip -br address show enp0s3
$ ip route
$ nmcli -f IP4 device show enp0s3
$ nmcli -f DHCP4 device show enp0s3
$ ping -c 3 192.168.50.1
```

Fill in this table from srv1's capture (copy it into your report):

Message (option 53)	Source IP:port	Destination IP:port	xid	Your-IP (offered address)
Discover				
Offer				
Request				
ACK				

Now look at the lease on srv1:

BASH · SRV1

```
$ sudo cat /var/lib/kea/kea-leases4.csv
$ date -d @1792000000      # replace with the expire value of your lease
```

CHECKPOINT 2

☐ client1 has an address in 192.168.50.100 to .199 and pings srv1. ☐ The lease file contains client1's MAC address and hostname.

QUESTIONS 7 TO 10

7. Was the OFFER sent to 255.255.255.255 or directly to the offered address? Using Masterclass 02, explain why both are allowed.
8. The REQUEST still comes from 0.0.0.0. Why does client1 not use its new address yet?
9. From `nmcli -f DHCP4` on client1, copy the lease time, the router, the DNS server and the domain name. Compare each with lines 5 and 11 to 15 of your configuration.
10. When does the lease expire (convert the `expire` field with `date`)? Why can client1 ping srv1 but not `fedoraproject.org`?

BREAK · 15 MINUTES

Leave both VMs running. If your laptop goes to sleep, check after the break that client1 still has its address.

Part 4 Lease timers: renewal, server failure, expiry

25 min

With a one-hour lease nothing visible happens for 30 minutes. We shorten the lease to **120 seconds** to watch the whole life of a lease. According to RFC 2131, client1 should renew at T1 = 50% (60 s), rebind at T2 = 87.5% (105 s) and lose the address at 120 s.

4.1 Watch a renewal

BASH · SRV1

```
$ sudo nano /etc/kea/kea-dhcp4.conf      # change 3600 to 120 on line 5
$ sudo kea-dhcp4 -t /etc/kea/kea-dhcp4.conf
$ sudo systemctl restart kea-dhcp4
$ sudo tcpdump -i enp0s8 -n port 67 or port 68
  # without -v: one short line per packet, with its time
```

BASH · CLIENT1

```
$ sudo nmcli connection up labnet       # a new lease of 120 s
$ nmcli -f DHCP4 device show enp0s3 | grep lease
```

Wait about two minutes while watching srv1's capture. Here is what a renewal looks like, from a real test with a 40-second lease: the DORA at 14:10:39, then, exactly 20 seconds later (50%), a **unicast** REQUEST from the client's address to the server, and the ACK.

REAL CAPTURE, TEST CLIENT WITH A 40 S LEASE (TIMES SHORTENED)

```
14:10:39.275 IP 0.0.0.0.68 > 255.255.255.255.67: BOOTP/DHCP, Request
14:10:39.276 IP 192.168.50.1.67 > 192.168.50.100.68: BOOTP/DHCP, Reply
14:10:39.299 IP 0.0.0.0.68 > 255.255.255.255.67: BOOTP/DHCP, Request
14:10:39.300 IP 192.168.50.1.67 > 192.168.50.100.68: BOOTP/DHCP, Reply
14:10:59.347 IP 192.168.50.100.68 > 192.168.50.1.67: BOOTP/DHCP, Request
14:10:59.348 IP 192.168.50.1.67 > 192.168.50.100.68: BOOTP/DHCP, Reply
```

4.2 The server fails

BASH · SRV1

```
  # Ctrl+C stops tcpdump, then:
$ sudo systemctl stop kea-dhcp4
$ sudo tcpdump -i enp0s8 -n port 67 or port 68
```

Watch for about three minutes. Every minute or so, run `ip -br address show enp0s3` on client1.

QUESTIONS 11 TO 13

11. Record the times of the renewals you saw while Kea was running. Do they match T1 = 60 s? Give the source and destination addresses of a renewal REQUEST.
12. After you stopped Kea, how did client1's messages change: destination address, source address, and interval? Relate what you saw to the RENEWING and REBINDING states, and note when client1 lost its address.
13. Why do networks use leases of several hours or days in practice, and not 120 seconds?

4.3 Back to normal

BASH · SRV1

```
$ sudo nano /etc/kea/kea-dhcp4.conf      # back to 3600
$ sudo kea-dhcp4 -t /etc/kea/kea-dhcp4.conf
$ sudo systemctl start kea-dhcp4
```

Then run `sudo nmcli connection up labnet` on client1 so that it gets a normal one-hour lease again.

Part 5 A reservation for client1

25 min

A reservation tells Kea to always give the same address to one MAC address. Our address plan keeps 192.168.50.10 to .99 for reservations, outside the pool. First find client1's MAC address:

BASH · CLIENT1

