Kathará

kathara lab

basic IPv6 configuration, ping, traceroute and ICMPv6

Version	1.0
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Description	basic IPv6 configuration commands, IPv6 stateless auto-configuration, usage of ping and traceroute, ICMPv6 behaviour

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content of the lab

- there are two routers, called r1 and r2, and three hosts, called pc1, pc2, and pc3
  - they are connected via three LANs
  - we force their MAC addresses to be easily readable
- we will learn how to:
  - administratively assign an IPv6 address and a netmask to the interface of a system
  - administratively assign a default gateway to the interface of a system
  - set the IPv6 addresses of a group of end-systems using the MAC-address-based stateless-auto configuration
  - set the routing table of a router
- we will use the ping and traceroute commands
- we will observe the behavior of ICMPv6

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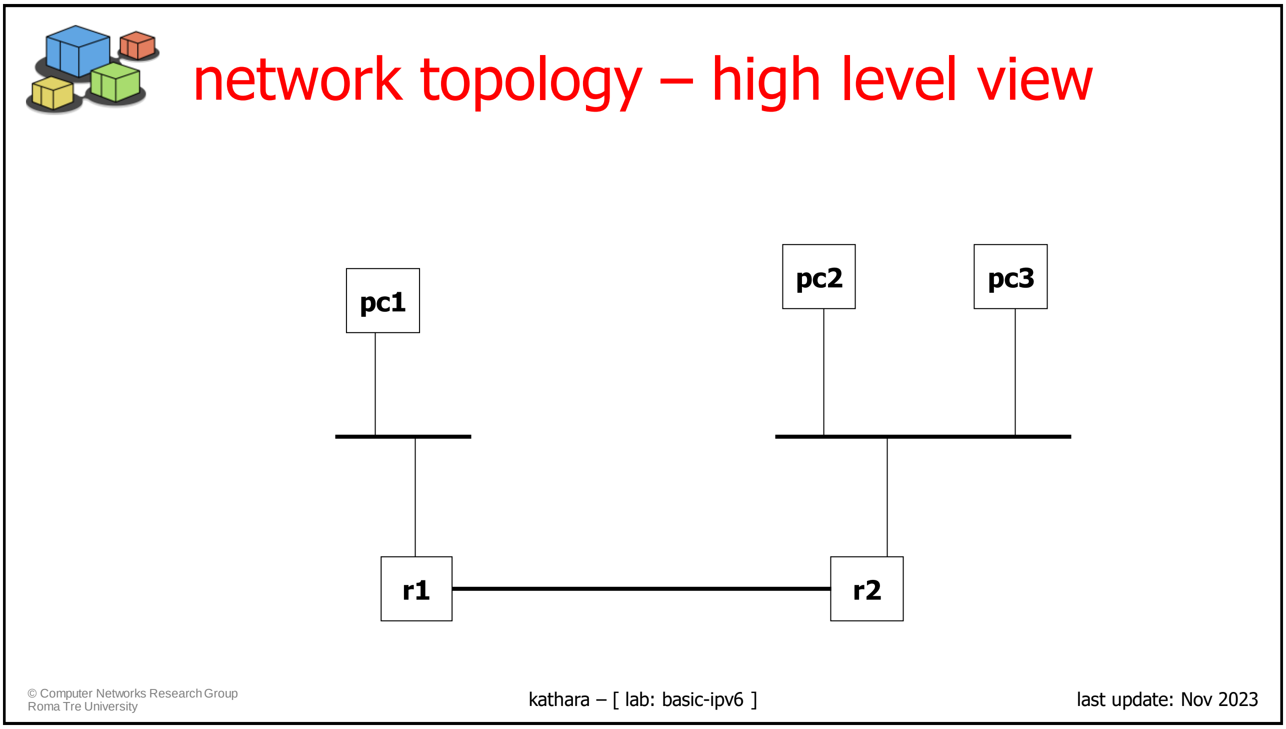
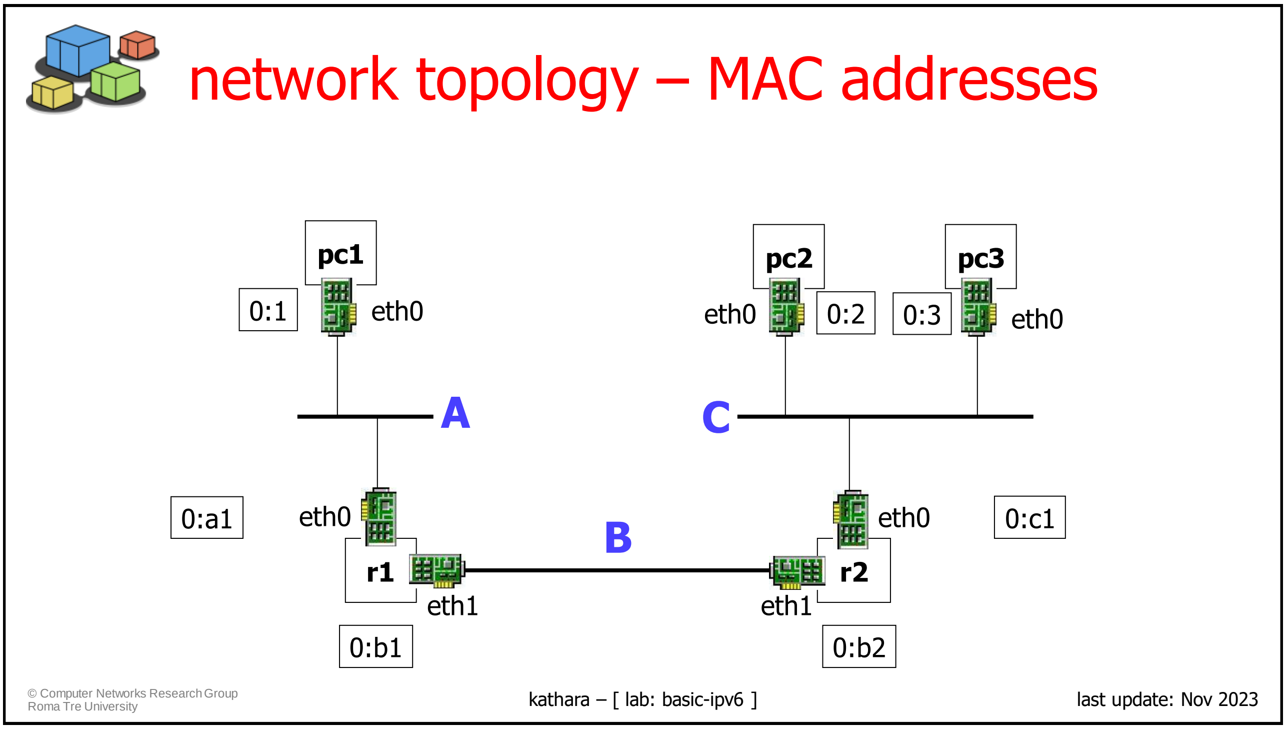
lab configuration

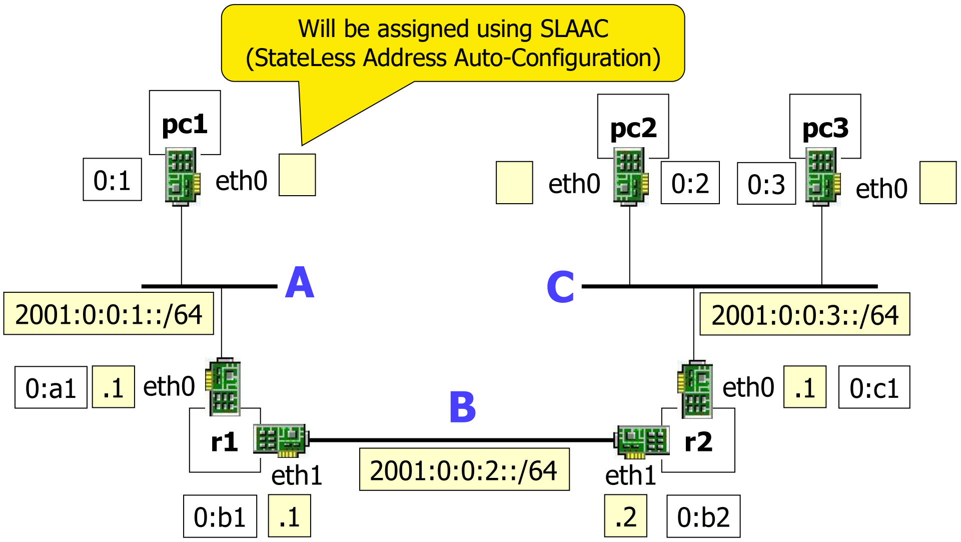


network topology – high level view



network topology – MAC addresses

network topology – IPv6 address plan



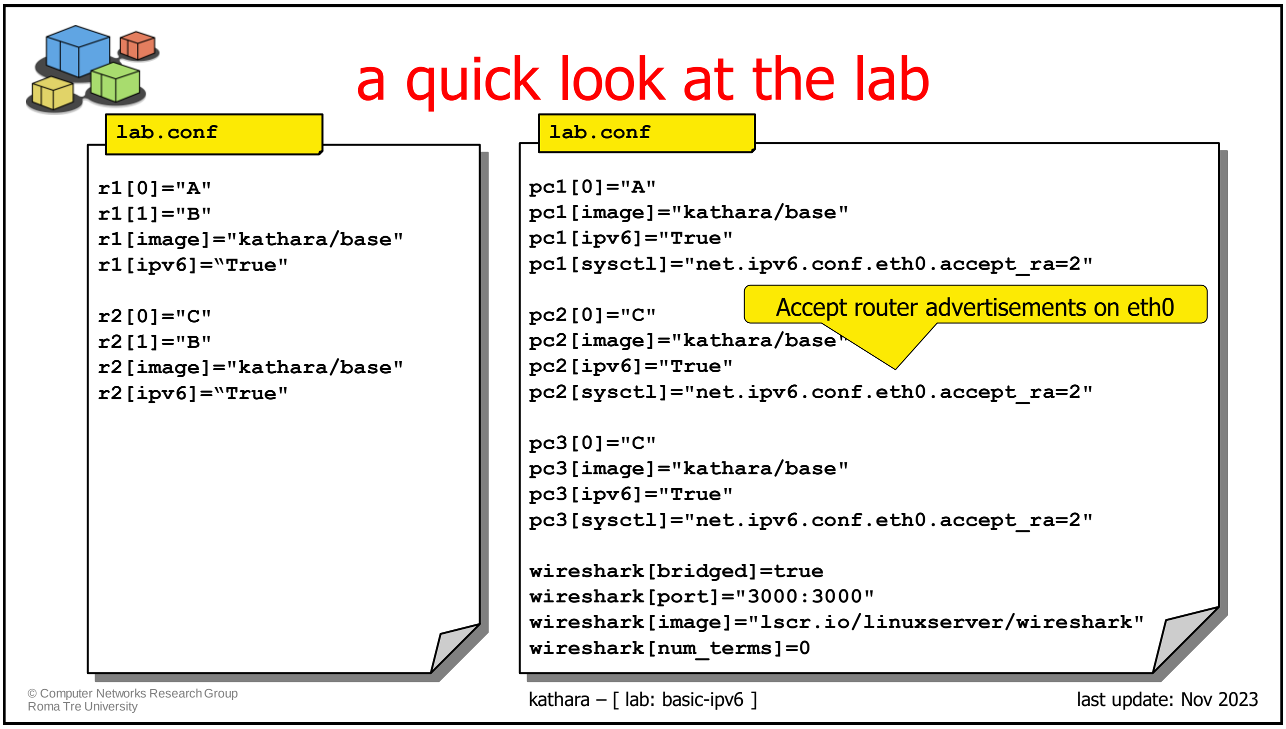
a quick look at the lab

lab.conf

```
r1[0]="A"
r1[1]="B"
r1[image]="kathara/base"
r1[ipv6]=“True"

r2[0]="C"
r2[1]="B"
r2[image]="kathara/base"
r2[ipv6]=“True"
```

lab.conf

```
pc1[0]="A"
pc1[image]="kathara/base"
pc1[ipv6]="True"
pc1[sysctl]="net.ipv6.conf.eth0.accept_ra=2"

pc2[0]="C"
pc2[image]="kathara/base"
pc2[ipv6]="True"
pc2[sysctl]="net.ipv6.conf.eth0.accept_ra=2"

pc3[0]="C"
pc3[image]="kathara/base"
pc3[ipv6]="True"
pc3[sysctl]="net.ipv6.conf.eth0.accept_ra=2"

wireshark[bridged]=true
wireshark[port]="3000:3000"
wireshark[image]="lscr.io/linuxserver/wireshark"
wireshark[num_terms]=0
```



a quick look at the lab

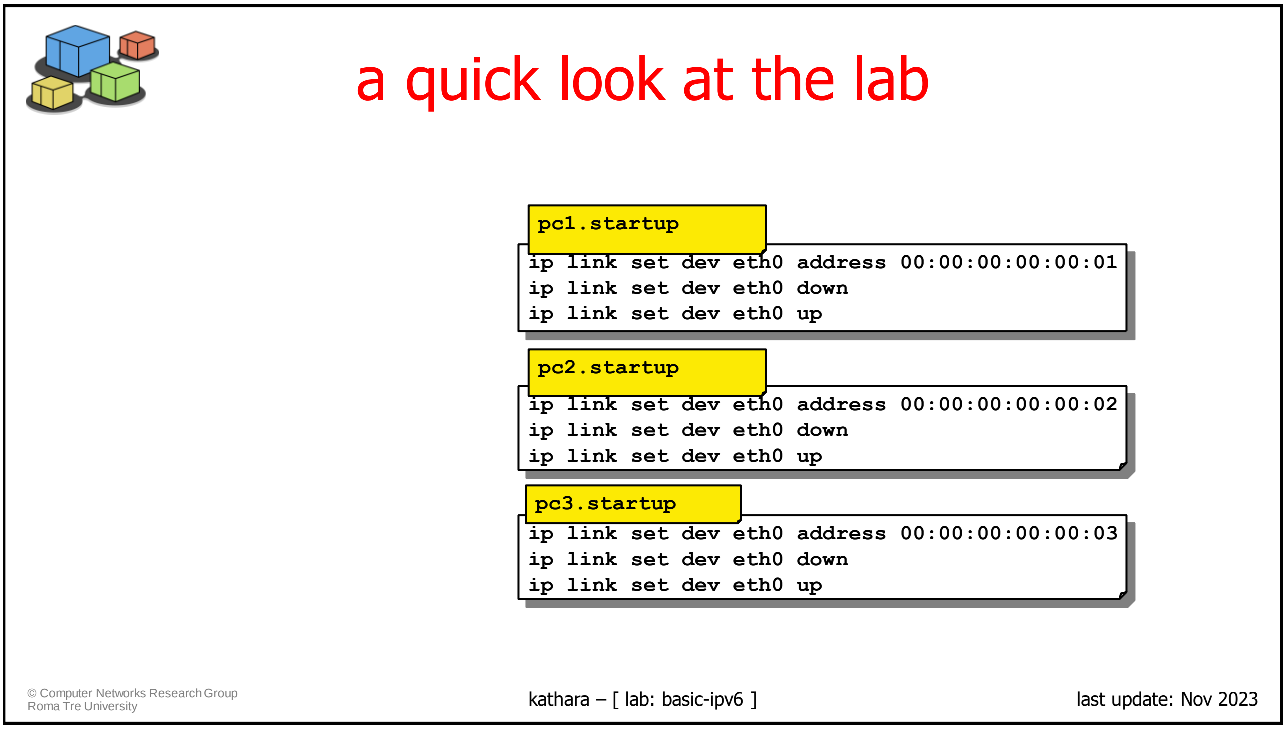
lab.conf

```
r1[0]="A"
r1[1]="B"
r1[image]="kathara/base"
r1[ipv6]=“True"

r2[0]="C"
r2[1]="B"
r2[image]="kathara/base"
r2[ipv6]=“True"
```

lab.conf

```
pc1[0]="A"
pc1[image]="kathara/base"
pc1[ipv6]="True"
pc1[sysctl]="net.ipv6.conf.eth0.accept_ra=2"

pc2[0]="C"
pc2[image]="kathara/base"
pc2[ipv6]="True"
pc2[sysctl]="net.ipv6.conf.eth0.accept_ra=2"

pc3[0]="C"
pc3[image]="kathara/base"
pc3[ipv6]="True"
pc3[sysctl]="net.ipv6.conf.eth0.accept_ra=2"

wireshark[bridged]=true
wireshark[port]="3000:3000"
wireshark[image]="lscr.io/linuxserver/wireshark"
wireshark[num_terms]=0
```

