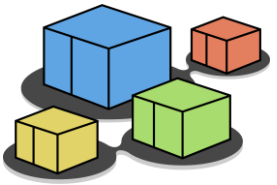


Kathará

Kathará lab

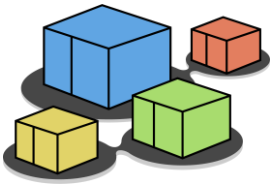
basic IPv6 configuration, ping, traceroute and ICMPv6

Version	2.1
Author(s)	L. Ariemma, T. Caiazzi, G. Di Battista
E-mail	contact@kathara.org
Web	http://www.kathara.org/
Description	basic IPv6 configuration commands, IPv6 stateless auto-configuration, usage of ping and traceroute, ICMPv6 behaviour



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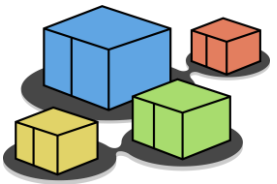


content of the lab

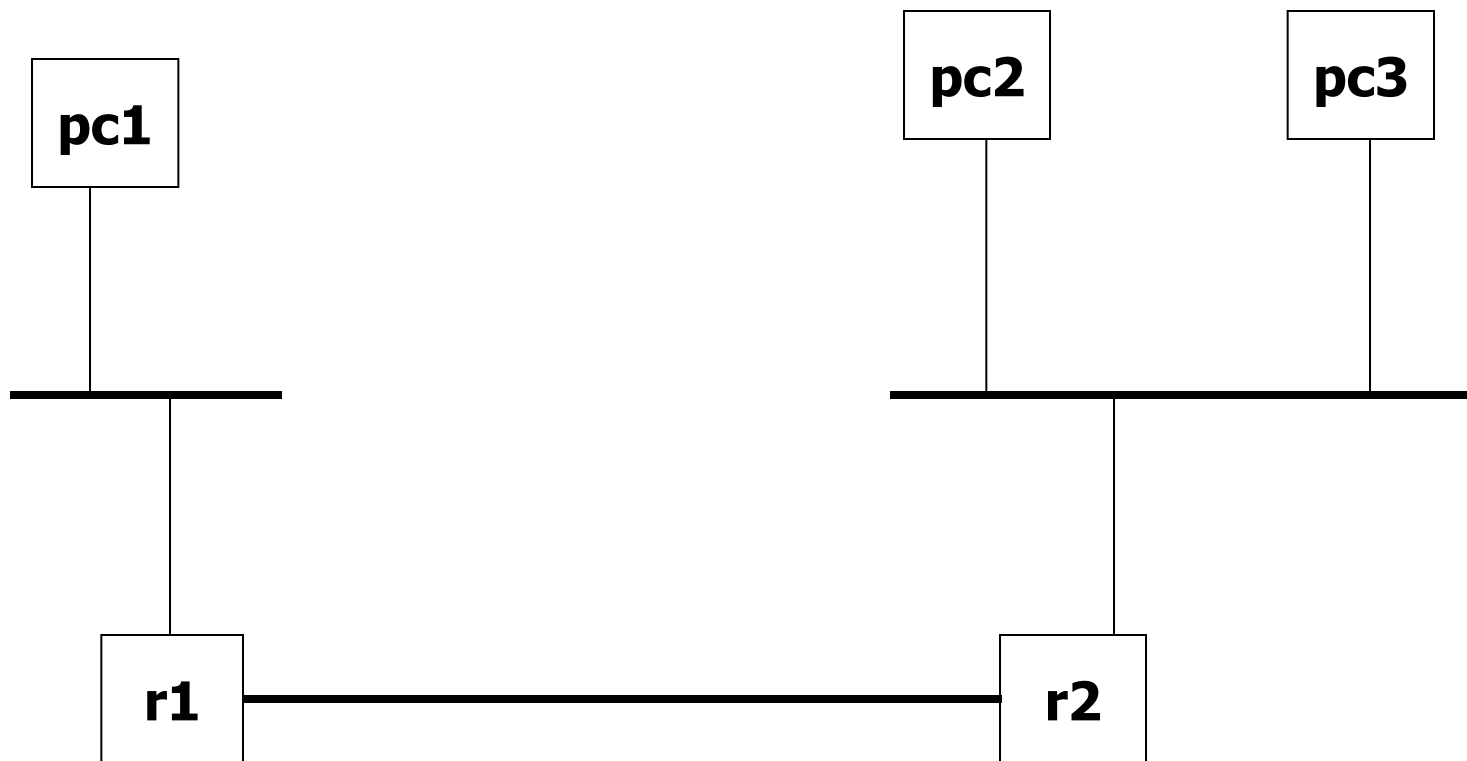
- there are two routers, called r1 and r2, and three hosts, called pc1, pc2, and pc3
 - they are connected via three LANs
 - we force their MAC addresses to be easily readable
- we will learn how to:
 - administratively assign an IPv6 address and a netmask to the interface of a system
 - administratively 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