```
$ ip link show enp0s3
  # the line link/ether 08:00:27:... is the MAC address
```

On srv1, open the configuration and insert these lines right after the `"pools"` line of subnet 1 (line 10), with **your** MAC address. Note the comma after the closing `]` : another item, `"option-data"`, follows.

JSON · INSERT AFTER THE "POOLS" LINE OF SUBNET 1

```
"reservations": [
  { "hw-address": "08:00:27:xx:xx:xx",
    "ip-address": "192.168.50.20",
    "hostname": "client1" }
],
```

BASH · SRV1

```
$ sudo kea-dhcp4 -t /etc/kea/kea-dhcp4.conf
$ sudo systemctl restart kea-dhcp4
$ sudo tcpdump -i enp0s8 -n -v port 67 or port 68
```

BASH · CLIENT1

```
$ sudo nmcli connection up labnet
$ ip -br address show enp0s3
```

client1 first asks to keep its old address. Depending on the timing, you may see Kea answer with a **DHCPNAK** before a new DISCOVER, or offer the reserved address directly. Either way, client1 should end with `192.168.50.20`.

CHECKPOINT 3

- ☐ client1 has `192.168.50.20/24`.
- ☐ The lease file shows .20 with client1's MAC address.

QUESTIONS 14 AND 15

14. Did you see a DHCPNAK? Copy the sequence of message types you saw, and explain why the reserved address is outside the pool .100 to .199.
15. Give two kinds of machines that should have a reservation in a company, and explain why a reservation is often better than a fixed address typed on the machine itself.

Part 6 A second network: labnet2 and client2

30 min

One DHCP server can serve several networks. srv1 gets a third card on a new internal network, `labnet2`, and a new VM, client2, lives there.

6.1 A third card for srv1

1. Shut srv1 down (`sudo poweroff`). In **Settings ▸ Network ▸ Adapter 3**: enable it, attach it to **Internal Network**, name `labnet2`. Start srv1.
2. Give the new card its fixed address:

BASH · SRV1

```
$ ip -br address                        # the new card is usually enp0s9
$ sudo nmcli connection add type ethernet \
      ifname enp0s9 con-name labnet2 \
      ipv4.method manual ipv4.addresses 192.168.60.1/24 \
      ipv6.method disabled
$ sudo nmcli connection up labnet2
```

6.2 Create client2

1. Shut client1 down. Clone it: name `client2`, **Full clone**, **Generate new MAC addresses for all network adapters**.
2. In client2's settings: Adapter 1 ▸ Internal Network ▸ `labnet2`. Start client2 and client1 again.
3. On client2, make it a different machine, as for client1 in Practical 01:

BASH · CLIENT2

```
$ sudo hostnamectl set-hostname client2.lab.internal
$ sudo rm /etc/machine-id
$ sudo systemd-machine-id-setup
$ sudo reboot
```

6.3 Serve labnet2

Here is the final configuration of srv1, with the reservation from Part 5 and a second subnet. Compare it with your file and add what is missing: `"enp0s9"` on line 3, the comma after the closing brace of the first subnet (line 21) and the whole second subnet (lines 22 to 29).

JSON · /ETC/KEA/KEA-DHCP4.CONF · FINAL VERSION

```
{
  "Dhcp4": {
    "interfaces-config": { "interfaces": [ "enp0s8", "enp0s9" ] },
    "lease-database": { "type": "memfile", "persist": true },
    "valid-lifetime": 3600,
    "subnet4": [
      {
        "id": 1,
        "subnet": "192.168.50.0/24",
        "pools": [ { "pool": "192.168.50.100 - 192.168.50.199" } ],
        "reservations": [
          { "hw-address": "08:00:27:xx:xx:xx",
            "ip-address": "192.168.50.20",
            "hostname": "client1" }
        ],
        "option-data": [
          { "name": "routers", "data": "192.168.50.254" },
          { "name": "domain-name-servers", "data": "192.168.50.2" },
          { "name": "domain-name", "data": "lab.internal" }
        ]
      },
      {
        "id": 2,
        "subnet": "192.168.60.0/24",
        "pools": [ { "pool": "192.168.60.100 - 192.168.60.199" } ],
        "option-data": [
          { "name": "routers", "data": "192.168.60.1" }
        ]
      }
    ]
  }
}
```

BASH · SRV1