Accept router advertisements on eth0



a quick look at the lab

pc1.startup

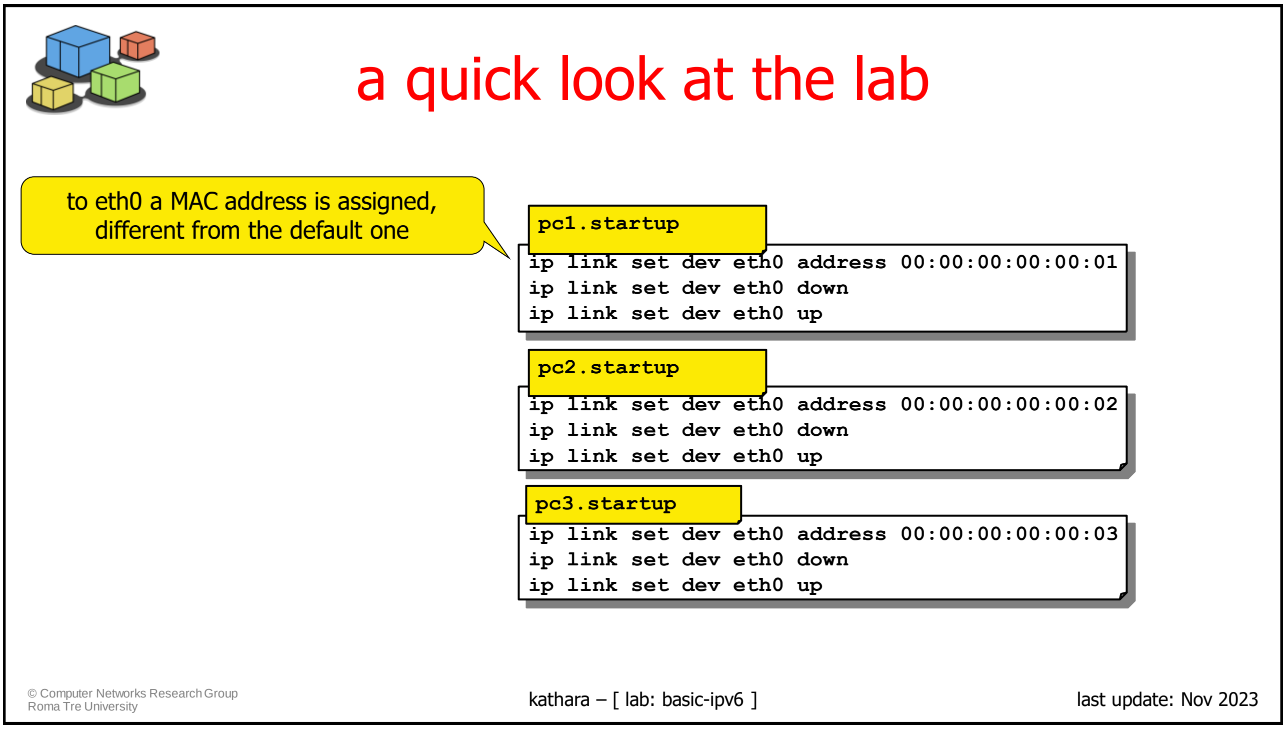
```
ip link set dev eth0 address 00:00:00:00:00:01
ip link set dev eth0 down
ip link set dev eth0 up
```

pc2.startup

```
ip link set dev eth0 address 00:00:00:00:00:02
ip link set dev eth0 down
ip link set dev eth0 up
```

pc3.startup

```
ip link set dev eth0 address 00:00:00:00:00:03
ip link set dev eth0 down
ip link set dev eth0 up
```



a quick look at the lab

to eth0 a MAC address is assigned, different from the default one

pc1.startup

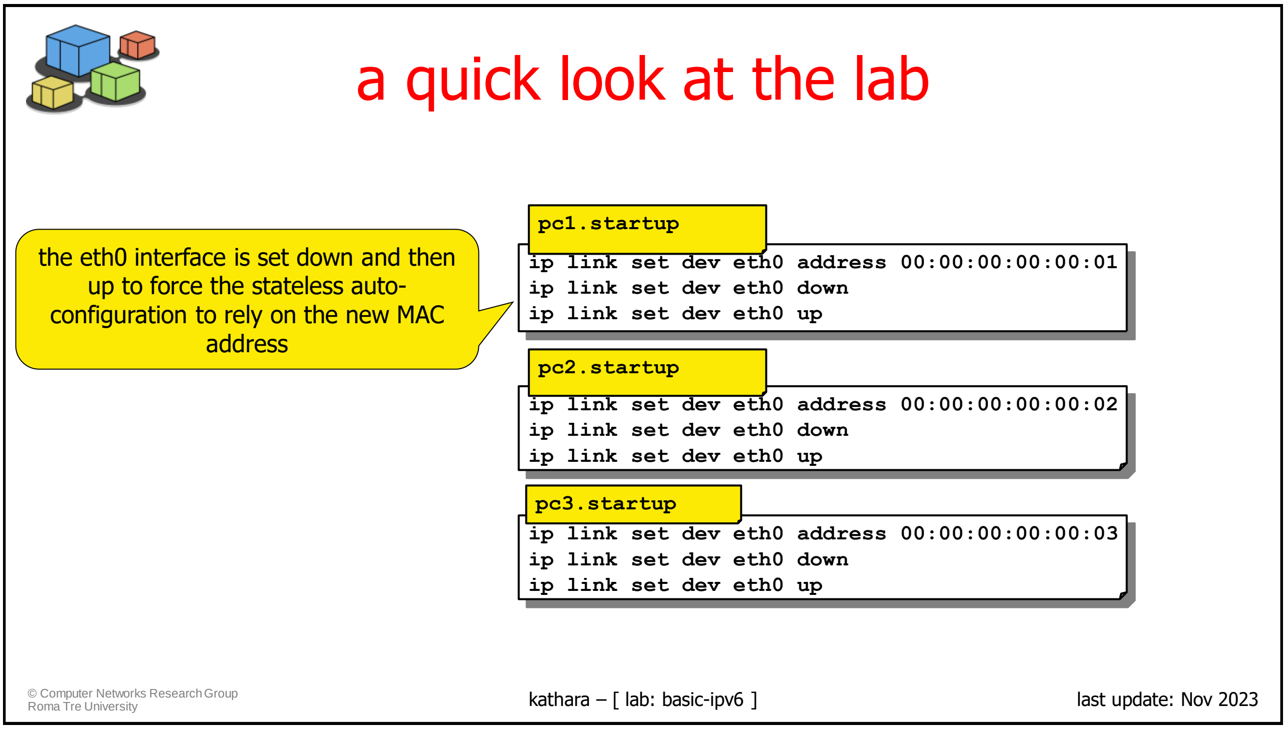
```
ip link set dev eth0 address 00:00:00:00:00:01
ip link set dev eth0 down
ip link set dev eth0 up
```

pc2.startup

```
ip link set dev eth0 address 00:00:00:00:00:02
ip link set dev eth0 down
ip link set dev eth0 up
```

pc3.startup

```
ip link set dev eth0 address 00:00:00:00:00:03
ip link set dev eth0 down
ip link set dev eth0 up
```



a quick look at the lab

the eth0 interface is set down and then up to force the stateless auto-configuration to rely on the new MAC address

pc1.startup

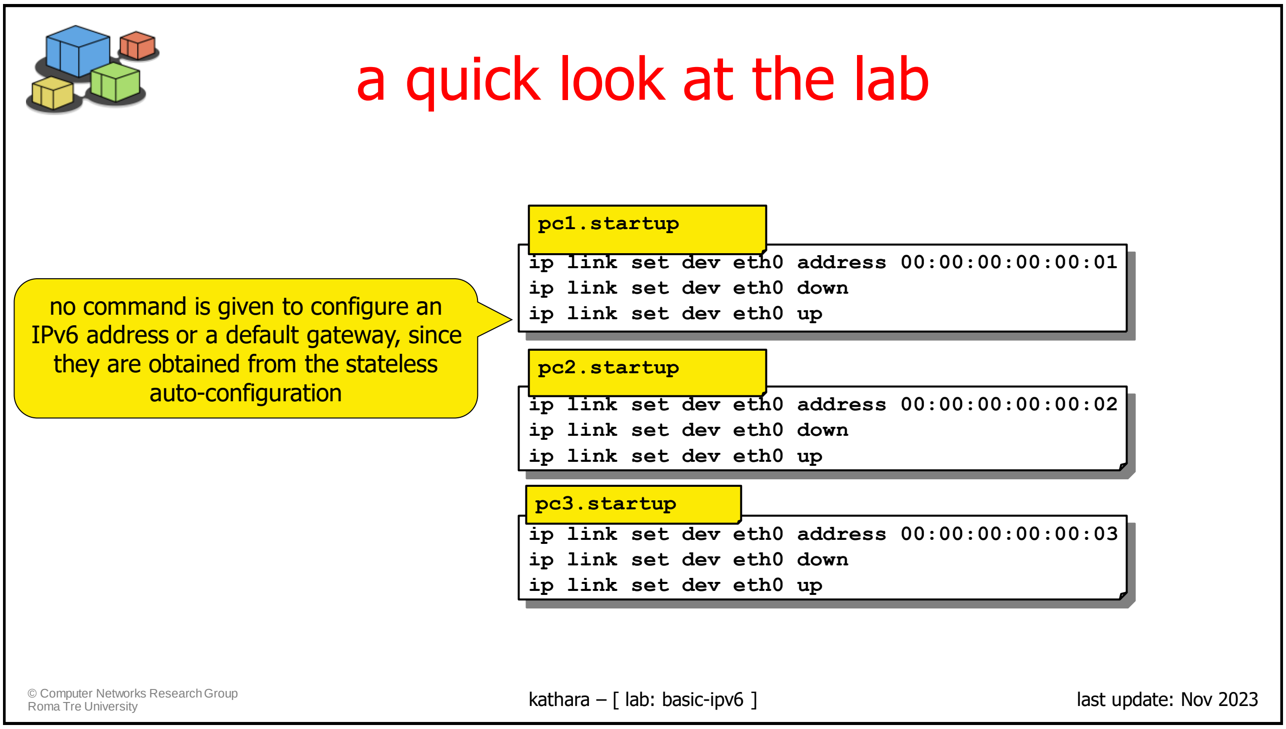
```
ip link set dev eth0 address 00:00:00:00:00:01
ip link set dev eth0 down
ip link set dev eth0 up
```

pc2.startup

```
ip link set dev eth0 address 00:00:00:00:00:02
ip link set dev eth0 down
ip link set dev eth0 up
```

pc3.startup

```
ip link set dev eth0 address 00:00:00:00:00:03
ip link set dev eth0 down
ip link set dev eth0 up
```



a quick look at the lab

no command is given to configure an IPv6 address or a default gateway, since they are obtained from the stateless auto-configuration

pc1.startup

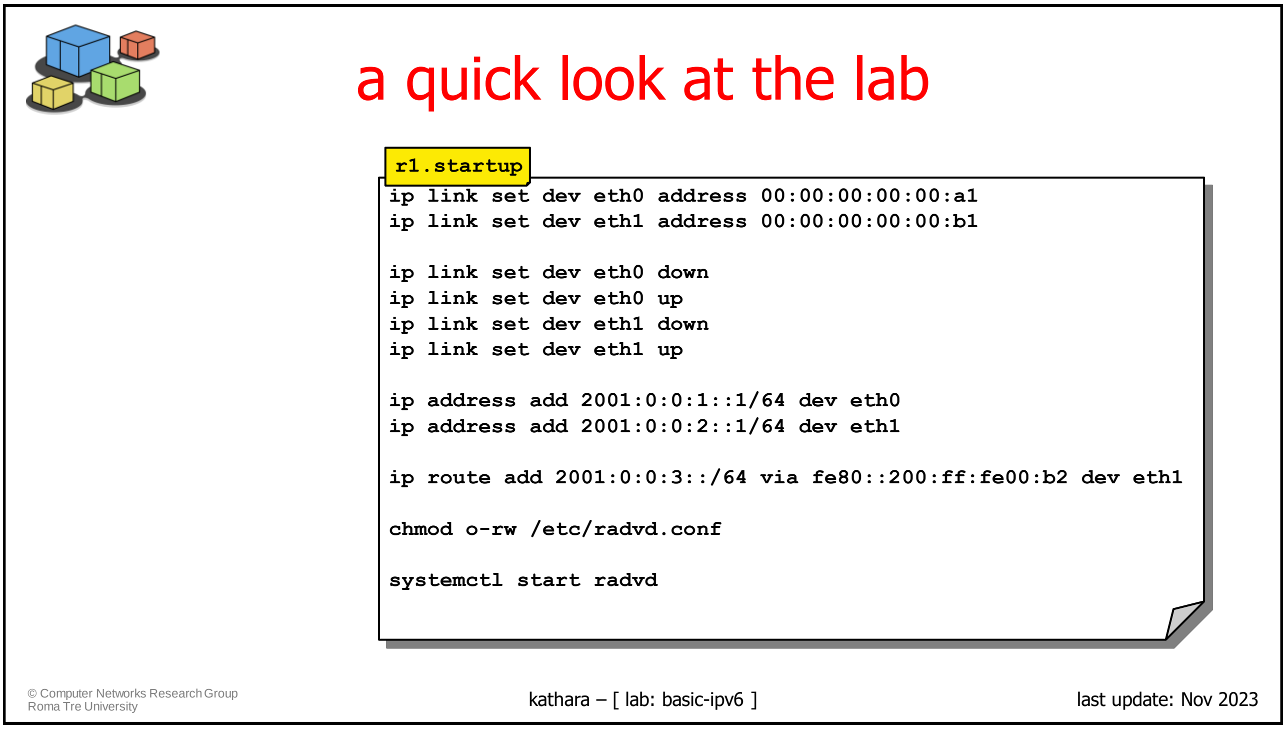
```
ip link set dev eth0 address 00:00:00:00:00:01
ip link set dev eth0 down
ip link set dev eth0 up
```

pc2.startup

```
ip link set dev eth0 address 00:00:00:00:00:02
ip link set dev eth0 down
ip link set dev eth0 up
```