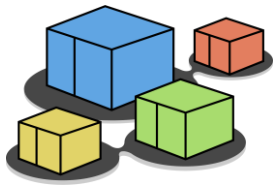


lab configuration

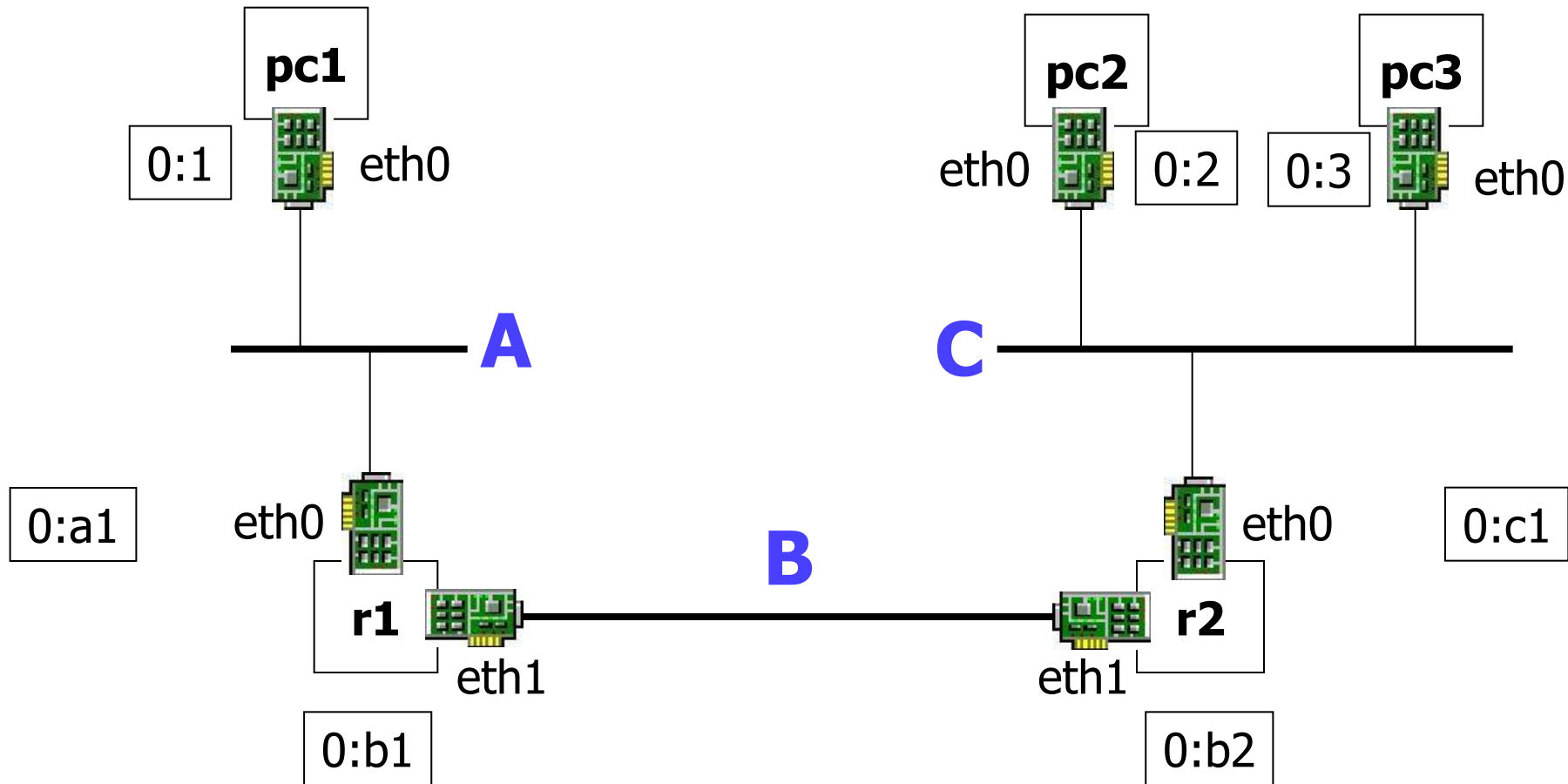


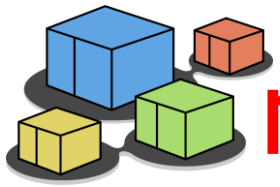
network topology – high level view



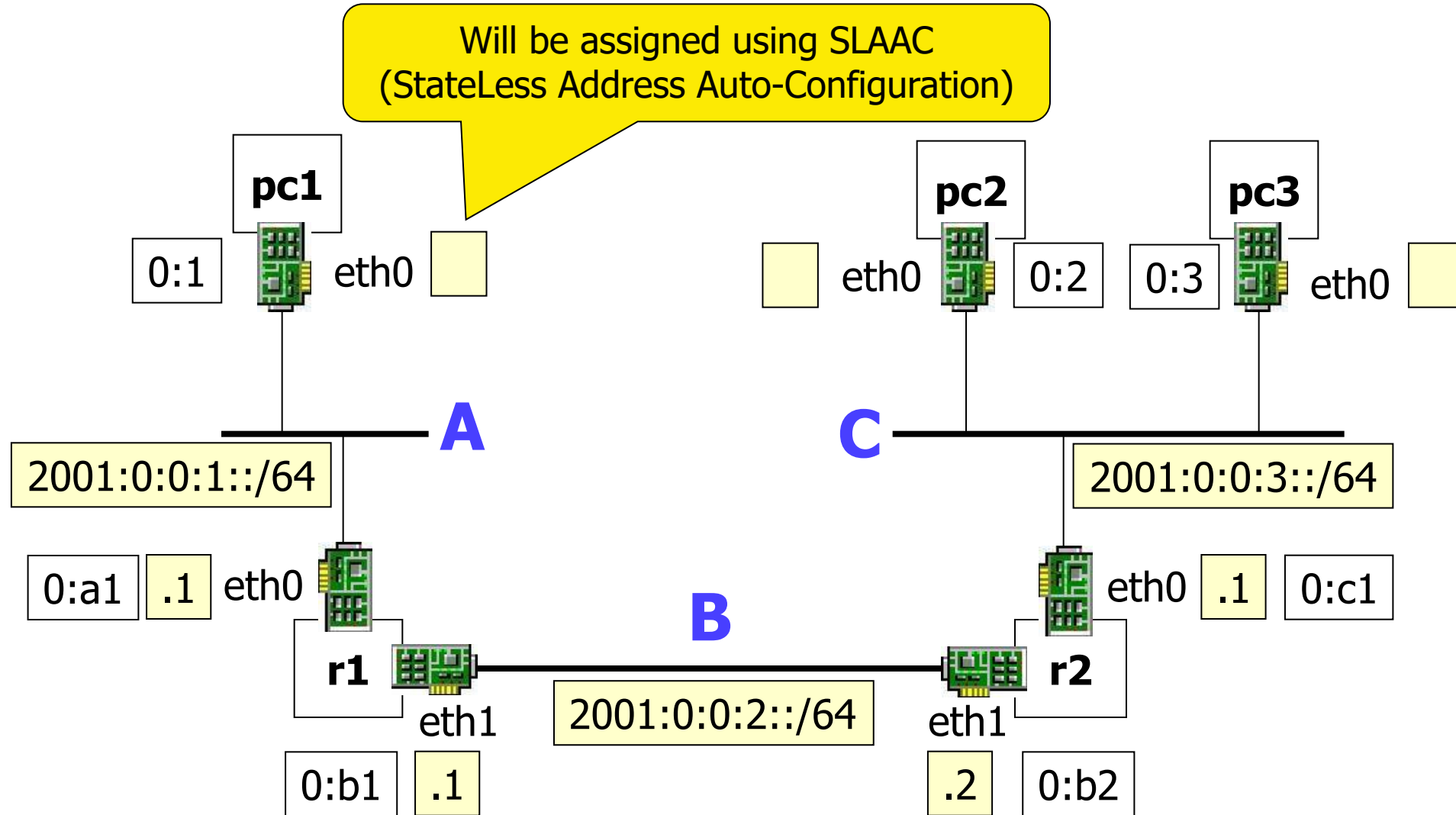


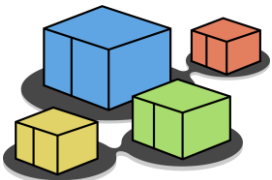
network topology – MAC addresses





network topology – IPv6 address plan





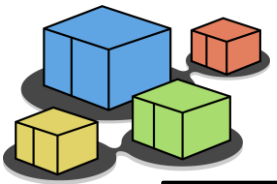
a quick look at the lab

lab.conf

```
r1[0]="A/00:00:00:00:00:a1"  
r1[1]="B/00:00:00:00:00:b1"  
r1[image]="kathara/base"  
r1[ipv6]="True"  
  
r2[0]="C/00:00:00:00:00:c1"  
r2[1]="B/00:00:00:00:00:b2"  
r2[image]="kathara/base"  
r2[ipv6]="True"
```

lab.conf

```
pc1[0]="A/00:00:00:00:00:01"  
pc1[image]="kathara/base"  
pc1[ipv6]="True"  
pc1[sysctl]="net.ipv6.conf.eth0.accept_ra=2"  
  
pc2[0]="C/00:00:00:00:00:02"  
pc2[image]="kathara/base"  
pc2[ipv6]="True"  
pc2[sysctl]="net.ipv6.conf.eth0.accept_ra=2"  
  
pc3[0]="C/00:00:00:00:00:03"  
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/00:00:00:00:00:a1"  
r1[1]="B/00:00:00:00:00:b1"  
r1[image]="kathara/base"  
r1[ipv6]="True"
```