```
$ sudo kea-dhcp4 -t /etc/kea/kea-dhcp4.conf
$ sudo systemctl restart kea-dhcp4
$ sudo cat /var/lib/kea/kea-leases4.csv
```

On client2 (its `labnet` connection, copied from client1, already uses DHCP):

BASH · CLIENT2

```
$ sudo nmcli connection up labnet
$ ip -br address show enp0s3
$ ip route
```

CHECKPOINT 4

☐ client2 has an address in 192.168.60.100 to .199 and pings 192.168.60.1. ☐ The lease file shows client2's lease with `subnet_id` 2.

QUESTIONS 16 TO 18

16. Both clients sent the same kind of broadcast DISCOVER. How did Kea know which pool to use for each one?
17. Why does each subnet need its own pool and its own `routers` option? What would happen to client2 with an address from 192.168.50.0/24?
18. Can client1 ping client2? Try it, and explain the result. If labnet2 were behind a separate router instead of being connected to srv1, what would that router need so that client2 still gets an address from srv1?

Part 7 Troubleshooting challenge in pairs

20 min

Take a snapshot of srv1 and client1 named **dhcp ok**. Student A creates **one** fault on their own lab while student B looks away; then B finds it **with commands only**, starting from the symptom "client1 gets no address after `sudo nmcli connection up labnet`". Swap roles with another fault.

#	Fault to create (student A)	How to undo it
a	`sudo systemctl stop kea-dhcp4` on srv1	`sudo systemctl start kea-dhcp4`
b	Delete the comma at the end of line 5 of the configuration, then `sudo systemctl restart kea-dhcp4`	Put the comma back, check, restart
c	Change the pool to `192.168.70.100 - 192.168.70.199`, then restart Kea	Restore the original pool, check, restart
d	In VirtualBox, attach client1's adapter to **NAT** instead of labnet	Attach it to `labnet` again

Useful commands for student B: on srv1 `systemctl status kea-dhcp4`, `sudo journalctl -u kea-dhcp4 -n 30`, `sudo kea-dhcp4 -t /etc/kea/kea-dhcp4.conf`, `sudo tcpdump -i enp0s8 -n port 67 or port 68`; on client1 `ip -br address` and `ip route`. If you are stuck, restore the snapshots **dhcp ok**.

QUESTION 19

For each fault you diagnosed, write: the symptom, the commands you ran and what they showed, the cause, and the fix. For fault c, copy the exact error message given by Kea. For fault d, which address did client1 receive, and from which DHCP server?

Before you leave

15 min

- Check that srv1 runs the final configuration of Part 6 with `"valid-lifetime": 3600`, that `kea-dhcp4 -t` prints nothing and that client1 has .20 and client2 an address in 192.168.60.100 to .199.
- Shut the three VMs down with `sudo poweroff` and take a snapshot of each named **dhcp final**.
- Next practical (DNS): you will add a fourth VM, ns1, at 192.168.50.2, the DNS server that srv1 already announces. Keep your RAM settings in mind.
- Your report contains the answers to questions 1 to 19, the DORA table of Part 3, the output of checkpoints 1 to 4 and your challenge table, with your name and group on the first page.

If something goes wrong

Symptom	Likely cause	What to do
`kea-dhcp4 -t` : `syntax error, unexpected ...`	Missing or extra comma, bracket or quote	Look at the reported line and the line before it
`Failed to select interface`	The interface name in line 3 does not exist on srv1	Copy the real name from `ip -br address`
`does not match the prefix of a subnet`	The pool is outside its subnet	Pool and subnet must use the same network part
Kea refuses to start	The configuration has an error	`sudo journalctl -u kea-dhcp4 -n 30`, then `kea-dhcp4 -t`
Nothing in tcpdump on srv1	client1 is not on labnet, or the network name is misspelt	Compare the VirtualBox settings of both VMs
client1 gets 10.0.2.15	Its card is on NAT: VirtualBox's own DHCP answered	Attach client1's adapter to `labnet`
client1 keeps 192.168.50.10	The fixed address was not removed	`sudo nmcli connection modify labnet ipv4.addresses ""`, then `up`
Three VMs are very slow	Not enough RAM on the laptop	1536 MB for each client; close other programs

References: RFC 2131, Dynamic Host Configuration Protocol (1997); ISC, Kea Administrator Reference Manual 3.0 (interface configuration and raw sockets, host reservations); Fedora Project, package kea (3.0.3 in Fedora 44); Red Hat, RHEL 10, Providing DHCP services; Masterclass 02 slides of this module. The renewal capture and the error messages in this handout come from real tests of these configurations with Kea 2.4.