pc3.startup

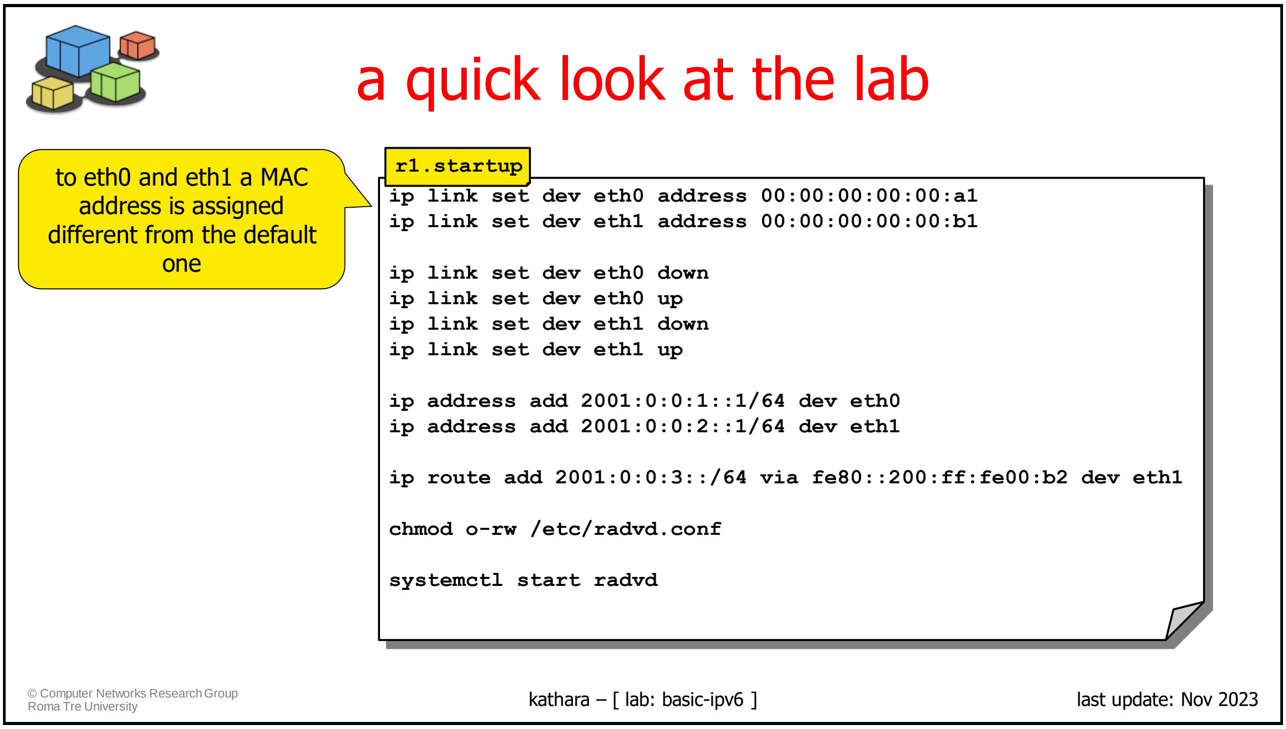
```
ip link set dev eth0 address 00:00:00:00:00:03
ip link set dev eth0 down
ip link set dev eth0 up
```



a quick look at the lab

r1.startup

```
ip link set dev eth0 address 00:00:00:00:00:a1
ip link set dev eth1 address 00:00:00:00:00:b1

ip link set dev eth0 down
ip link set dev eth0 up
ip link set dev eth1 down
ip link set dev eth1 up

ip address add 2001:0:0:1::1/64 dev eth0
ip address add 2001:0:0:2::1/64 dev eth1

ip route add 2001:0:0:3::/64 via fe80::200:ff:fe00:b2 dev eth1

chmod o-rw /etc/radvd.conf

systemctl start radvd
```

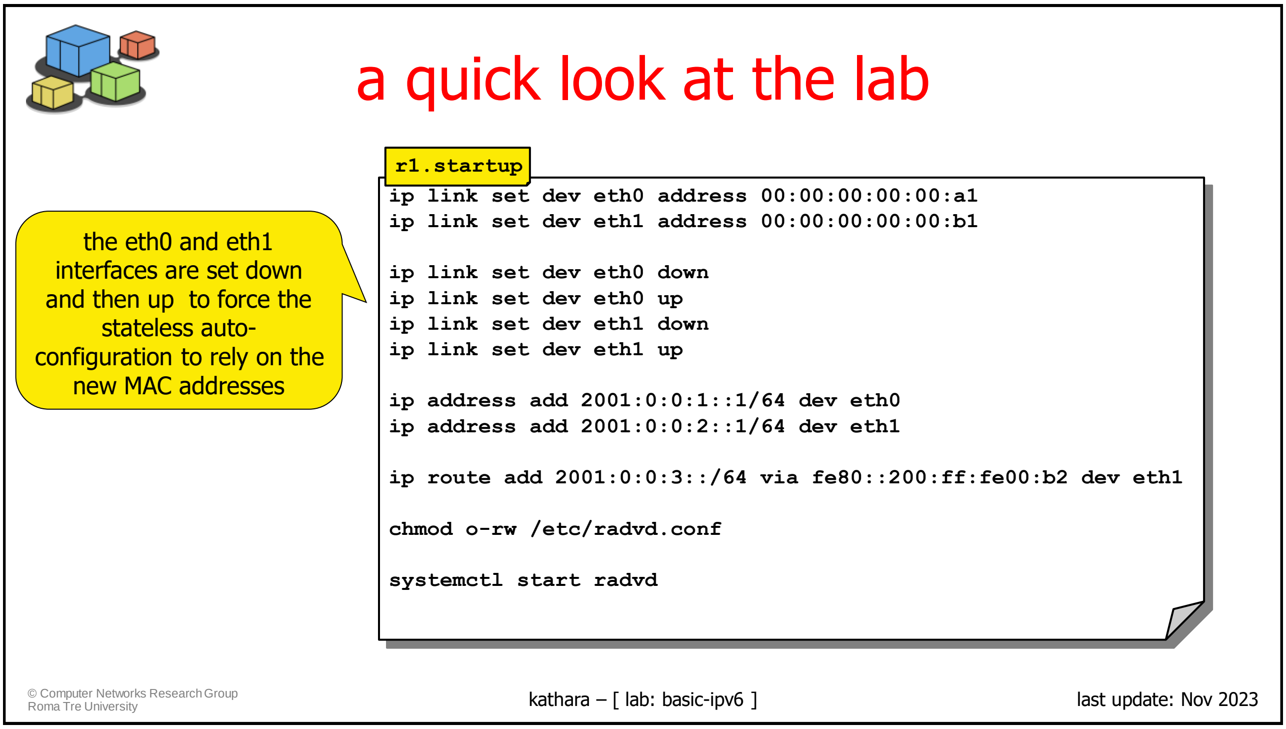


a quick look at the lab

to eth0 and eth1 a MAC address is assigned different from the default one

r1.startup

```
ip link set dev eth0 address 00:00:00:00:00:a1
ip link set dev eth1 address 00:00:00:00:00:b1

ip link set dev eth0 down
ip link set dev eth0 up
ip link set dev eth1 down
ip link set dev eth1 up

ip address add 2001:0:0:1::1/64 dev eth0
ip address add 2001:0:0:2::1/64 dev eth1

ip route add 2001:0:0:3::/64 via fe80::200:ff:fe00:b2 dev eth1

chmod o-rw /etc/radvd.conf

systemctl start radvd
```



a quick look at the lab

the eth0 and eth1 interfaces are set down and then up to force the stateless auto-configuration to rely on the new MAC addresses

r1.startup

```
ip link set dev eth0 address 00:00:00:00:00:a1
ip link set dev eth1 address 00:00:00:00:00:b1

ip link set dev eth0 down
ip link set dev eth0 up
ip link set dev eth1 down
ip link set dev eth1 up

ip address add 2001:0:0:1::1/64 dev eth0
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ip route add 2001:0:0:3::/64 via fe80::200:ff:fe00:b2 dev eth1

chmod o-rw /etc/radvd.conf

systemctl start radvd
```
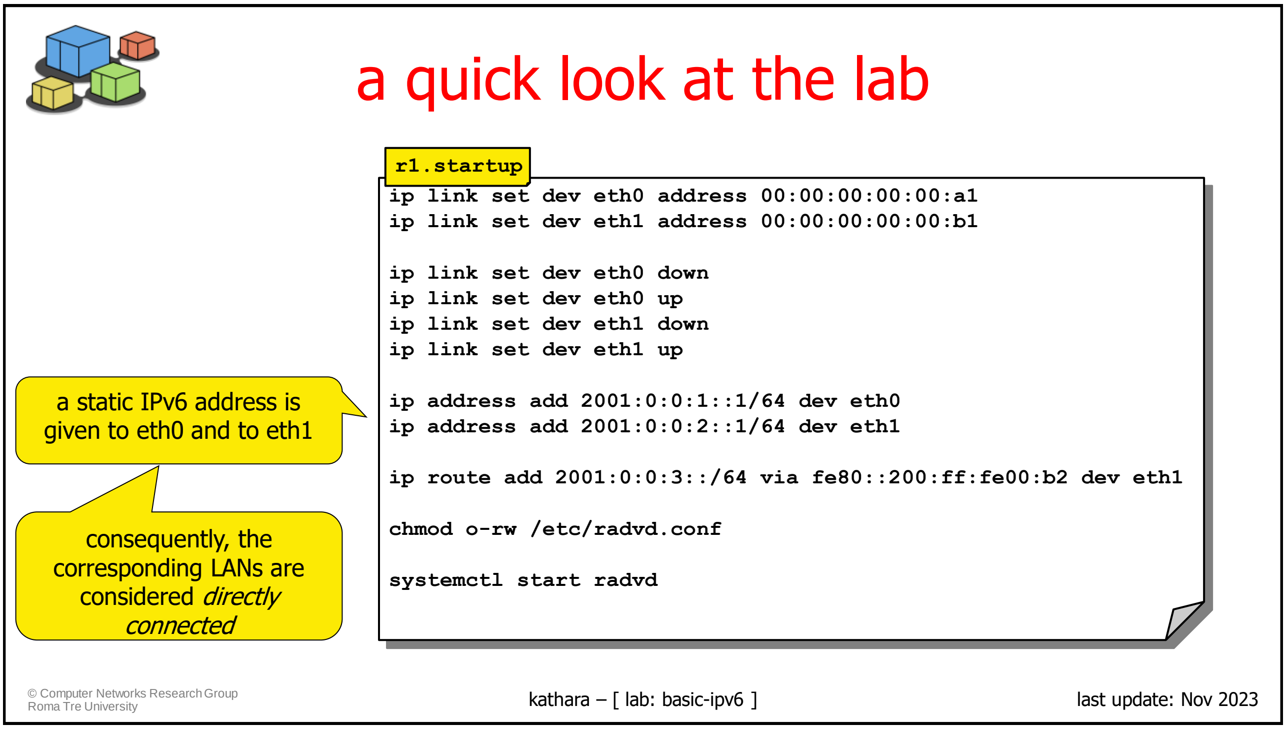



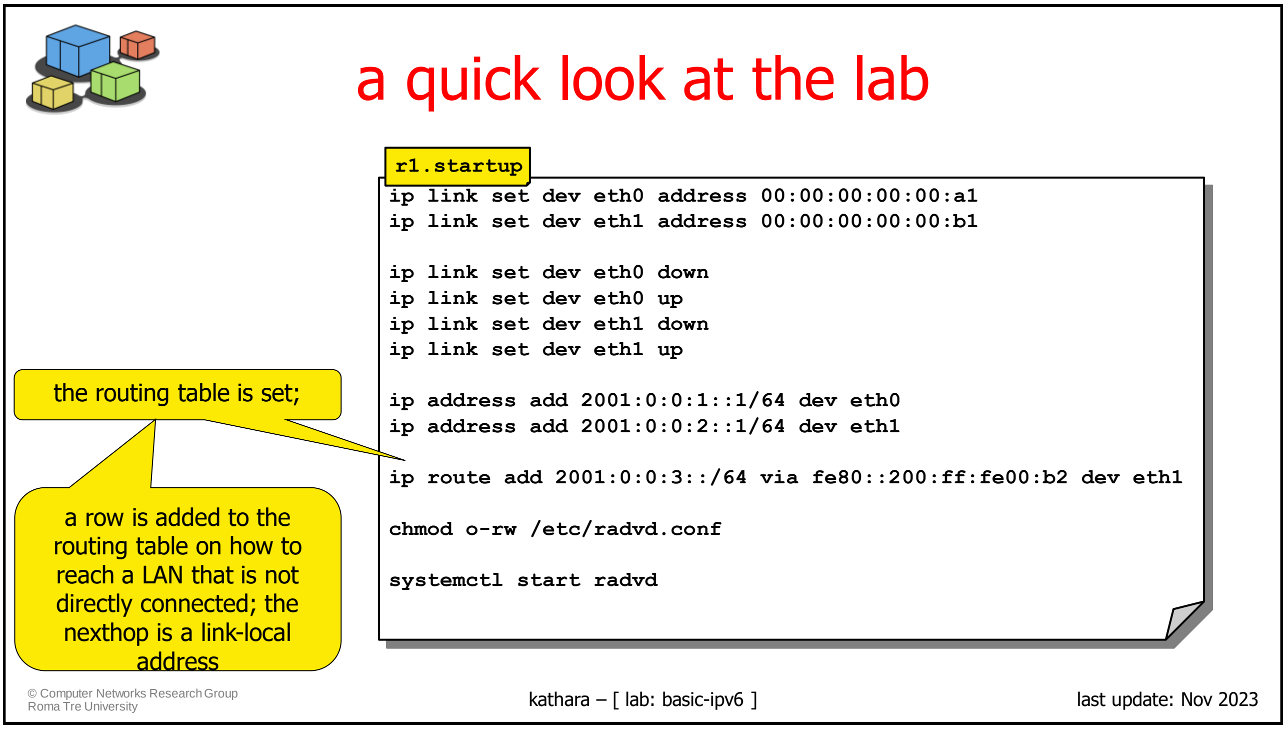
a quick look at the lab

r1.startup

```
ip link set dev eth0 address 00:00:00:00:00:a1
ip link set dev eth1 address 00:00:00:00:00:b1

ip link set dev eth0 down
ip link set dev eth0 up
ip link set dev eth1 down
ip link set dev eth1 up

ip address add 2001:0:0:1::1/64 dev eth0
ip address add 2001:0:0:2::1/64 dev eth1

ip route add 2001:0:0:3::/64 via fe80::200:ff:fe00:b2 dev eth1

chmod o-rw /etc/radvd.conf

systemctl start radvd
```

a static IPv6 address is given to eth0 and to eth1

consequently, the corresponding LANs are considered *directly connected*



a quick look at the lab

r1.startup

```
ip link set dev eth0 address 00:00:00:00:00:a1
ip link set dev eth1 address 00:00:00:00:00:b1

ip link set dev eth0 down
ip link set dev eth0 up
ip link set dev eth1 down
ip link set dev eth1 up

ip address add 2001:0:0:1::1/64 dev eth0
ip address add 2001:0:0:2::1/64 dev eth1

ip route add 2001:0:0:3::/64 via fe80::200:ff:fe00:b2 dev eth1

chmod o-rw /etc/radvd.conf

systemctl start radvd
```

the routing table is set;

a row is added to the routing table on how to reach a LAN that is not directly connected; the nexthop is a link-local address

a quick look at the lab

r1.startup

```
ip link set dev eth0 address 00:00:00:00:00:a1
ip link set dev eth1 address 00:00:00:00:00:b1

ip link set dev eth0 down
ip link set dev eth0 up
ip link set dev eth1 down
ip link set dev eth1 up

ip address add 2001:0:0:1::1/64 dev eth0
ip address add 2001:0:0:2::1/64 dev eth1

ip route add 2001:0:0:3::/64 via fe80::200:ff:fe00:b2 dev eth1

chmod o-rw /etc/radvd.conf

systemctl start radvd
```