```
r2[0]="C/00:00:00:00:00:c1"  
r2[1]="B/00:00:00:00:00:b2"  
r2[image]="kathara/base"  
r2[ipv6]="True"
```

Set the MAC address on the interface

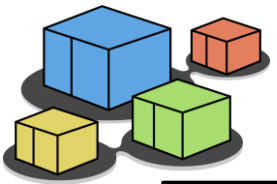
lab.conf

```
pc1[0]="A/00:00:00:00:00:01"  
pc1[image]="kathara/base"  
pc1[ipv6]="True"  
pc1[sysctl]="net.ipv6.conf.eth0.accept_ra=2"
```

```
pc2[0]="C/00:00:00:00:00:02"  
pc2[image]="kathara/base"  
pc2[ipv6]="True"  
pc2[sysctl]="net.ipv6.conf.eth0.accept_ra=2"
```

```
pc3[0]="C/00:00:00:00:00:03"  
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/00:00:00:00:00:a1"  
r1[1]="B/00:00:00:00:00:b1"  
r1[image]="kathara/base"  
r1[ipv6]="True"
```

```
r2[0]="C/00:00:00:00:00:c1"  
r2[1]="B/00:00:00:00:00:b2"  
r2[image]="kathara/base"  
r2[ipv6]="True"
```

Set the MAC address on the interface

lab.conf

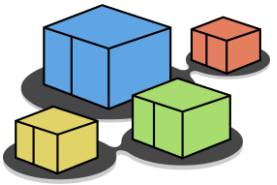
```
pc1[0]="A/00:00:00:00:00:01"  
pc1[image]="kathara/base"  
pc1[sysctl]="net.ipv6.conf.eth0.accept_ra=2"
```

```
pc2[0]="C/00:00:00:00:00:02"  
pc2[image]="kathara/base"  
pc2[ipv6]="True"  
pc2[sysctl]="net.ipv6.conf.eth0.accept_ra=2"
```