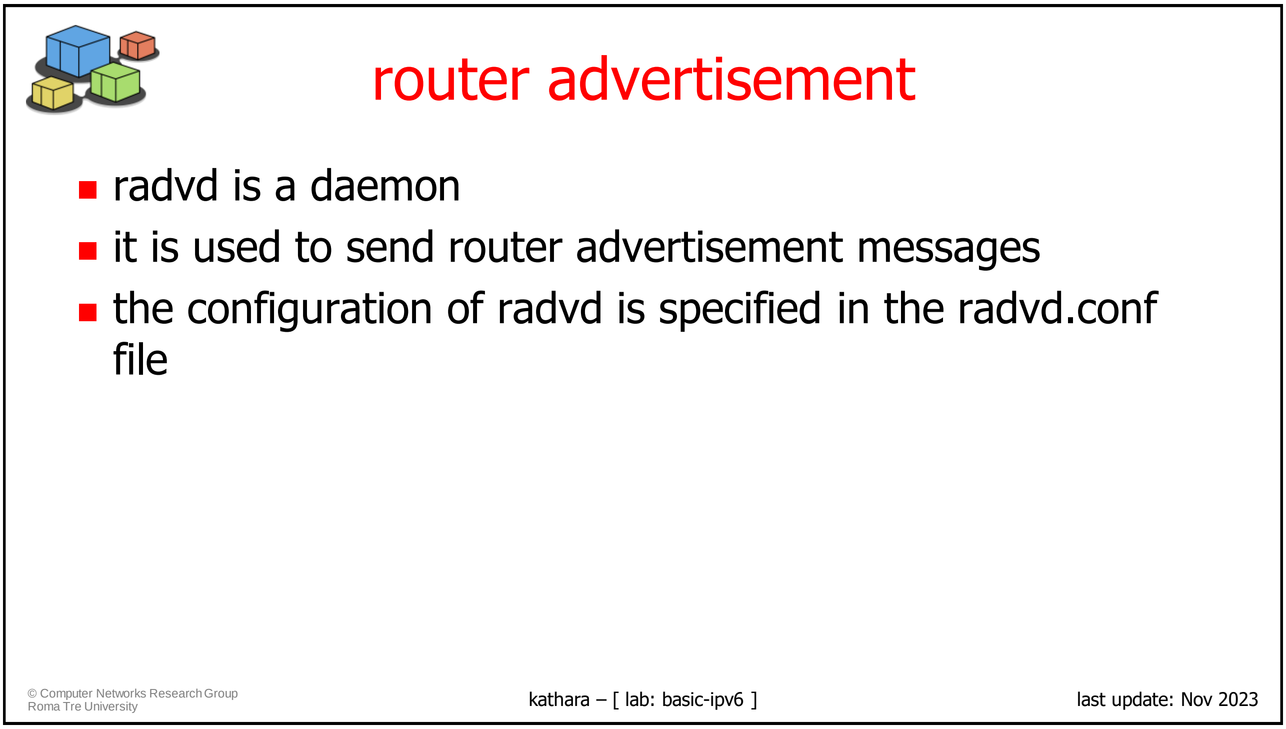
the correct privileges for radvd.conf are set and the radvd service is started

a quick look at the lab

radvd.conf

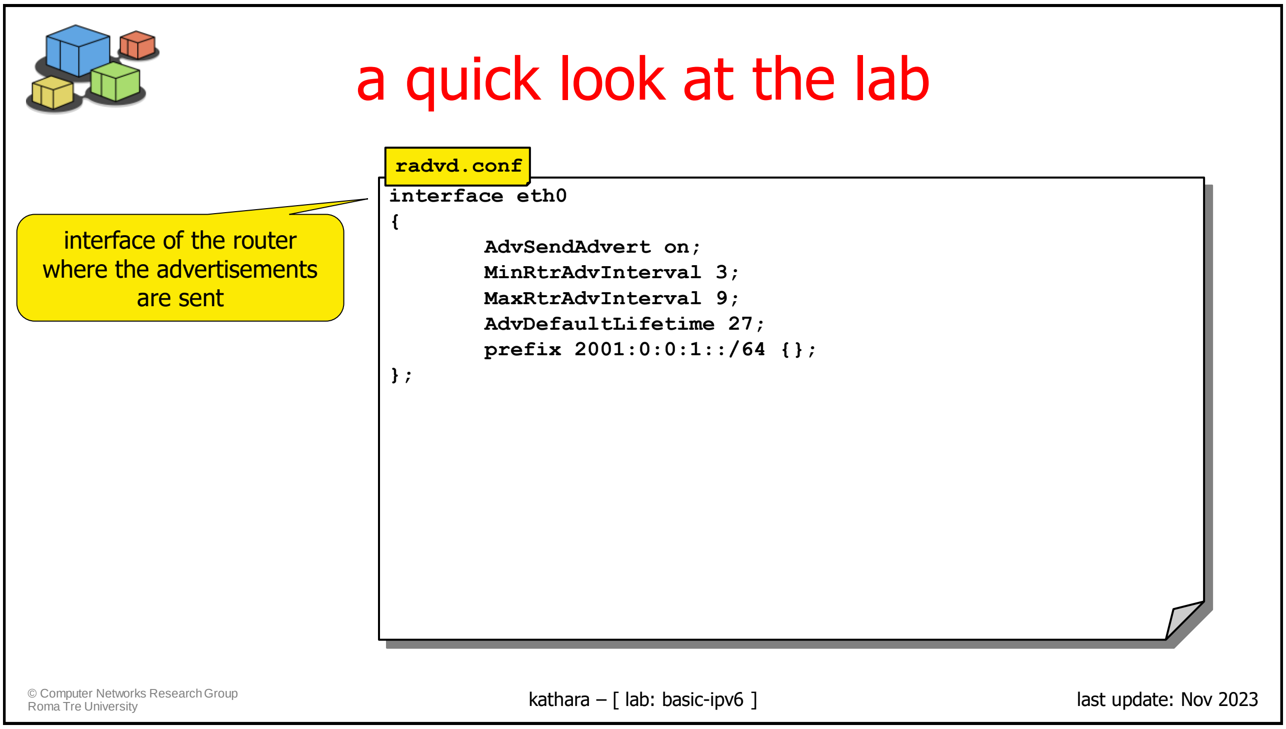
```
interface eth0
{
        AdvSendAdvert on;
        MinRtrAdvInterval 3;
        MaxRtrAdvInterval 9;
        AdvDefaultLifetime 27;
        prefix 2001:0:0:1::/64 {};
};
```

this configuration file, of the radvd daemon, is in the /etc directory of r1



router advertisement

- radvd is a daemon
- it is used to send router advertisement messages
- the configuration of radvd is specified in the radvd.conf file

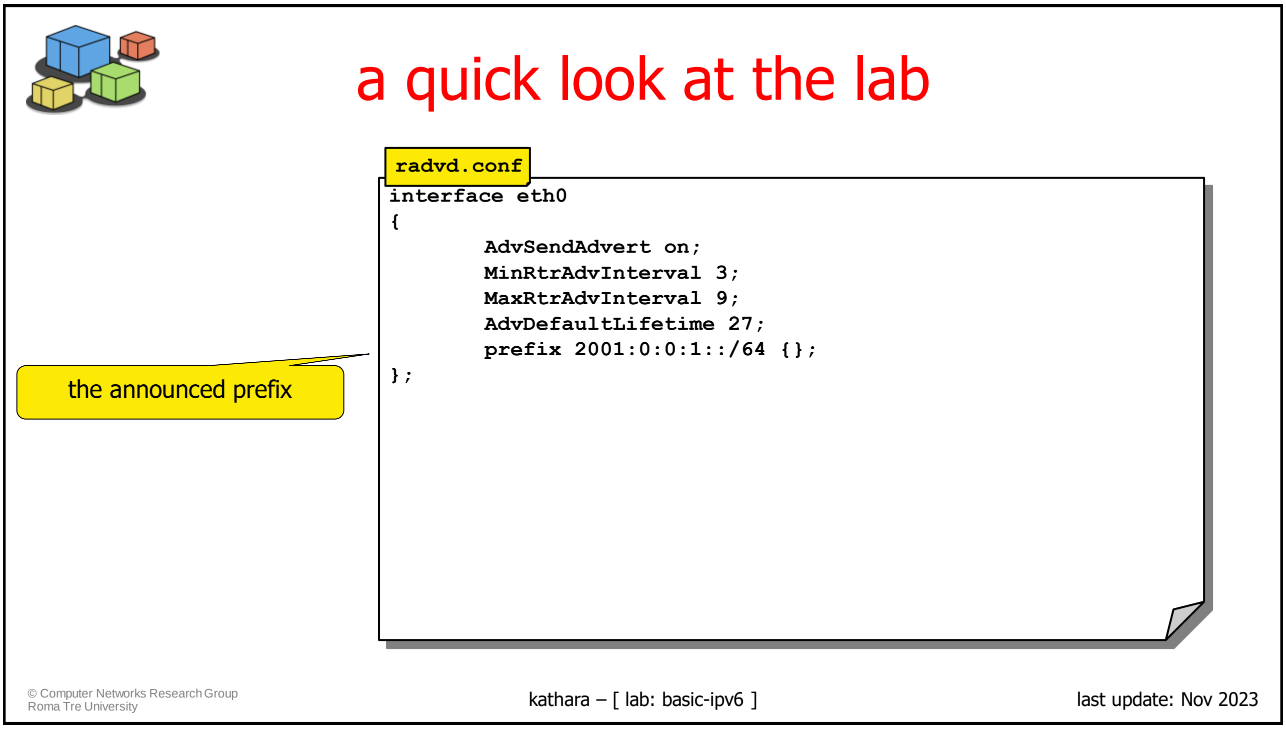


a quick look at the lab

radvd.conf

```
interface eth0
{
        AdvSendAdvert on;
        MinRtrAdvInterval 3;
        MaxRtrAdvInterval 9;
        AdvDefaultLifetime 27;
        prefix 2001:0:0:1::/64 {};
};
```

interface of the router where the advertisements are sent

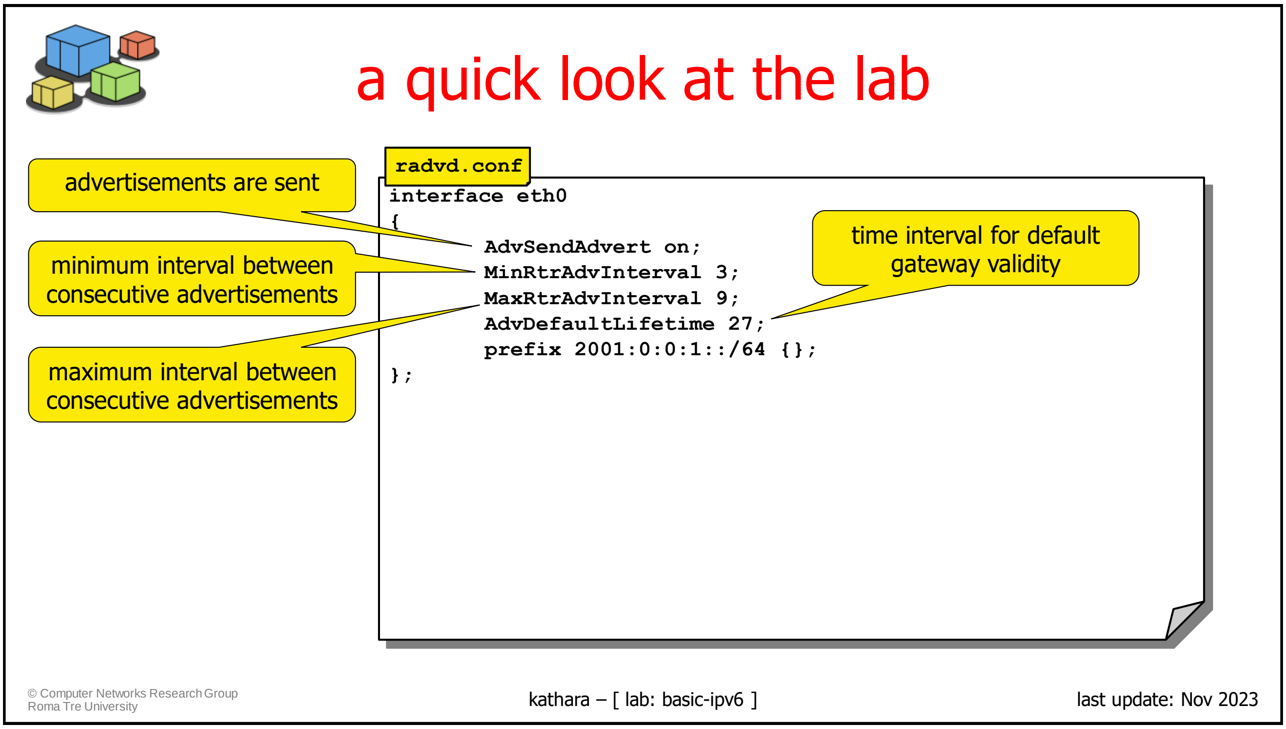


a quick look at the lab

radvd.conf

```
interface eth0
{
        AdvSendAdvert on;
        MinRtrAdvInterval 3;
        MaxRtrAdvInterval 9;
        AdvDefaultLifetime 27;
        prefix 2001:0:0:1::/64 {};
};
```

the announced prefix



a quick look at the lab

radvd.conf

```
interface eth0
{
        AdvSendAdvert on;
        MinRtrAdvInterval 3;
        MaxRtrAdvInterval 9;
        AdvDefaultLifetime 27;
        prefix 2001:0:0:1::/64 {};
};
```

advertisements are sent

minimum interval between consecutive advertisements

maximum interval between consecutive advertisements

time interval for default gateway validity

a quick look at the lab

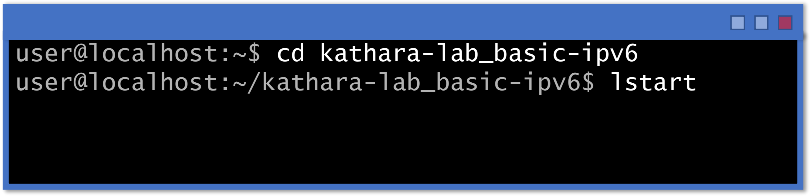
r1.startup

```
ip link set dev eth0 address 00:00:00:00:00:a1
ip link set dev eth1 address 00:00:00:00:00:b1

ip link set dev eth0 down
ip link set dev eth0 up
ip link set dev eth1 down
ip link set dev eth1 up

ip address add 2001:0:0:1::1/64 dev eth0
ip address add 2001:0:0:2::1/64 dev eth1

ip route add 2001:0:0:3::/64 via fe80::200:ff:fe00:b2 dev eth1

chmod o-rw /etc/radvd.conf

systemctl start radvd
```

similar configuration for router r2

start the lab

- start the lab



```
user@localhost:~$ cd kathara-lab_basic-ipv6
user@localhost:~/kathara-lab_basic-ipv6$ lstart
```

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useful commands

check the IPv6 addresses

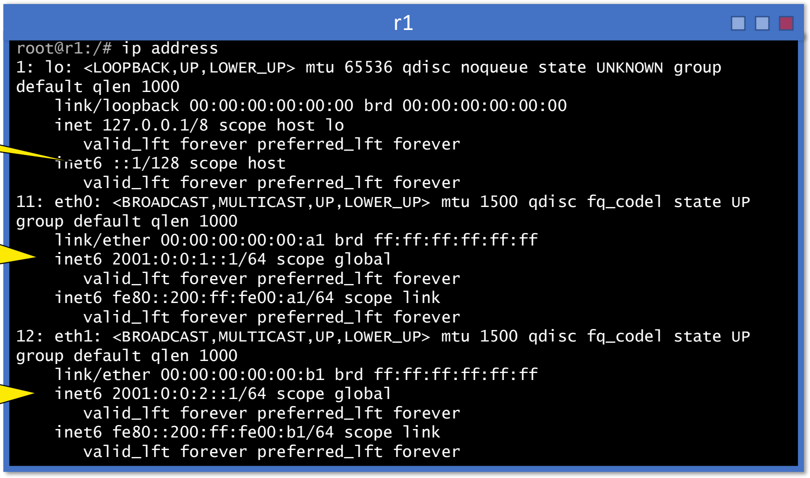
- on r1, and r2
  - perform the `ip address` command, to check the addresses assigned to the interfaces
    - the `ip -6 address` command shows only the IPv6 addresses
    - look at eth and loopback interfaces

check the IPv6 addresses

loopback
IPv4: 127.0.0.1/8
IPv6: ::1/128

eth0
global unicast: 2001:0:0:1::1/64
link-local: fe80::200:ff:fe00:a1/64

eth1
global unicast: 2001:0:0:2::1/64
link-local: fe80::200:ff:fe00:b1/64

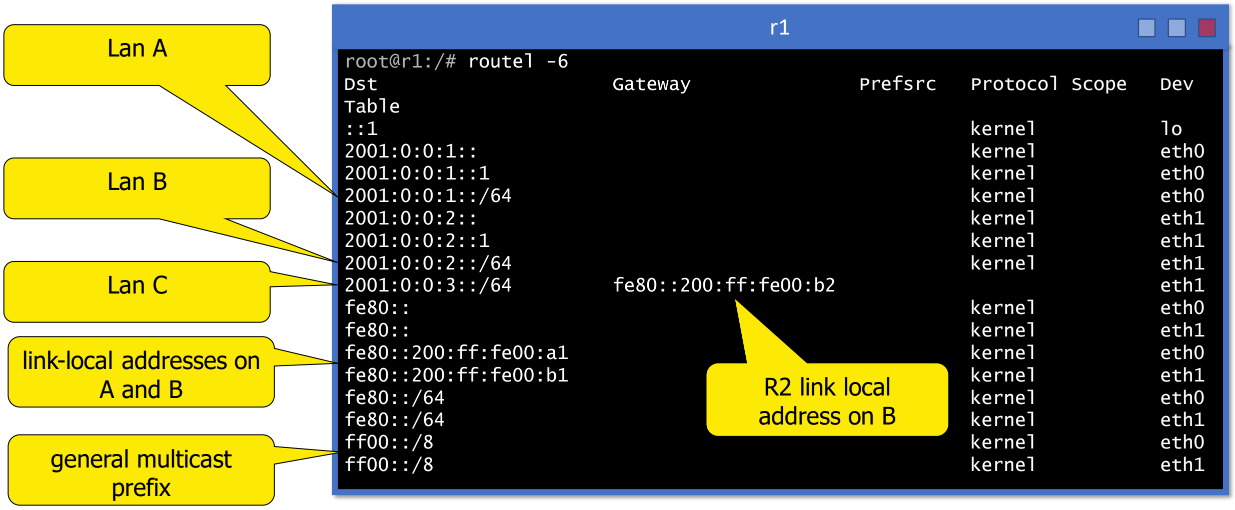


```
root@r1:/# ip address
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group
default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
11: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP
group default qlen 1000
    link/ether 00:00:00:00:00:a1 brd ff:ff:ff:ff:ff:ff
    inet6 2001:0:0:1::1/64 scope global
       valid_lft forever preferred_lft forever
    inet6 fe80::200:ff:fe00:a1/64 scope link
       valid_lft forever preferred_lft forever
12: eth1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP
group default qlen 1000
    link/ether 00:00:00:00:00:b1 brd ff:ff:ff:ff:ff:ff
    inet6 2001:0:0:2::1/64 scope global
       valid_lft forever preferred_lft forever
    inet6 fe80::200:ff:fe00:b1/64 scope link
       valid_lft forever preferred_lft forever
```

check the router routing table

- on r1 and r2
  - perform the **`route -6`** command, to check the routing table

check the router routing table



```
root@r1:/# routel -6
Dst                     Gateway               Prefsrc   Protocol Scope     Dev
Table
::1                                                     kernel             lo
2001:0:0:1::                                            kernel             eth0
2001:0:0:1::1                                           kernel             eth0
2001:0:0:1::/64                                         kernel             eth0
2001:0:0:2::                                            kernel             eth1
2001:0:0:2::1                                           kernel             eth1
2001:0:0:2::/64                                         kernel             eth1
2001:0:0:3::/64         fe80::200:ff:fe00:b2                               eth1
fe80::                                                  kernel             eth0
fe80::                                                  kernel             eth1
fe80::200:ff:fe00:a1                                    kernel             eth0
fe80::200:ff:fe00:b1                                    kernel             eth1
fe80::/64                                               kernel             eth0
fe80::/64                                               kernel             eth1
ff00::/8                                                kernel             eth0
ff00::/8                                                kernel             eth1
```

Lan A

Lan B

Lan C

link-local addresses on A and B

general multicast prefix

R2 link local address on B

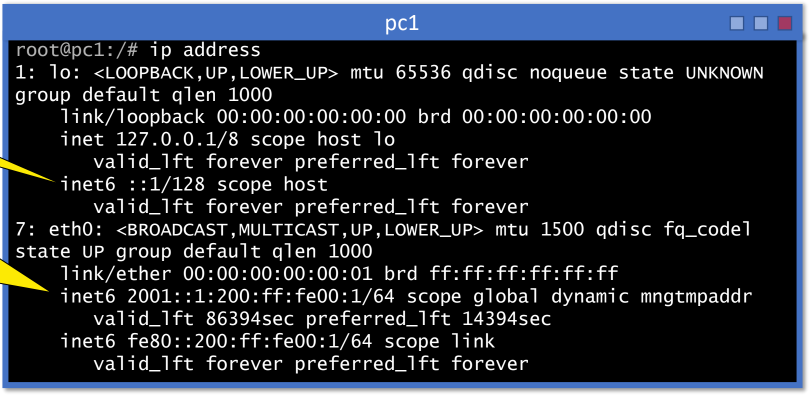
check auto-configured IPv6 addresses

- on pc1, pc2, pc3
  - perform the `ip address` command, to check the IPv6 addresses assigned to the interfaces by the stateless auto-configuration
    - possibly, perform the `ip -6 address` command
    - look at eth and loopback interfaces

check auto-configured IPv6 addresses

loopback
IPv4: 127.0.0.1/8
IPv6: ::1/128

eth0
global unicast: 2001::1:200:ff:fe00:1/64
link-local: fe80::200:ff:fe00:1/64



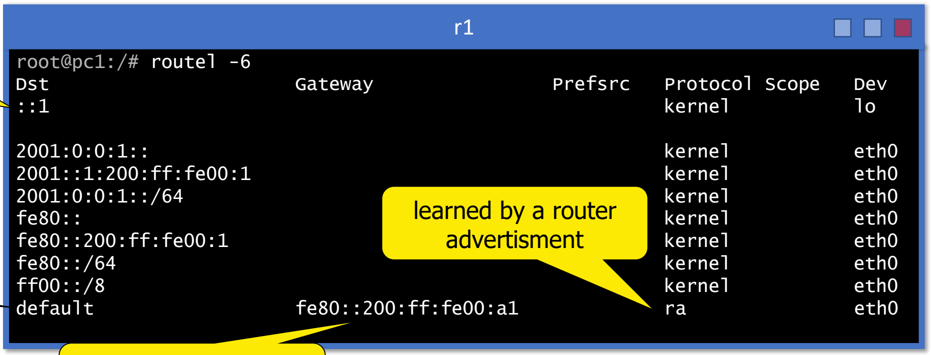
```
root@pc1:/# ip address
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN
group default qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
7: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel
state UP group default qlen 1000
    link/ether 00:00:00:00:00:01 brd ff:ff:ff:ff:ff:ff
    inet6 2001::1:200:ff:fe00:1/64 scope global dynamic mngtmpaddr
       valid_lft 86394sec preferred_lft 14394sec
    inet6 fe80::200:ff:fe00:1/64 scope link
       valid_lft forever preferred_lft forever
```

check the default route

- on pc1, pc2, and pc3
  - perform the **`routel -6`** command, to check the presence of a default route

check the default route

- on pc1, pc2, and pc3
  - perform the **`routel -6`** command, to check the presence of a default route



```
root@pc1:/# routel -6
Dst                      Gateway                Prefsrc   Protocol Scope    Dev
::1                                                       kernel            lo

2001:0:0:1::                                              kernel            eth0
2001::1:200:ff:fe00:1                                     kernel            eth0
2001:0:0:1::/64                                           kernel            eth0
fe80::                                                    kernel            eth0
fe80::200:ff:fe00:1                                       kernel            eth0
fe80::/64                                                 kernel            eth0
ff00::/8                                                  kernel            eth0
default                  fe80::200:ff:fe00:a1             ra                eth0
```

loopback prefix

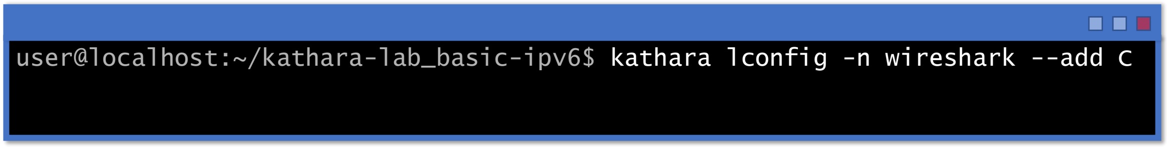
default route by r1

learned by a router advertisment

link-local address of r1 on A

sniff the traffic

- connect the wireshark device to collision domain C



```
user@localhost:~/kathara-lab_basic-ipv6$ kathara lconfig -n wireshark --add C
```

- open any browser on the host machine
  - on **localhost:3000**
  - sniff eth1

Kathará

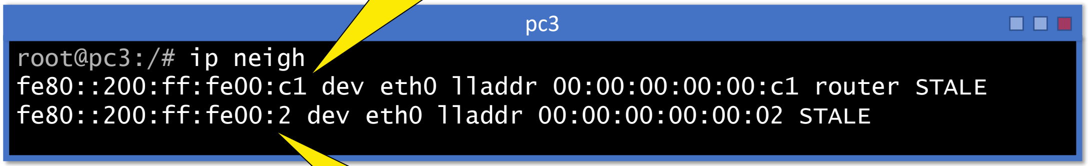
ping from pc3 to pc2 and related ICMPv6 behaviour

on pc3

1. inspect the neighbor cache
2. execute a ping command towards pc2
3. inspect again the neighbor cache
4. give a look at the packets captured by Wireshark

inspecting the neighbor cache

- similar to the IPv4 ARP cache

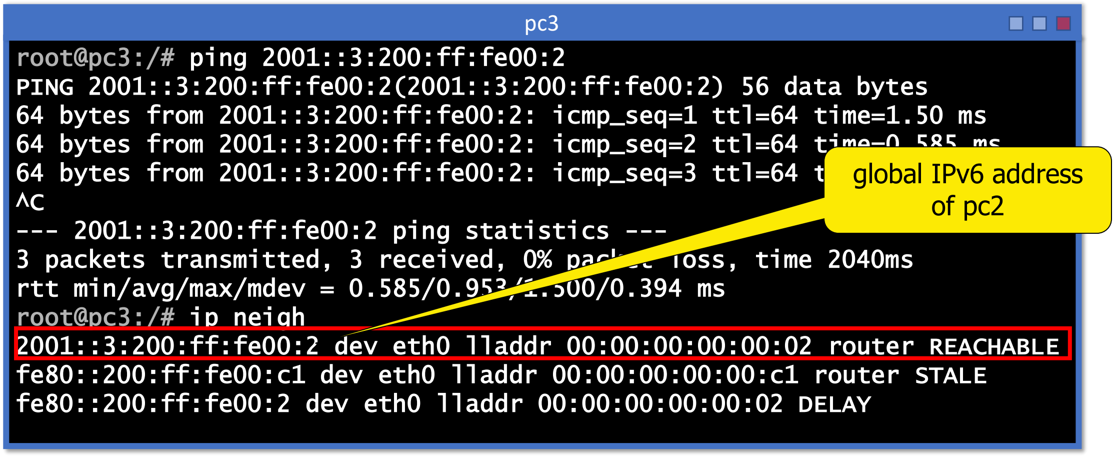


link-local address of r2 on C

```
pc3
root@pc3:/# ip neigh
fe80::200:ff:fe00:c1 dev eth0 lladdr 00:00:00:00:00:c1 router STALE
fe80::200:ff:fe00:2 dev eth0 lladdr 00:00:00:00:00:02 STALE
```

link-local address of pc2

ping and inspect the neighbor cache

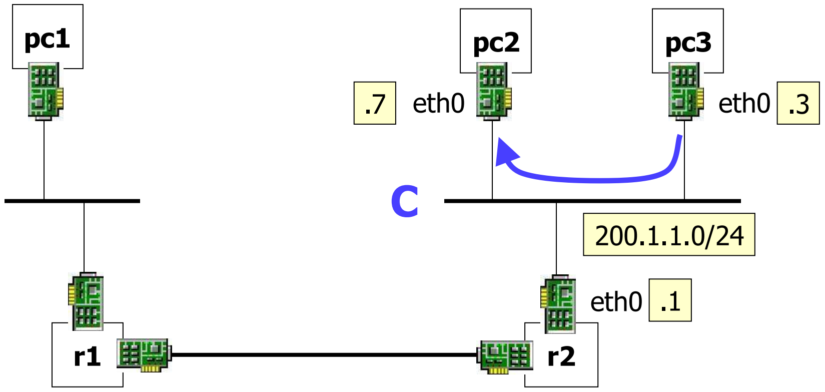


```
pc3
root@pc3:/# ping 2001::3:200:ff:fe00:2
PING 2001::3:200:ff:fe00:2(2001::3:200:ff:fe00:2) 56 data bytes
64 bytes from 2001::3:200:ff:fe00:2: icmp_seq=1 ttl=64 time=1.50 ms
64 bytes from 2001::3:200:ff:fe00:2: icmp_seq=2 ttl=64 time=0.585 ms
64 bytes from 2001::3:200:ff:fe00:2: icmp_seq=3 ttl=64 t
^C
--- 2001::3:200:ff:fe00:2 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2040ms
rtt min/avg/max/mdev = 0.585/0.953/1.500/0.394 ms
root@pc3:/# ip neigh
2001::3:200:ff:fe00:2 dev eth0 lladdr 00:00:00:00:00:02 router REACHABLE
fe80::200:ff:fe00:c1 dev eth0 lladdr 00:00:00:00:00:c1 router STALE
fe80::200:ff:fe00:2 dev eth0 lladdr 00:00:00:00:00:02 DELAY
```