Accept router advertisements on eth0

```
pc3[0]="C/00:00:00:00:00:03"  
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
```

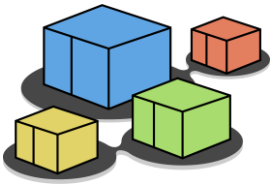


a quick look at the lab

`pc1.startup`

`pc2.startup`

`pc3.startup`



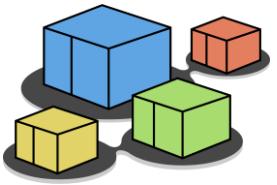
a quick look at the lab

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

`pc1.startup`

`pc2.startup`

`pc3.startup`



a quick look at the lab

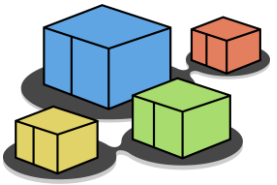
no command is given to configure an IPv6 address or a default gateway, since they come from the **stateless auto-configuration**

Since the .startup files for pc1, pc2, and pc3 are empty, there's no need to include them in the lab configuration

pc1.startup

pc2.startup

pc3.startup



a quick look at the lab

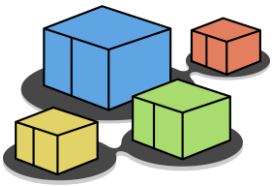
r1.startup

```
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

a static IPv6 address is given to eth0 and to eth1

consequently, the corresponding LANs are considered *directly connected*

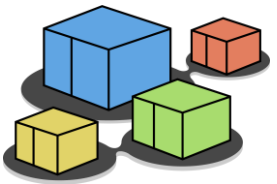
r1.startup

```
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 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

r1.startup

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

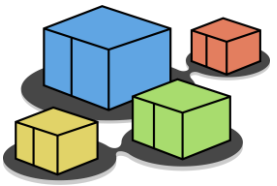
r1.startup

```
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
```

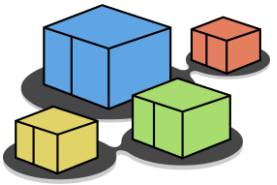


a quick look at the lab

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

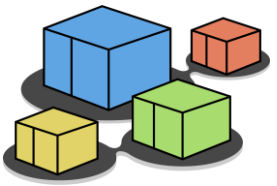
radvd.conf

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



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

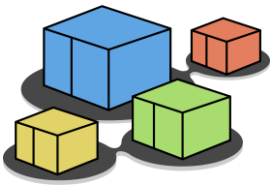


a quick look at the lab

interface of the router
where the advertisements
are sent

radvd.conf

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

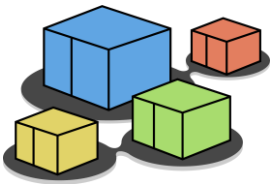


a quick look at the lab

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

advertisements are sent

minimum interval between consecutive advertisements

maximum interval between consecutive advertisements

radvd.conf

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

time interval for default gateway validity



a quick look at the lab

r1.startup

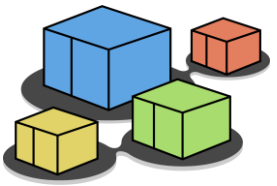
```
ip address add 2001:0:0:1::1/64 dev eth0
ip address add 2001:0:0:2::1/64 dev eth1

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
```

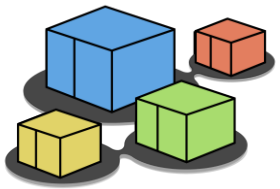
similar configuration for
router r2



start the lab

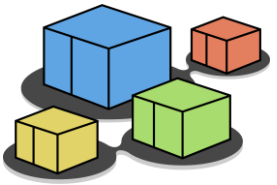
■ start the lab

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

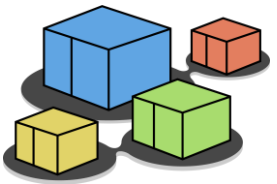
Kathará

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

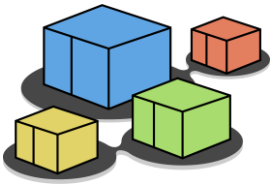
link-local: fe80::200:ff:fe00:a1/64

eth1

global unicast: 2001:0:0:2::1/64

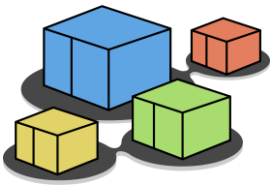
link-local: fe80::200:ff:fe00:b1/64

```
r1
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_code1 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_code1 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 **route1 -6** command, to check the routing table



check the router routing table

Lan A

Lan B

Lan C

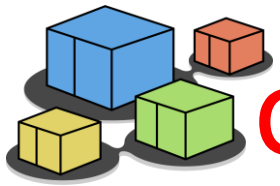
link-local addresses on
A and B

general multicast
prefix

```
root@r1:/# route1 -6
```

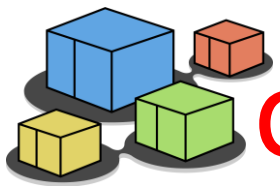
Dst	Gateway	Prefsrc	Protocol	Scope	Dev
Table					
::1			kernel		lo
2001:0:0:1::			kernel		eth0
2001:0:0:1::1			kernel		eth0
2001:0:0:1::/64			kernel		eth0
2001:0:0:2::			kernel		eth1
2001:0:0:2::1			kernel		eth1
2001:0:0:2::/64			kernel		eth1
2001:0:0:3::/64	fe80::200:ff:fe00:b2				eth1
fe80::			kernel		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

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

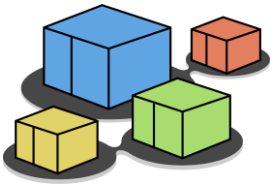
IPv6: ::1/128

eth0

global unicast: 2001::1:200:ff:fe00:1/64

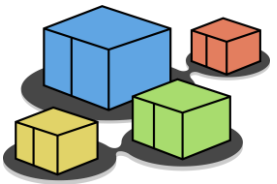
link-local: fe80::200:ff:fe00:1/64

```
pc1
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_code1
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 **route1 -6** command, to check the presence of a default route



check the default route

- on pc1, pc2, and pc3
 - perform the **route1 -6** command, to check the presence of a default route

```
root@pc1:/# route1 -6
```

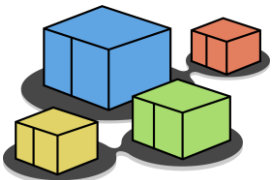
Dst	Gateway	Prefsrc	Protocol	Scope	Dev
::1			kernel		lo
2001:0:0:1::			kernel		eth0
2001::1:200:ff:fe00:1			kernel		eth0
2001:0:0:1::/64			kernel		eth0
fe80::			kernel		eth0
fe80::200:ff:fe00:1			kernel		eth0
fe80::/64			kernel		eth0
ff00::/8			kernel		eth0
default	fe80::200:ff:fe00:a1		ra		eth0

loopback prefix

default route by r1

learned by a router advertisement

link-local address of r1 on A

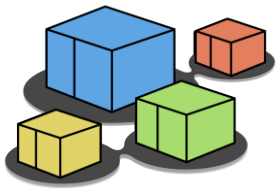


sniff the traffic

- connect the wireshark device to collision domain C

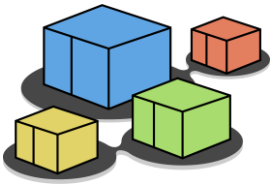
```
user@localhost:~/kathara-lab_basic-ipv6$ kathara lconfig -n wireshark --add C
```

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



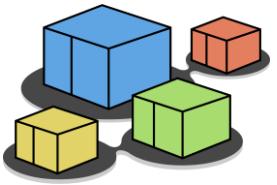
Kathará

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



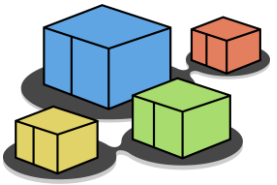
inspecting the neighbor cache

- 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

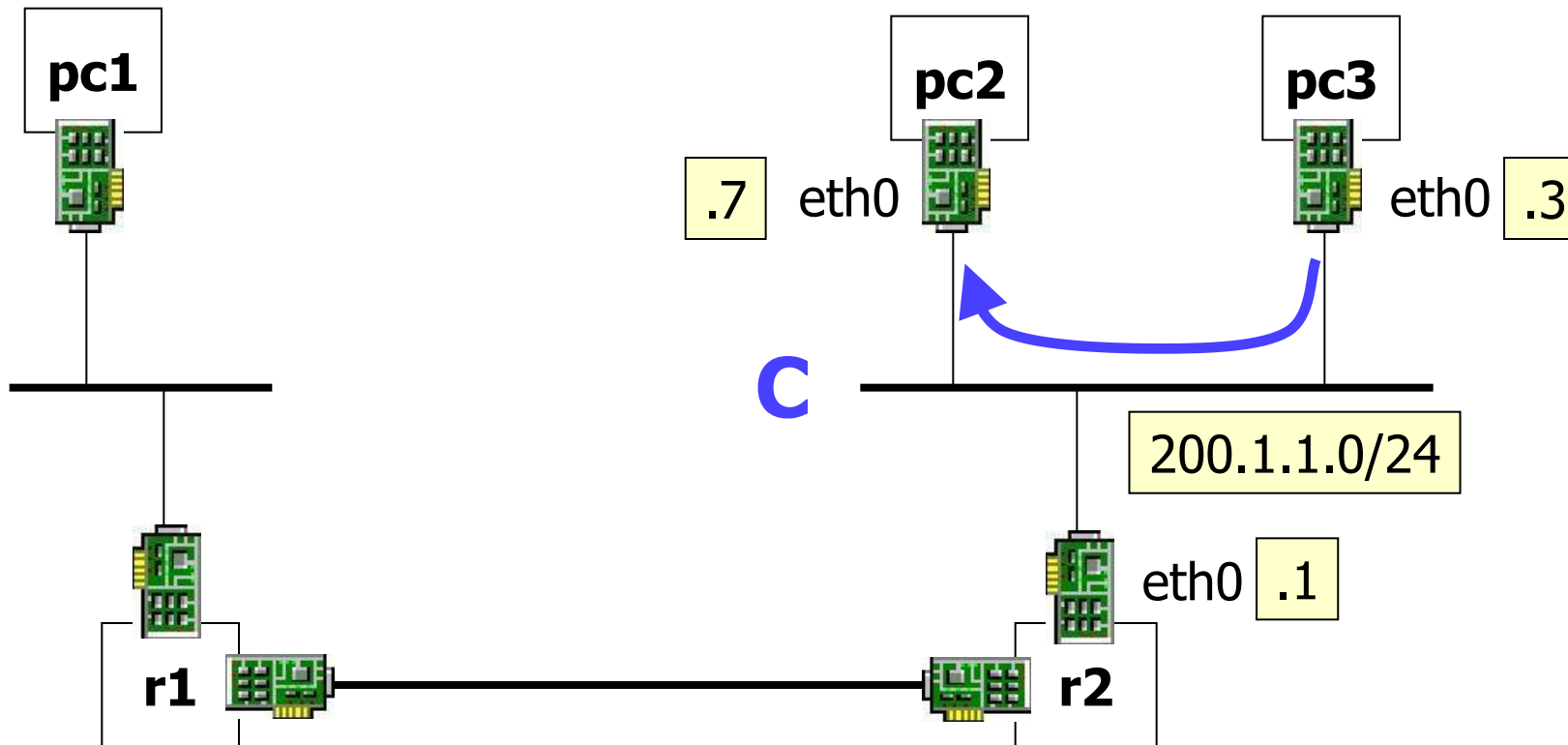
```
pc3
root@pc3:/# ping 2001::3:200:ff:fe00:2
PING 2001::3:200:ff:fe00:2(2001::3:200:ff:fe00:2) 56 data bytes
64 bytes from 2001::3:200:ff:fe00:2: icmp_seq=1 ttl=64 time=1.50 ms
64 bytes from 2001::3:200:ff:fe00:2: icmp_seq=2 ttl=64 time=0.585 ms
64 bytes from 2001::3:200:ff:fe00:2: icmp_seq=3 ttl=64 time=0.394 ms
^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
```