global IPv6 address of pc2

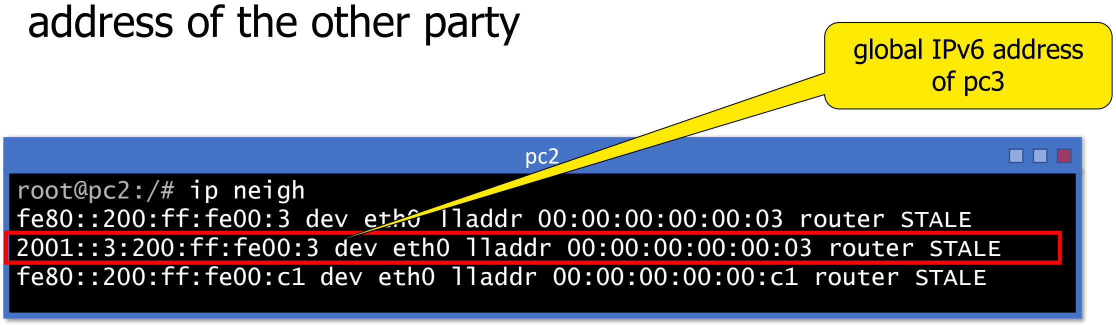
inspecting the neighbor cache

- traffic within the same network does not traverse routers



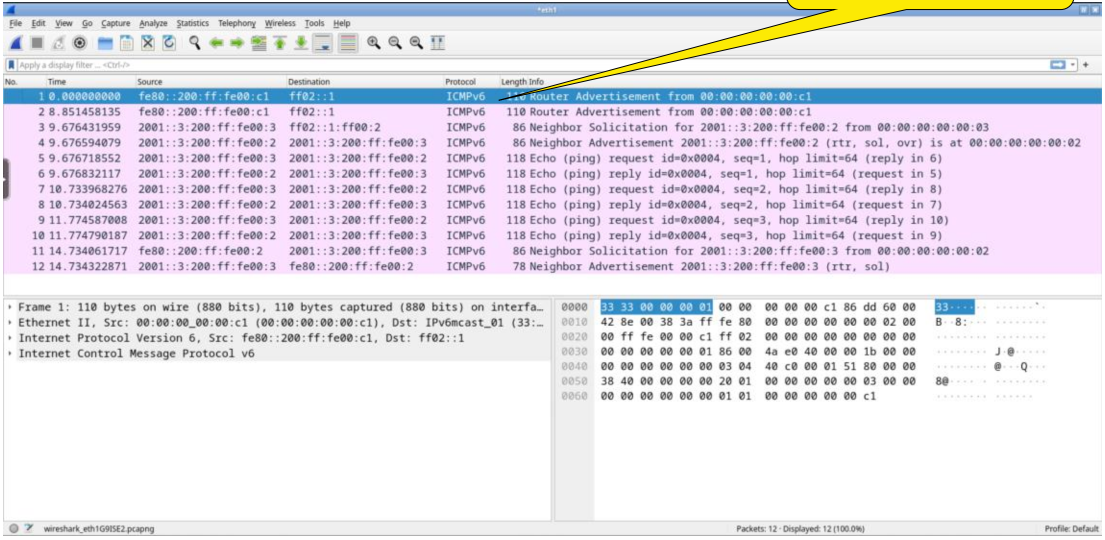
inspecting the neighbor cache

- communications are usually bi-directional
- the receiver of the neighbor solicitation learns the mac address of the other party


global IPv6 address of pc3

```
root@pc2:/# ip neigh
fe80::200:ff:fe00:3 dev eth0 lladdr 00:00:00:00:00:03 router STALE
2001::3:200:ff:fe00:3 dev eth0 lladdr 00:00:00:00:00:03 router STALE
fe80::200:ff:fe00:c1 dev eth0 lladdr 00:00:00:00:00:c1 router STALE
```

wireshark



periodic router advertisments

*eth1
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>

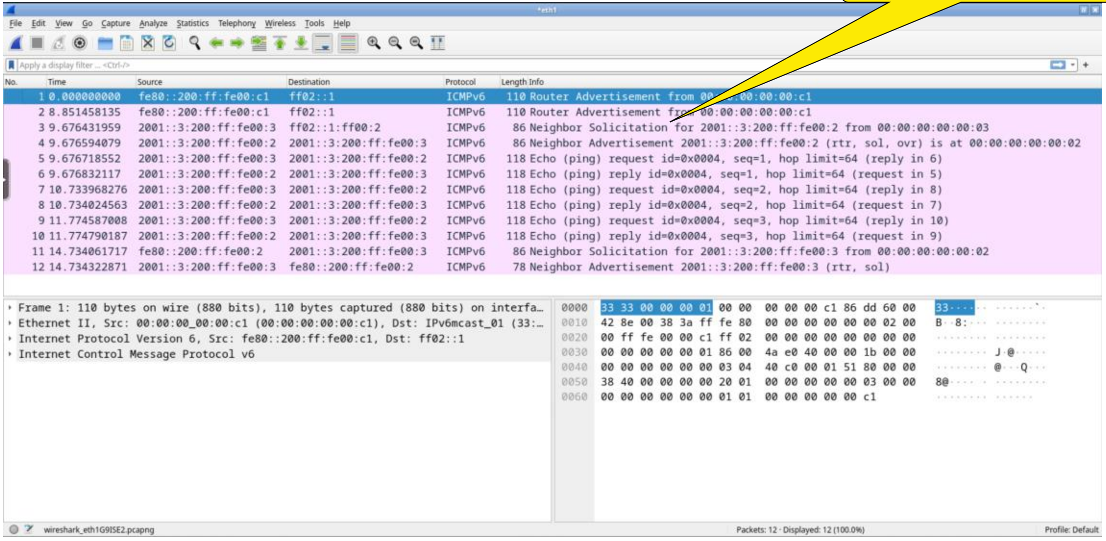
```
No.   Time         Source                   Destination              Protocol  Length Info
    1 0.000000000  fe80::200:ff:fe00:c1     ff02::1                  ICMPv6    110 Router Advertisement from 00:00:00:00:00:c1
    2 8.851458135  fe80::200:ff:fe00:c1     ff02::1                  ICMPv6    110 Router Advertisement from 00:00:00:00:00:c1
    3 9.676431959  2001::3:200:ff:fe00:3    ff02::1:ff00:2           ICMPv6     86 Neighbor Solicitation for 2001::3:200:ff:fe00:2 from 00:00:00:00:00:03
    4 9.676594079  2001::3:200:ff:fe00:2    2001::3:200:ff:fe00:3    ICMPv6     86 Neighbor Advertisement 2001::3:200:ff:fe00:2 (rtr, sol, ovr) is at 00:00:00:00:00:02
    5 9.676718552  2001::3:200:ff:fe00:3    2001::3:200:ff:fe00:2    ICMPv6    118 Echo (ping) request id=0x0004, seq=1, hop limit=64 (reply in 6)
    6 9.676832117  2001::3:200:ff:fe00:2    2001::3:200:ff:fe00:3    ICMPv6    118 Echo (ping) reply id=0x0004, seq=1, hop limit=64 (request in 5)
    7 10.733968276 2001::3:200:ff:fe00:3    2001::3:200:ff:fe00:2    ICMPv6    118 Echo (ping) request id=0x0004, seq=2, hop limit=64 (reply in 8)
    8 10.734024563 2001::3:200:ff:fe00:2    2001::3:200:ff:fe00:3    ICMPv6    118 Echo (ping) reply id=0x0004, seq=2, hop limit=64 (request in 7)
    9 11.774587008 2001::3:200:ff:fe00:3    2001::3:200:ff:fe00:2    ICMPv6    118 Echo (ping) request id=0x0004, seq=3, hop limit=64 (reply in 10)
   10 11.774790187 2001::3:200:ff:fe00:2    2001::3:200:ff:fe00:3    ICMPv6    118 Echo (ping) reply id=0x0004, seq=3, hop limit=64 (request in 9)
   11 14.734061717 fe80::200:ff:fe00:2      2001::3:200:ff:fe00:3    ICMPv6     86 Neighbor Solicitation for 2001::3:200:ff:fe00:3 from 00:00:00:00:00:02
   12 14.734322871 2001::3:200:ff:fe00:3    fe80::200:ff:fe00:2      ICMPv6     78 Neighbor Advertisement 2001::3:200:ff:fe00:3 (rtr, sol)
```

```
› Frame 1: 110 bytes on wire (880 bits), 110 bytes captured (880 bits) on interfa…
› Ethernet II, Src: 00:00:00_00:00:c1 (00:00:00:00:00:c1), Dst: IPv6mcast_01 (33:…
› Internet Protocol Version 6, Src: fe80::200:ff:fe00:c1, Dst: ff02::1
› Internet Control Message Protocol v6
```

```
0000  33 33 00 00 00 01 00 00  00 00 00 c1 86 dd 60 00   33······ ·······`·
0010  42 8e 00 38 3a ff fe 80  00 00 00 00 00 00 02 00   B··8:··· ········
0020  00 ff fe 00 00 c1 ff 02  00 00 00 00 00 00 00 00   ········ ········
0030  00 00 00 00 00 01 86 00  4a e0 40 00 00 1b 00 00   ········ J·@·····
0040  00 00 00 00 00 00 03 04  40 c0 00 01 51 80 00 00   ········ @···Q···
0050  38 40 00 00 00 00 20 01  00 00 00 00 00 03 00 00   8@······ ········
0060  00 00 00 00 00 00 01 01  00 00 00 00 00 c1         ········ ······
```

wireshark_eth1G9ISE2.pcapng
Packets: 12 · Displayed: 12 (100.0%)
Profile: Default

wireshark



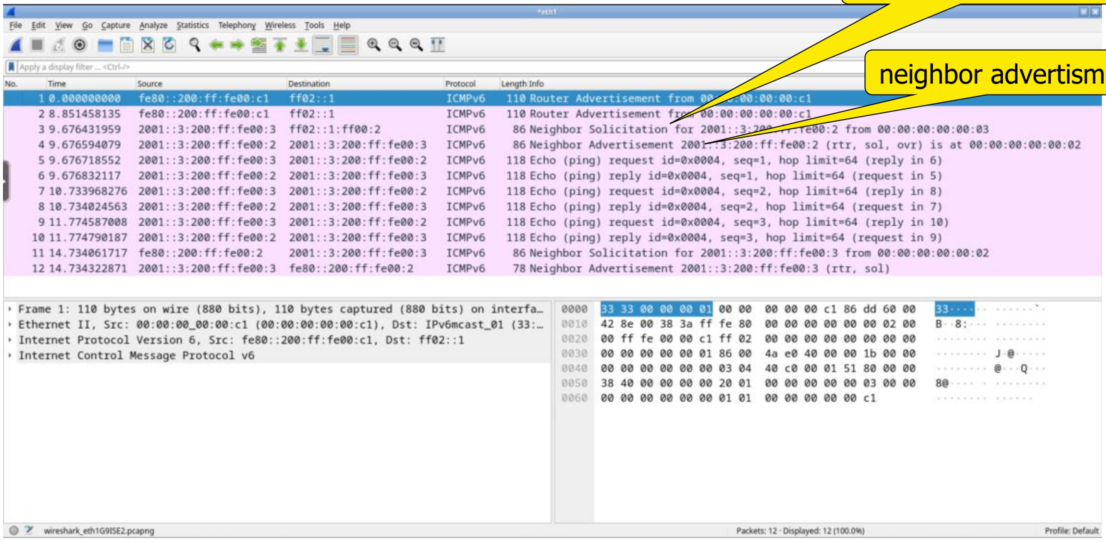
neighbor solicitation

```
No.   Time         Source                   Destination              Protocol  Length Info
    1 0.000000000  fe80::200:ff:fe00:c1     ff02::1                  ICMPv6    110 Router Advertisement from 00:00:00:00:00:c1
    2 8.851458135  fe80::200:ff:fe00:c1     ff02::1                  ICMPv6    110 Router Advertisement from 00:00:00:00:00:c1
    3 9.676431959  2001::3:200:ff:fe00:3    ff02::1:ff00:2           ICMPv6     86 Neighbor Solicitation for 2001::3:200:ff:fe00:2 from 00:00:00:00:00:03
    4 9.676594079  2001::3:200:ff:fe00:2    2001::3:200:ff:fe00:3    ICMPv6     86 Neighbor Advertisement 2001::3:200:ff:fe00:2 (rtr, sol, ovr) is at 00:00:00:00:00:02
    5 9.676718552  2001::3:200:ff:fe00:3    2001::3:200:ff:fe00:2    ICMPv6    118 Echo (ping) request id=0x0004, seq=1, hop limit=64 (reply in 6)
    6 9.676832117  2001::3:200:ff:fe00:2    2001::3:200:ff:fe00:3    ICMPv6    118 Echo (ping) reply id=0x0004, seq=1, hop limit=64 (request in 5)
    7 10.733968276 2001::3:200:ff:fe00:3    2001::3:200:ff:fe00:2    ICMPv6    118 Echo (ping) request id=0x0004, seq=2, hop limit=64 (reply in 8)
    8 10.734024563 2001::3:200:ff:fe00:2    2001::3:200:ff:fe00:3    ICMPv6    118 Echo (ping) reply id=0x0004, seq=2, hop limit=64 (request in 7)
    9 11.774587008 2001::3:200:ff:fe00:3    2001::3:200:ff:fe00:2    ICMPv6    118 Echo (ping) request id=0x0004, seq=3, hop limit=64 (reply in 10)
   10 11.774790187 2001::3:200:ff:fe00:2    2001::3:200:ff:fe00:3    ICMPv6    118 Echo (ping) reply id=0x0004, seq=3, hop limit=64 (request in 9)
   11 14.734061717 fe80::200:ff:fe00:2      2001::3:200:ff:fe00:3    ICMPv6     86 Neighbor Solicitation for 2001::3:200:ff:fe00:3 from 00:00:00:00:00:02
   12 14.734322871 2001::3:200:ff:fe00:3    fe80::200:ff:fe00:2      ICMPv6     78 Neighbor Advertisement 2001::3:200:ff:fe00:3 (rtr, sol)
```

```
› Frame 1: 110 bytes on wire (880 bits), 110 bytes captured (880 bits) on interfa…
› Ethernet II, Src: 00:00:00_00:00:c1 (00:00:00:00:00:c1), Dst: IPv6mcast_01 (33:…
› Internet Protocol Version 6, Src: fe80::200:ff:fe00:c1, Dst: ff02::1
› Internet Control Message Protocol v6
```

```
0000  33 33 00 00 00 01 00 00  00 00 00 c1 86 dd 60 00   33······ ·······`·
0010  42 8e 00 38 3a ff fe 80  00 00 00 00 00 00 02 00   B··8:··· ········
0020  00 ff fe 00 00 c1 ff 02  00 00 00 00 00 00 00 00   ········ ········
0030  00 00 00 00 00 01 86 00  4a e0 40 00 00 1b 00 00   ········ J·@·····
0040  00 00 00 00 00 00 03 04  40 c0 00 01 51 80 00 00   ········ @···Q···
0050  38 40 00 00 00 00 20 01  00 00 00 00 00 03 00 00   8@······ ········
0060  00 00 00 00 00 00 01 01  00 00 00 00 00 c1         ········ ······
```

wireshark


*eth1
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>

```
No.  Time          Source                  Destination             Protocol  Length Info
  1  0.000000000   fe80::200:ff:fe00:c1    ff02::1                 ICMPv6    110 Router Advertisement from 00:00:00:00:00:c1
  2  8.851458135   fe80::200:ff:fe00:c1    ff02::1                 ICMPv6    110 Router Advertisement from 00:00:00:00:00:c1
  3  9.676431959   2001::3:200:ff:fe00:3   ff02::1:ff00:2          ICMPv6     86 Neighbor Solicitation for 2001::3:200:ff:fe00:2 from 00:00:00:00:00:03
  4  9.676594079   2001::3:200:ff:fe00:2   2001::3:200:ff:fe00:3   ICMPv6     86 Neighbor Advertisement 2001::3:200:ff:fe00:2 (rtr, sol, ovr) is at 00:00:00:00:00:02
  5  9.676718552   2001::3:200:ff:fe00:3   2001::3:200:ff:fe00:2   ICMPv6    118 Echo (ping) request id=0x0004, seq=1, hop limit=64 (reply in 6)
  6  9.676832117   2001::3:200:ff:fe00:2   2001::3:200:ff:fe00:3   ICMPv6    118 Echo (ping) reply id=0x0004, seq=1, hop limit=64 (request in 5)
  7 10.733968276   2001::3:200:ff:fe00:3   2001::3:200:ff:fe00:2   ICMPv6    118 Echo (ping) request id=0x0004, seq=2, hop limit=64 (reply in 8)
  8 10.734024563   2001::3:200:ff:fe00:2   2001::3:200:ff:fe00:3   ICMPv6    118 Echo (ping) reply id=0x0004, seq=2, hop limit=64 (request in 7)
  9 11.774587008   2001::3:200:ff:fe00:3   2001::3:200:ff:fe00:2   ICMPv6    118 Echo (ping) request id=0x0004, seq=3, hop limit=64 (reply in 10)
 10 11.774790187   2001::3:200:ff:fe00:2   2001::3:200:ff:fe00:3   ICMPv6    118 Echo (ping) reply id=0x0004, seq=3, hop limit=64 (request in 9)
 11 14.734061717   fe80::200:ff:fe00:2     2001::3:200:ff:fe00:3   ICMPv6     86 Neighbor Solicitation for 2001::3:200:ff:fe00:3 from 00:00:00:00:00:02
 12 14.734322871   2001::3:200:ff:fe00:3   fe80::200:ff:fe00:2     ICMPv6     78 Neighbor Advertisement 2001::3:200:ff:fe00:3 (rtr, sol)
```

```
› Frame 1: 110 bytes on wire (880 bits), 110 bytes captured (880 bits) on interfa…
› Ethernet II, Src: 00:00:00_00:00:c1 (00:00:00:00:00:c1), Dst: IPv6mcast_01 (33:…
› Internet Protocol Version 6, Src: fe80::200:ff:fe00:c1, Dst: ff02::1
› Internet Control Message Protocol v6
```