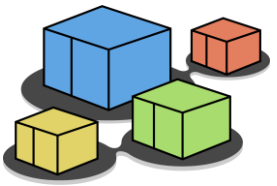
global IPv6 address
of pc2



inspecting the neighbor cache

- traffic within the same network does not traverse routers





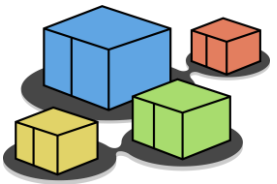
inspecting the neighbor cache

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

global IPv6 address
of pc3

pc2

```
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 advertisements

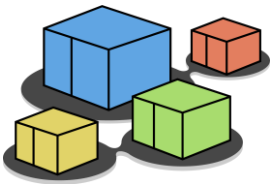
The image shows a Wireshark capture of network traffic on the *eth1 interface. The packet list on the left shows 12 packets, with the first packet (No. 1) being an ICMPv6 Router Advertisement from 00:00:00:00:00:c1 to ff02::1. A yellow callout points to this packet with the text 'periodic router advertisements'. The packet details pane on the right shows the structure of the first packet: Ethernet II, Internet Protocol Version 6, and Internet Control Message Protocol v6. The packet bytes pane at the bottom shows the raw data in hexadecimal and ASCII.

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 c1

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



wireshark

neighbor solicitation

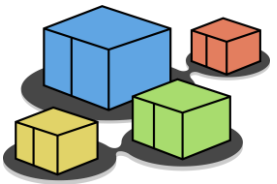
Wireshark interface showing network traffic analysis. The packet list displays several ICMPv6 messages, including Router Advertisements and Neighbor Solicitations. A yellow callout points to the 'Neighbor Solicitation' entry (packet 3).

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:fe00:2	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:fe00:3	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

neighbor advertisement

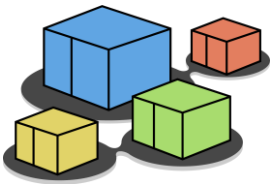
Wireshark interface showing network traffic capture on interface *eth1. The packet list displays ICMPv6 messages, including Router Advertisements and Neighbor Solicitations/Advertisements. The packet details pane shows the structure of the first packet (Frame 1).

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

Packets: 12 · Displayed: 12 (100.0%) Profile: Default



wireshark

neighbor solicitation

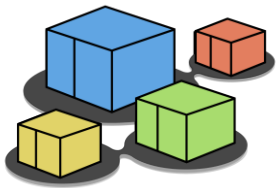
neighbor advertisement

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:fe00:2	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

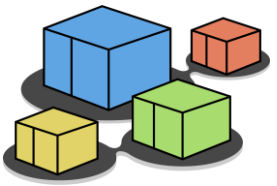
0000 33 33 00 00 00 01 00 00 00 00 00 c1 86 dd 60 00 33...
0010 42 8e 00 38 3a ff fe 80 00 00 00 00 00 00 02 00 B...8:...
0020 00 ff fe 00 00 c1 ff 02 00 00 00 00 00 00 00 00
0030 00 00 00 00 00 01 86 00 4a e0 40 00 00 1b 00 00 J...@...
0040 00 00 00 00 00 00 03 04 40 c0 00 01 51 80 00 00 @...Q...
0050 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
0070

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



Kathará

ping from pc2 to pc1 and related
ICMPv6 behavior

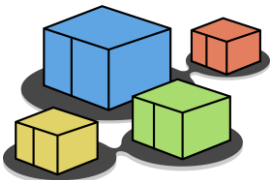


sniff the traffic

- connect the wireshark host to collision domain B

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

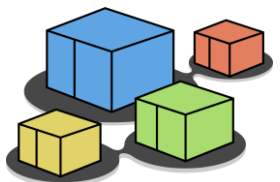
- open any browser on the host machine
 - on **localhost:3000**
 - sniff eth2



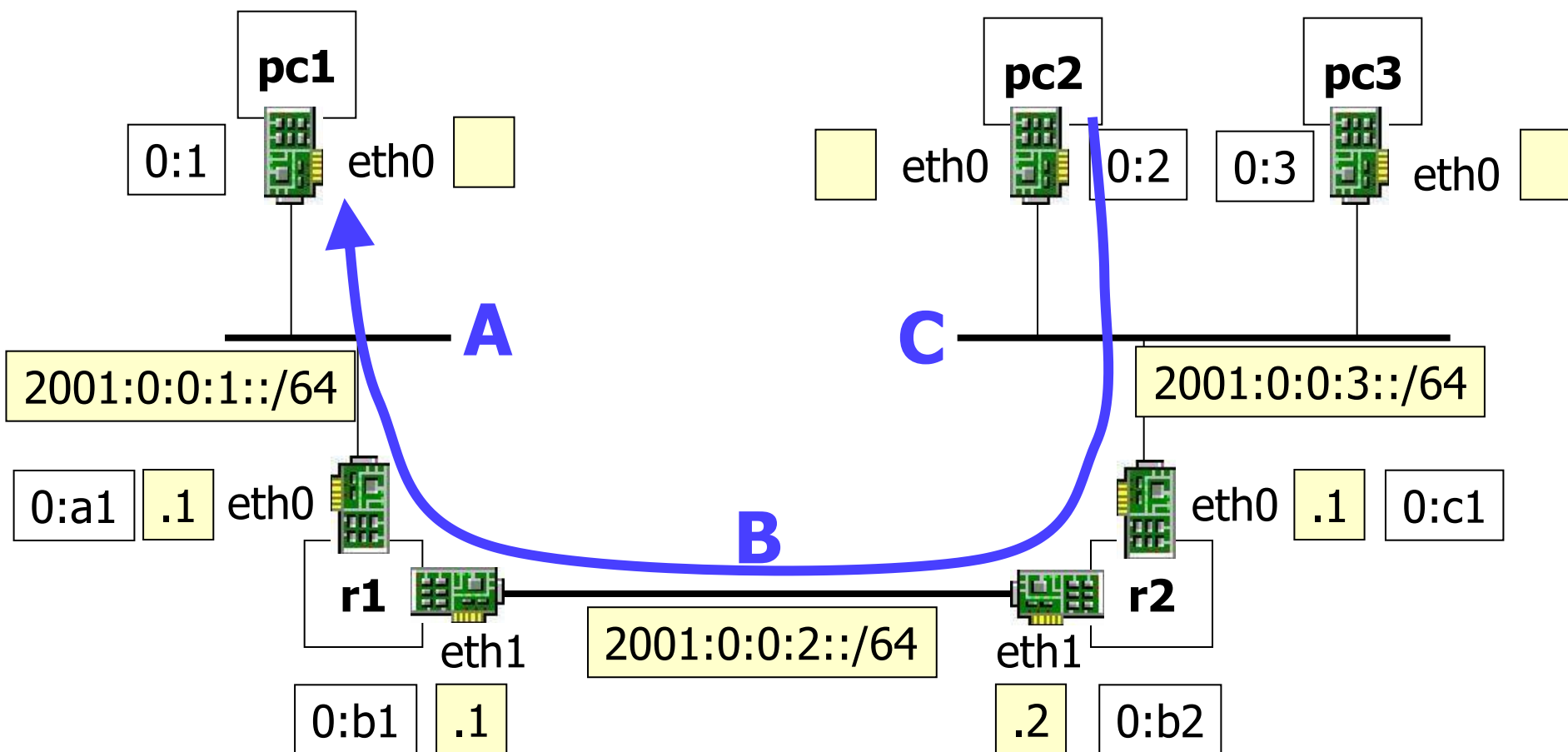
on pc2

- execute a ping command towards pc1

```
pc2
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



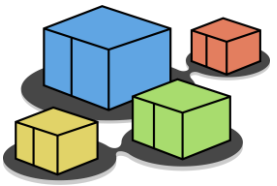


inspecting the neighbor cache

- 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

```
pc2
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)

r2 (eth1)

```
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
```

pc1

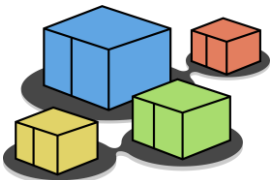
pc1

r1 (eth1)