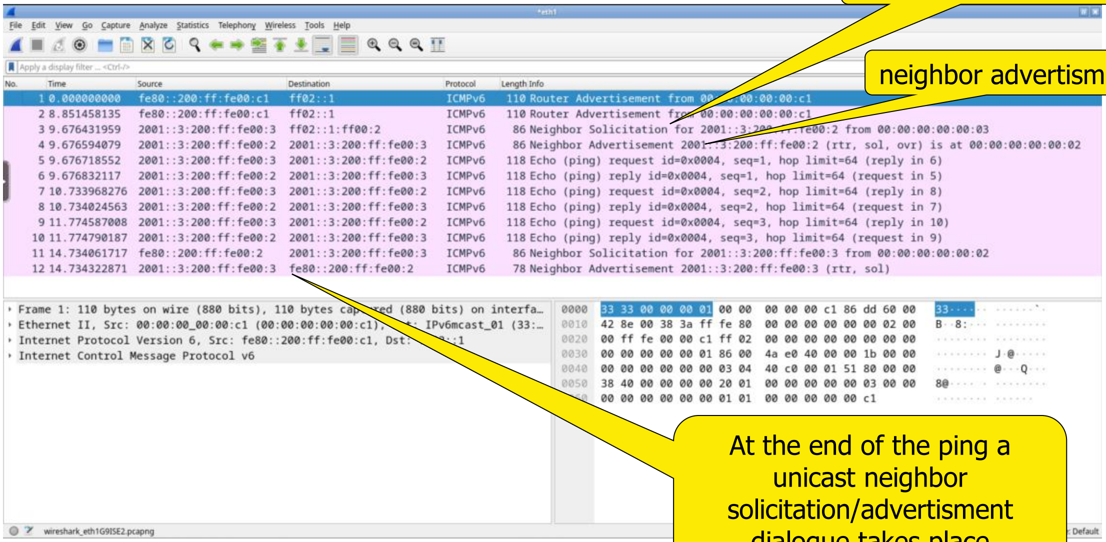
```
0000  33 33 00 00 00 01 00 00  00 00 00 c1 86 dd 60 00   33······ ·······`·
0010  42 8e 00 38 3a ff fe 80  00 00 00 00 00 00 02 00   B··8:··· ········
0020  00 ff fe 00 00 c1 ff 02  00 00 00 00 00 00 00 00   ········ ········
0030  00 00 00 00 00 01 86 00  4a e0 40 00 00 1b 00 00   ········ J·@·····
0040  00 00 00 00 00 00 03 04  40 c0 00 01 51 80 00 00   ········ @···Q···
0050  38 40 00 00 00 00 20 01  00 00 00 00 00 03 00 00   8@······ ········
0060  00 00 00 00 00 00 01 01  00 00 00 00 00 c1         ········ ······
```

wireshark_eth1G9ISE2.pcapng   Packets: 12 · Displayed: 12 (100.0%)   Profile: Default

neighbor solicitation

neighbor advertisment

wireshark


*eth1
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>

```
No.  Time          Source                  Destination             Protocol  Length Info
  1  0.000000000   fe80::200:ff:fe00:c1    ff02::1                 ICMPv6    110 Router Advertisement from 00:00:00:00:00:c1
  2  8.851458135   fe80::200:ff:fe00:c1    ff02::1                 ICMPv6    110 Router Advertisement from 00:00:00:00:00:c1
  3  9.676431959   2001::3:200:ff:fe00:3   ff02::1:ff00:2          ICMPv6     86 Neighbor Solicitation for 2001::3:200:ff:fe00:2 from 00:00:00:00:00:03
  4  9.676594079   2001::3:200:ff:fe00:2   2001::3:200:ff:fe00:3   ICMPv6     86 Neighbor Advertisement 2001::3:200:ff:fe00:2 (rtr, sol, ovr) is at 00:00:00:00:00:02
  5  9.676718552   2001::3:200:ff:fe00:3   2001::3:200:ff:fe00:2   ICMPv6    118 Echo (ping) request id=0x0004, seq=1, hop limit=64 (reply in 6)
  6  9.676832117   2001::3:200:ff:fe00:2   2001::3:200:ff:fe00:3   ICMPv6    118 Echo (ping) reply id=0x0004, seq=1, hop limit=64 (request in 5)
  7 10.733968276   2001::3:200:ff:fe00:3   2001::3:200:ff:fe00:2   ICMPv6    118 Echo (ping) request id=0x0004, seq=2, hop limit=64 (reply in 8)
  8 10.734024563   2001::3:200:ff:fe00:2   2001::3:200:ff:fe00:3   ICMPv6    118 Echo (ping) reply id=0x0004, seq=2, hop limit=64 (request in 7)
  9 11.774587008   2001::3:200:ff:fe00:3   2001::3:200:ff:fe00:2   ICMPv6    118 Echo (ping) request id=0x0004, seq=3, hop limit=64 (reply in 10)
 10 11.774790187   2001::3:200:ff:fe00:2   2001::3:200:ff:fe00:3   ICMPv6    118 Echo (ping) reply id=0x0004, seq=3, hop limit=64 (request in 9)
 11 14.734061717   fe80::200:ff:fe00:2     2001::3:200:ff:fe00:3   ICMPv6     86 Neighbor Solicitation for 2001::3:200:ff:fe00:3 from 00:00:00:00:00:02
 12 14.734322871   2001::3:200:ff:fe00:3   fe80::200:ff:fe00:2     ICMPv6     78 Neighbor Advertisement 2001::3:200:ff:fe00:3 (rtr, sol)
```

```
› Frame 1: 110 bytes on wire (880 bits), 110 bytes captured (880 bits) on interfa…
› Ethernet II, Src: 00:00:00_00:00:c1 (00:00:00:00:00:c1), Dst: IPv6mcast_01 (33:…
› Internet Protocol Version 6, Src: fe80::200:ff:fe00:c1, Dst: ff02::1
› Internet Control Message Protocol v6
```

```
0000  33 33 00 00 00 01 00 00  00 00 00 c1 86 dd 60 00   33······ ·······`·
0010  42 8e 00 38 3a ff fe 80  00 00 00 00 00 00 02 00   B··8:··· ········
0020  00 ff fe 00 00 c1 ff 02  00 00 00 00 00 00 00 00   ········ ········
0030  00 00 00 00 00 01 86 00  4a e0 40 00 00 1b 00 00   ········ J·@·····
0040  00 00 00 00 00 00 03 04  40 c0 00 01 51 80 00 00   ········ @···Q···
0050  38 40 00 00 00 00 20 01  00 00 00 00 00 03 00 00   8@······ ········
0060  00 00 00 00 00 00 01 01  00 00 00 00 00 c1         ········ ······
```

wireshark_eth1G9ISE2.pcapng   Profile: Default

neighbor solicitation

neighbor advertisment

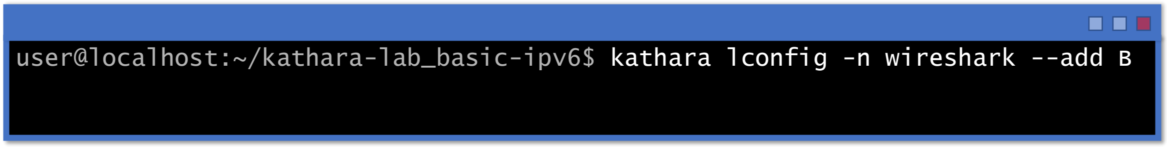
At the end of the ping a unicast neighbor solicitation/advertisment dialogue takes place

Kathará

ping from pc2 to pc1 and related ICMPv6 behavior

sniff the traffic

- connect the wireshark host to collision domain B

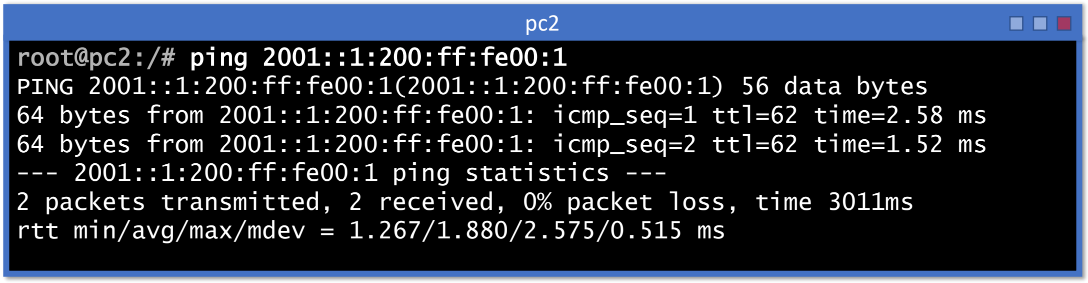


```
user@localhost:~/kathara-lab_basic-ipv6$ kathara lconfig -n wireshark --add B
```

- open any browser on the host machine
  - on **localhost:3000**
  - sniff eth2

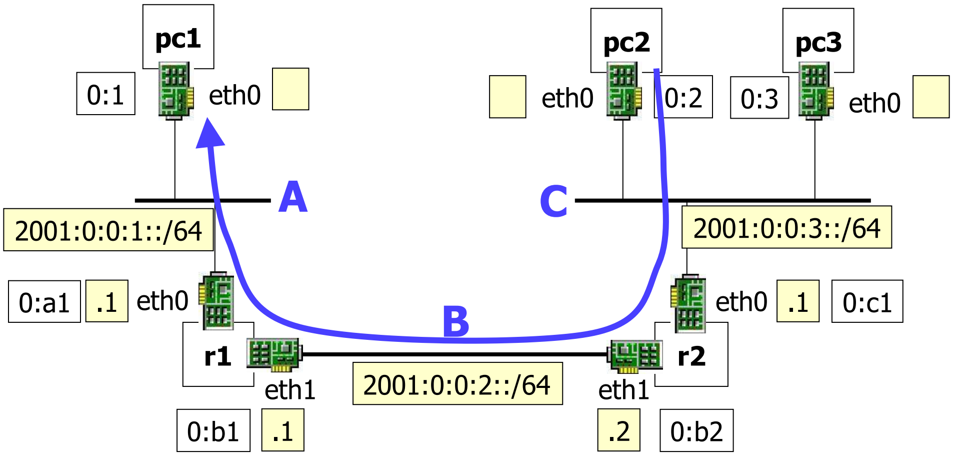
on pc2

- execute a ping command towards pc1



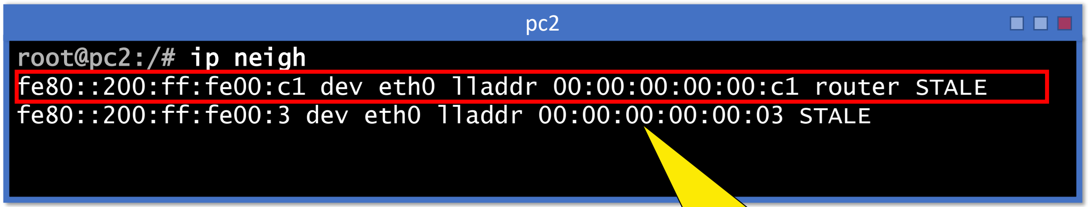
```
root@pc2:/# ping 2001::1:200:ff:fe00:1
PING 2001::1:200:ff:fe00:1(2001::1:200:ff:fe00:1) 56 data bytes
64 bytes from 2001::1:200:ff:fe00:1: icmp_seq=1 ttl=62 time=2.58 ms
64 bytes from 2001::1:200:ff:fe00:1: icmp_seq=2 ttl=62 time=1.52 ms
--- 2001::1:200:ff:fe00:1 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 3011ms
rtt min/avg/max/mdev = 1.267/1.880/2.575/0.515 ms
```

inspecting the neighbor cache



inspecting the neighbor cache

- when IP traffic is addressed outside the local network, the sender needs the mac address of the router
- ICMPv6 ND requests can get replies only within the local network

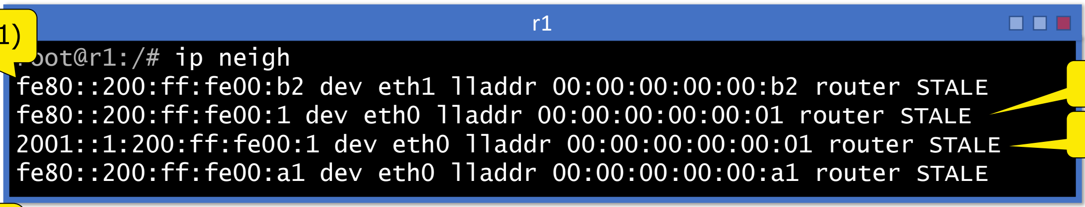


```
root@pc2:/# ip neigh
fe80::200:ff:fe00:c1 dev eth0 lladdr 00:00:00:00:00:c1 router STALE
fe80::200:ff:fe00:3 dev eth0 lladdr 00:00:00:00:00:03 STALE
```

mac address of eth0 on r2

inspecting the neighbor cache

- what about routers?
- routers perform ND too (hence have neighbor caches)