```
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
```

pc2

pc2



wireshark

which is the mac
address of r1

Capturing from eth1

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

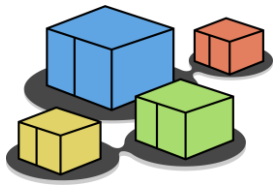
No.	Time	Source	Destination	Protocol	Length	Info
1	0.0000...	2001::3:20...	2001::1:20...	ICM...	1...	Echo (ping) request id=0x0002, seq=1, hop limit=63 (reply in 2)
2	0.0006...	2001::1:20...	2001::3:20...	ICM...	1...	Echo (ping) reply id=0x0002, seq=1, hop limit=63 (request in 1)
3	1.0027...	2001::3:20...	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: 00:00:00:
Internet Protocol Version 6, Src: fe80::200:ff:fe00:b2, Dst: fe80::200:
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)

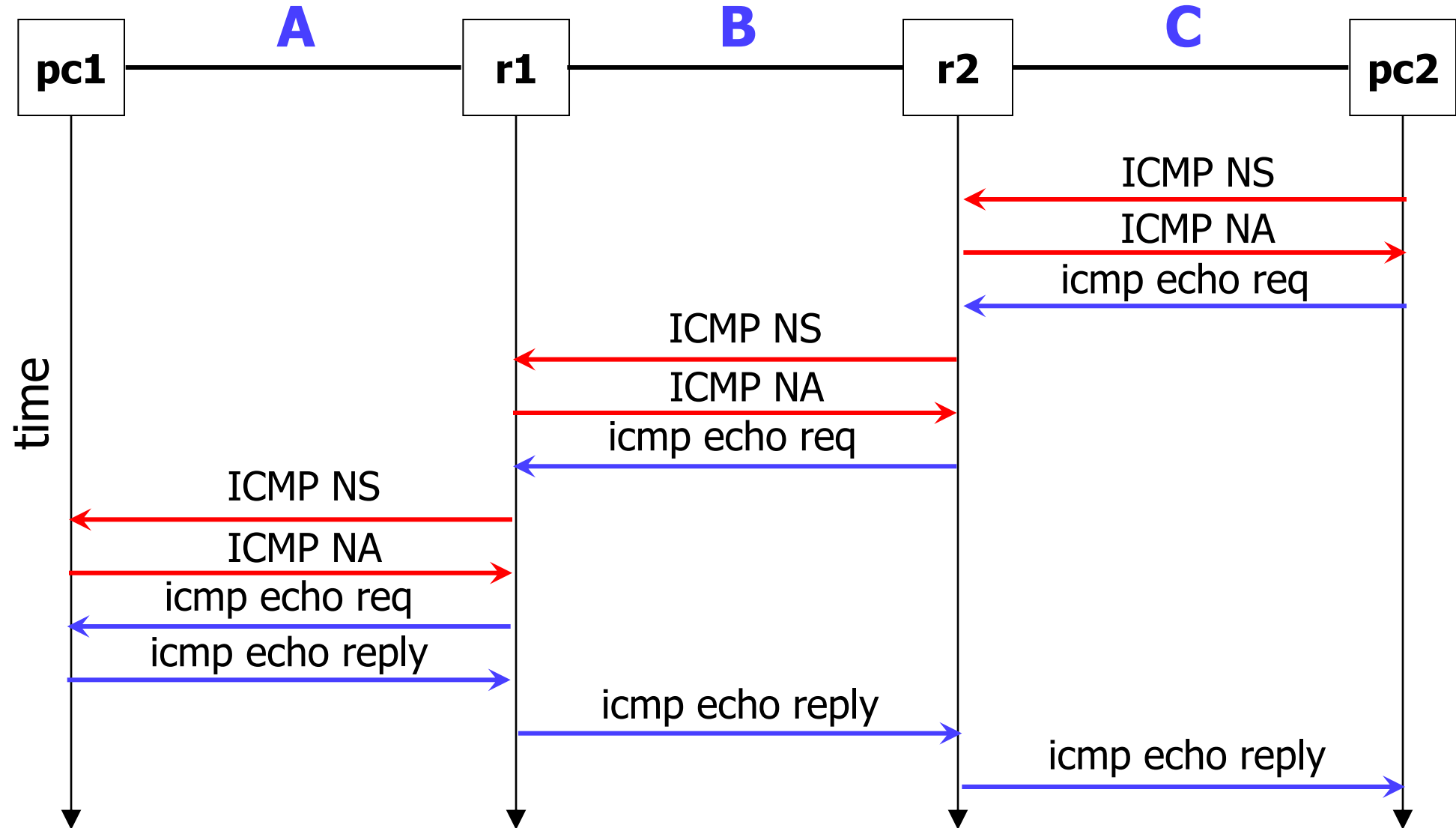
0000 00 00 00 00 00 b1 00 00 00 00 00 b2 86 dd 60 00
0010 00 00 00 20 3a ff fe 80 00 00 00 00 00 02 00 ... :...
0020 00 ff fe 00 00 b2 fe 80 00 00 00 00 00 02 00
0030 00 ff fe 00 00 b1 87 00 76 5b 00 00 00 00 fe 80 v[..
0040 00 00 00 00 00 00 02 00 00 ff fe 00 00 b1 01 01
0050 00 00 00 00 00 b2

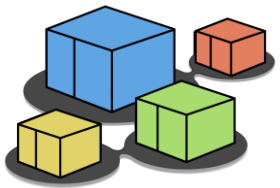
The IP address of the target of the solicitation (icmpv6.nd.ns.target_address), 16 byte(s)

Packets: 8 · Displayed: 8 (100.0%) Profile: Default



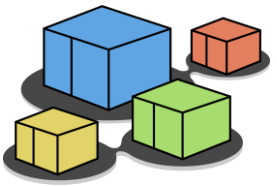
understanding the whole picture





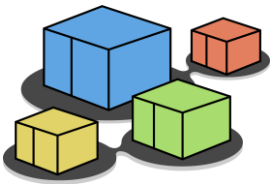
Kathará

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

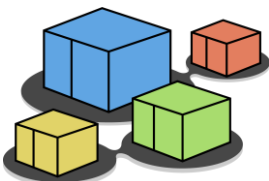
eth0 of
r2

eth1 of
r1

eth0 of
pc1

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

```
pc2
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:/#
```



wireshark

udp packet and corresponding
ICMP Time-to-live exceeded

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



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?