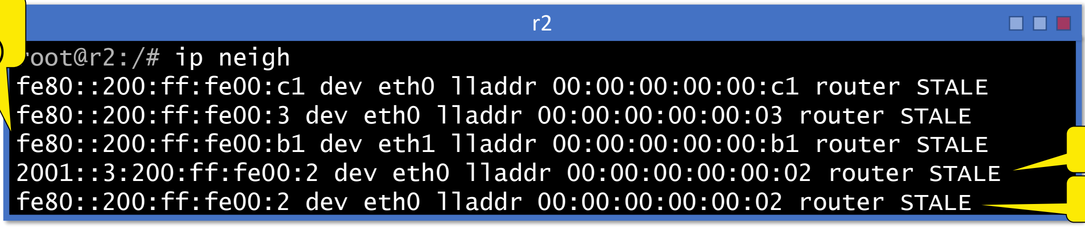


```
root@r1:/# ip neigh
fe80::200:ff:fe00:b2 dev eth1 lladdr 00:00:00:00:00:b2 router STALE
fe80::200:ff:fe00:1 dev eth0 lladdr 00:00:00:00:00:01 router STALE
2001::1:200:ff:fe00:1 dev eth0 lladdr 00:00:00:00:00:01 router STALE
fe80::200:ff:fe00:a1 dev eth0 lladdr 00:00:00:00:00:a1 router STALE
```

r2 (eth1)

pc1

pc1



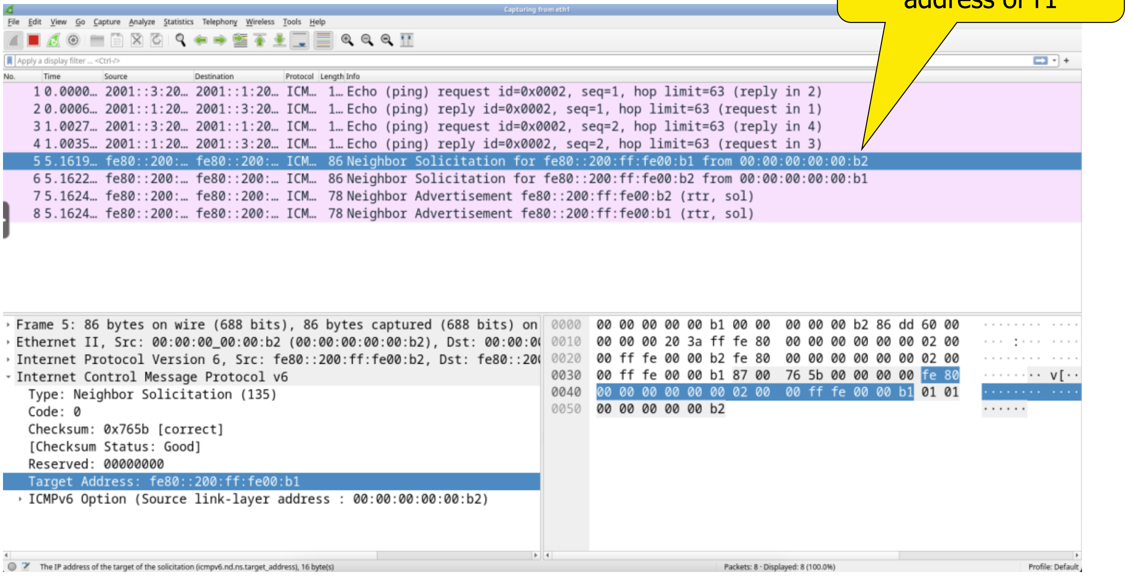
```
root@r2:/# ip neigh
fe80::200:ff:fe00:c1 dev eth0 lladdr 00:00:00:00:00:c1 router STALE
fe80::200:ff:fe00:3 dev eth0 lladdr 00:00:00:00:00:03 router STALE
fe80::200:ff:fe00:b1 dev eth1 lladdr 00:00:00:00:00:b1 router STALE
2001::3:200:ff:fe00:2 dev eth0 lladdr 00:00:00:00:00:02 router STALE
fe80::200:ff:fe00:2 dev eth0 lladdr 00:00:00:00:00:02 router STALE
```

r1 (eth1)

pc2

pc2

wireshark



Capturing from eth1
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>

```
No.  Time      Source         Destination    Protocol Length Info
  1 0.0000…  2001::3:20…  2001::1:20…  ICM…  1… Echo (ping) request id=0x0002, seq=1, hop limit=63 (reply in 2)
  2 0.0006…  2001::1:20…  2001::3:20…  ICM…  1… Echo (ping) reply id=0x0002, seq=1, hop limit=63 (request in 1)
  3 1.0027…  2001::3:20…  2001::1:20…  ICM…  1… Echo (ping) request id=0x0002, seq=2, hop limit=63 (reply in 4)
  4 1.0035…  2001::1:20…  2001::3:20…  ICM…  1… Echo (ping) reply id=0x0002, seq=2, hop limit=63 (request in 3)
  5 5.1619…  fe80::200:…  fe80::200:…  ICM…  86 Neighbor Solicitation for fe80::200:ff:fe00:b1 from 00:00:00:00:00:b2
  6 5.1622…  fe80::200:…  fe80::200:…  ICM…  86 Neighbor Solicitation for fe80::200:ff:fe00:b2 from 00:00:00:00:00:b1
  7 5.1624…  fe80::200:…  fe80::200:…  ICM…  78 Neighbor Advertisement fe80::200:ff:fe00:b2 (rtr, sol)
  8 5.1624…  fe80::200:…  fe80::200:…  ICM…  78 Neighbor Advertisement fe80::200:ff:fe00:b1 (rtr, sol)
```

```
› Frame 5: 86 bytes on wire (688 bits), 86 bytes captured (688 bits) on
› Ethernet II, Src: 00:00:00_00:00:b2 (00:00:00:00:00:b2), Dst: 00:00:0(
› Internet Protocol Version 6, Src: fe80::200:ff:fe00:b2, Dst: fe80::20(
˅ Internet Control Message Protocol v6
    Type: Neighbor Solicitation (135)
    Code: 0
    Checksum: 0x765b [correct]
    [Checksum Status: Good]
    Reserved: 00000000
    Target Address: fe80::200:ff:fe00:b1
  › ICMPv6 Option (Source link-layer address : 00:00:00:00:00:b2)
```

```
0000  00 00 00 00 00 b1 00 00  00 00 00 b2 86 dd 60 00   ········ ····
0010  00 00 00 20 3a ff fe 80  00 00 00 00 00 00 02 00   ··· :··· ····
0020  00 ff fe 00 00 b2 fe 80  00 00 00 00 00 00 02 00   ········ ····
0030  00 ff fe 00 00 b1 87 00  76 5b 00 00 00 00 fe 80   ········ v[··
0040  00 00 00 00 00 00 02 00  00 ff fe 00 00 b1 01 01   ········ ····
0050  00 00 00 00 00 b2                                  ······
```

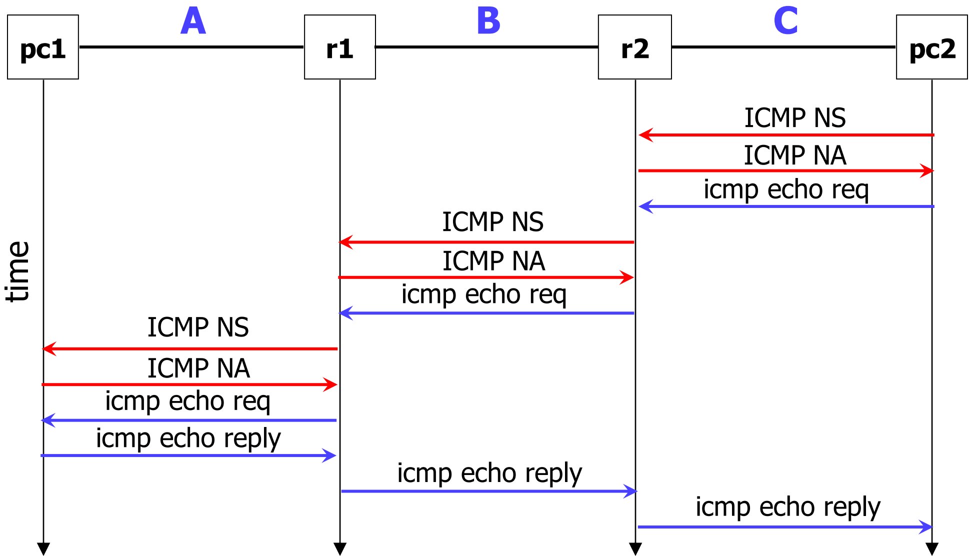
The IP address of the target of the solicitation (icmpv6.nd.ns.target_address), 16 byte(s)

Packets: 8 · Displayed: 8 (100.0%)

Profile: Default

which is the mac address of r1

understanding the whole picture



Kathará

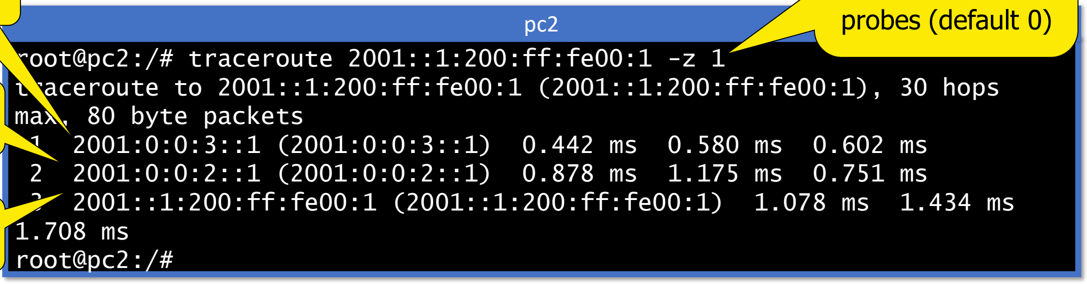
traceroute from pc2 to pc1 and related ICMPv6 behaviour

sniff the traffic

- the wireshark host is already connected to collision domain C
- open any browser on the host machine
  - on **localhost:3000**
  - sniff eth1

on pc2

- execute a traceroute command towards pc1



```
root@pc2:/# traceroute 2001::1:200:ff:fe00:1 -z 1
traceroute to 2001::1:200:ff:fe00:1 (2001::1:200:ff:fe00:1), 30 hops
max, 80 byte packets
 1  2001:0:0:3::1 (2001:0:0:3::1)  0.442 ms  0.580 ms  0.602 ms
 2  2001:0:0:2::1 (2001:0:0:2::1)  0.878 ms  1.175 ms  0.751 ms
 3  2001::1:200:ff:fe00:1 (2001::1:200:ff:fe00:1)  1.078 ms  1.434 ms
1.708 ms
root@pc2:/#
```

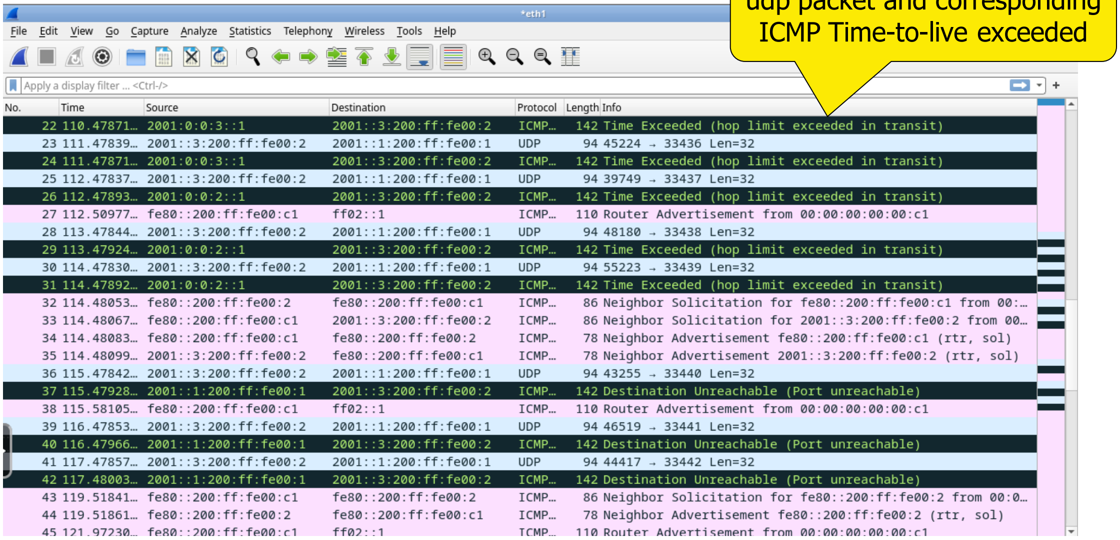
eth0 of r2

eth1 of r1

eth0 of pc1

Minimal time (sec. if ≤10, ms if >10) interval between probes (default 0)

wireshark



*eth1
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
Apply a display filter ... <Ctrl-/>

```
No.  Time         Source                  Destination             Protocol Length Info
  22 110.47871…   2001:0:0:3::1           2001::3:200:ff:fe00:2   ICMP…    142 Time Exceeded (hop limit exceeded in transit)
  23 111.47839…   2001::3:200:ff:fe00:2   2001::1:200:ff:fe00:1   UDP       94 45224 → 33436 Len=32
  24 111.47871…   2001:0:0:3::1           2001::3:200:ff:fe00:2   ICMP…    142 Time Exceeded (hop limit exceeded in transit)
  25 112.47837…   2001::3:200:ff:fe00:2   2001::1:200:ff:fe00:1   UDP       94 39749 → 33437 Len=32
  26 112.47893…   2001:0:0:2::1           2001::3:200:ff:fe00:2   ICMP…    142 Time Exceeded (hop limit exceeded in transit)
  27 112.50977…   fe80::200:ff:fe00:c1    ff02::1                 ICMP…    110 Router Advertisement from 00:00:00:00:00:c1
  28 113.47844…   2001::3:200:ff:fe00:2   2001::1:200:ff:fe00:1   UDP       94 48180 → 33438 Len=32
  29 113.47924…   2001:0:0:2::1           2001::3:200:ff:fe00:2   ICMP…    142 Time Exceeded (hop limit exceeded in transit)
  30 114.47830…   2001::3:200:ff:fe00:2   2001::1:200:ff:fe00:1   UDP       94 55223 → 33439 Len=32
  31 114.47892…   2001:0:0:2::1           2001::3:200:ff:fe00:2   ICMP…    142 Time Exceeded (hop limit exceeded in transit)
  32 114.48053…   fe80::200:ff:fe00:2     fe80::200:ff:fe00:c1    ICMP…     86 Neighbor Solicitation for fe80::200:ff:fe00:c1 from 00:…
  33 114.48067…   fe80::200:ff:fe00:c1    2001::3:200:ff:fe00:2   ICMP…     86 Neighbor Solicitation for 2001::3:200:ff:fe00:2 from 00…
  34 114.48083…   fe80::200:ff:fe00:c1    fe80::200:ff:fe00:2     ICMP…     78 Neighbor Advertisement fe80::200:ff:fe00:c1 (rtr, sol)
  35 114.48099…   2001::3:200:ff:fe00:2   fe80::200:ff:fe00:c1    ICMP…     78 Neighbor Advertisement 2001::3:200:ff:fe00:2 (rtr, sol)
  36 115.47842…   2001::3:200:ff:fe00:2   2001::1:200:ff:fe00:1   UDP       94 43255 → 33440 Len=32
  37 115.47928…   2001::1:200:ff:fe00:1   2001::3:200:ff:fe00:2   ICMP…    142 Destination Unreachable (Port unreachable)
  38 115.58105…   fe80::200:ff:fe00:c1    ff02::1                 ICMP…    110 Router Advertisement from 00:00:00:00:00:c1
  39 116.47853…   2001::3:200:ff:fe00:2   2001::1:200:ff:fe00:1   UDP       94 46519 → 33441 Len=32
  40 116.47966…   2001::1:200:ff:fe00:1   2001::3:200:ff:fe00:2   ICMP…    142 Destination Unreachable (Port unreachable)
  41 117.47857…   2001::3:200:ff:fe00:2   2001::1:200:ff:fe00:1   UDP       94 44417 → 33442 Len=32
  42 117.48003…   2001::1:200:ff:fe00:1   2001::3:200:ff:fe00:2   ICMP…    142 Destination Unreachable (Port unreachable)
  43 119.51841…   fe80::200:ff:fe00:c1    fe80::200:ff:fe00:2     ICMP…     86 Neighbor Solicitation for fe80::200:ff:fe00:2 from 00:0…
  44 119.51861…   fe80::200:ff:fe00:2     fe80::200:ff:fe00:c1    ICMP…     78 Neighbor Advertisement fe80::200:ff:fe00:2 (rtr, sol)
  45 121.97230…   fe80::200:ff:fe00:c1    ff02::1                 ICMP…    110 Router Advertisement from 00:00:00:00:00:c1
```

udp packet and corresponding ICMP Time-to-live exceeded

proposed exercises

- check the different error messages obtained by trying to ping an unreachable destination in the case of
  - local destination
  - non-local destination
- which packets are exchanged in the local collision domain in the two cases?