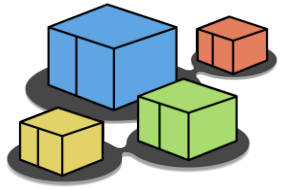

Kathará

kathara lab

basic IPv4 configuration, ping, traceroute and arp

Version	1.0
Author(s)	L. Ariemma, T. Caiazzi, G. Di Battista, M. Patrignani, M. Pizzonia, F. Ricci, M. Rimondini
E-mail	contact@kathara.org
Web	http://www.kathara.org/
Description	basic IPv4 configuration commands, usage of ping and traceroute, arp behaviour

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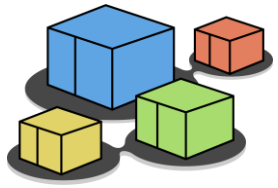

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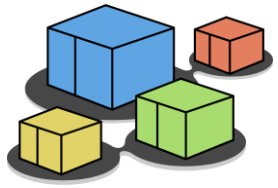
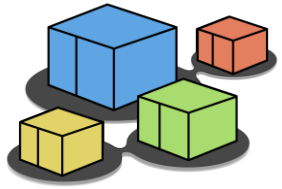


content of the lab

- 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:
  - assign an IPv4 address and a netmask to the interface of a host
  - assign a default gateway to the interface of a host
  - set the routing table of a router
- we will use the ping and traceroute commands
- we will observe the behavior of ARP



Kathará

lab configuration

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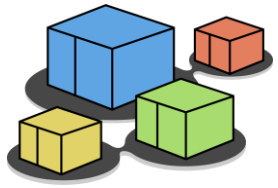
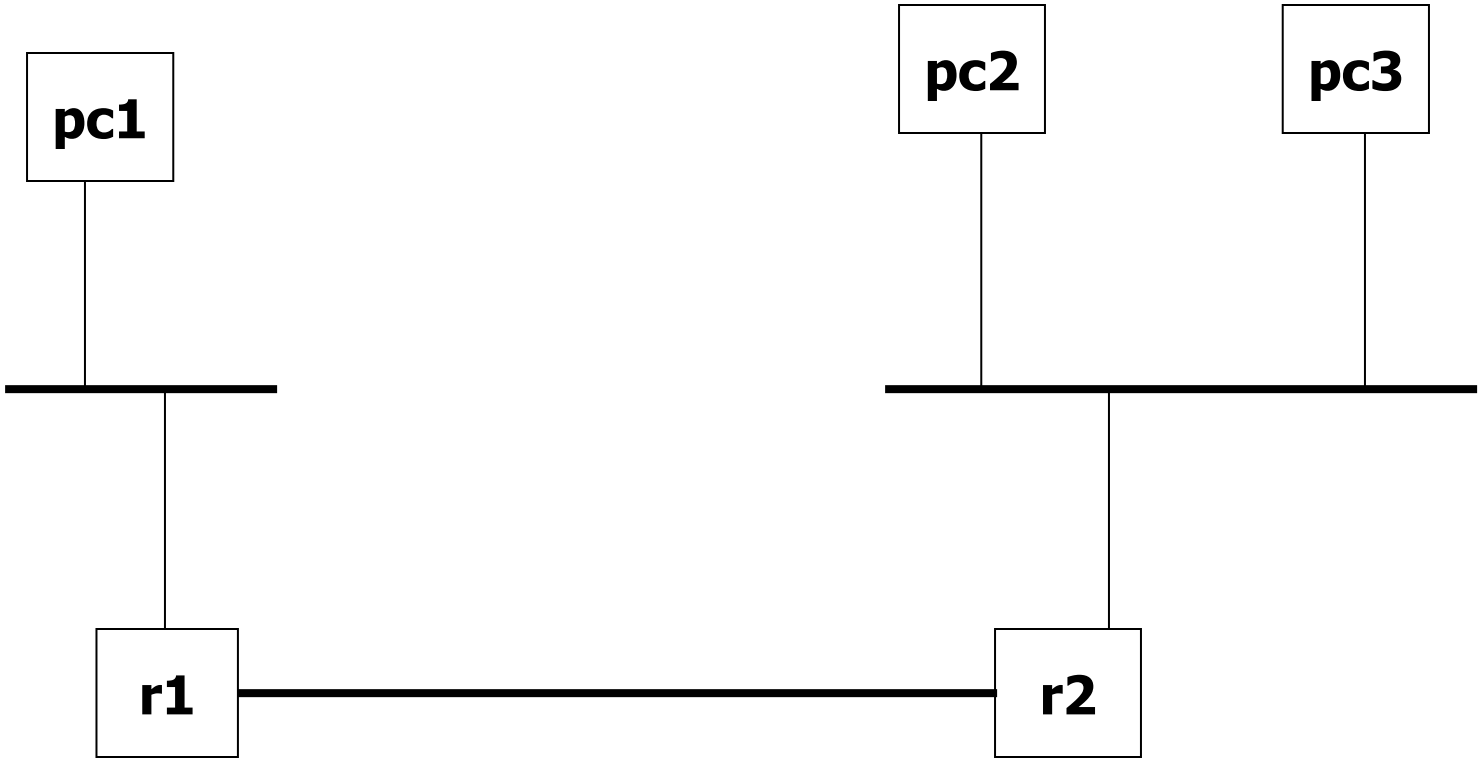


network topology – high level view



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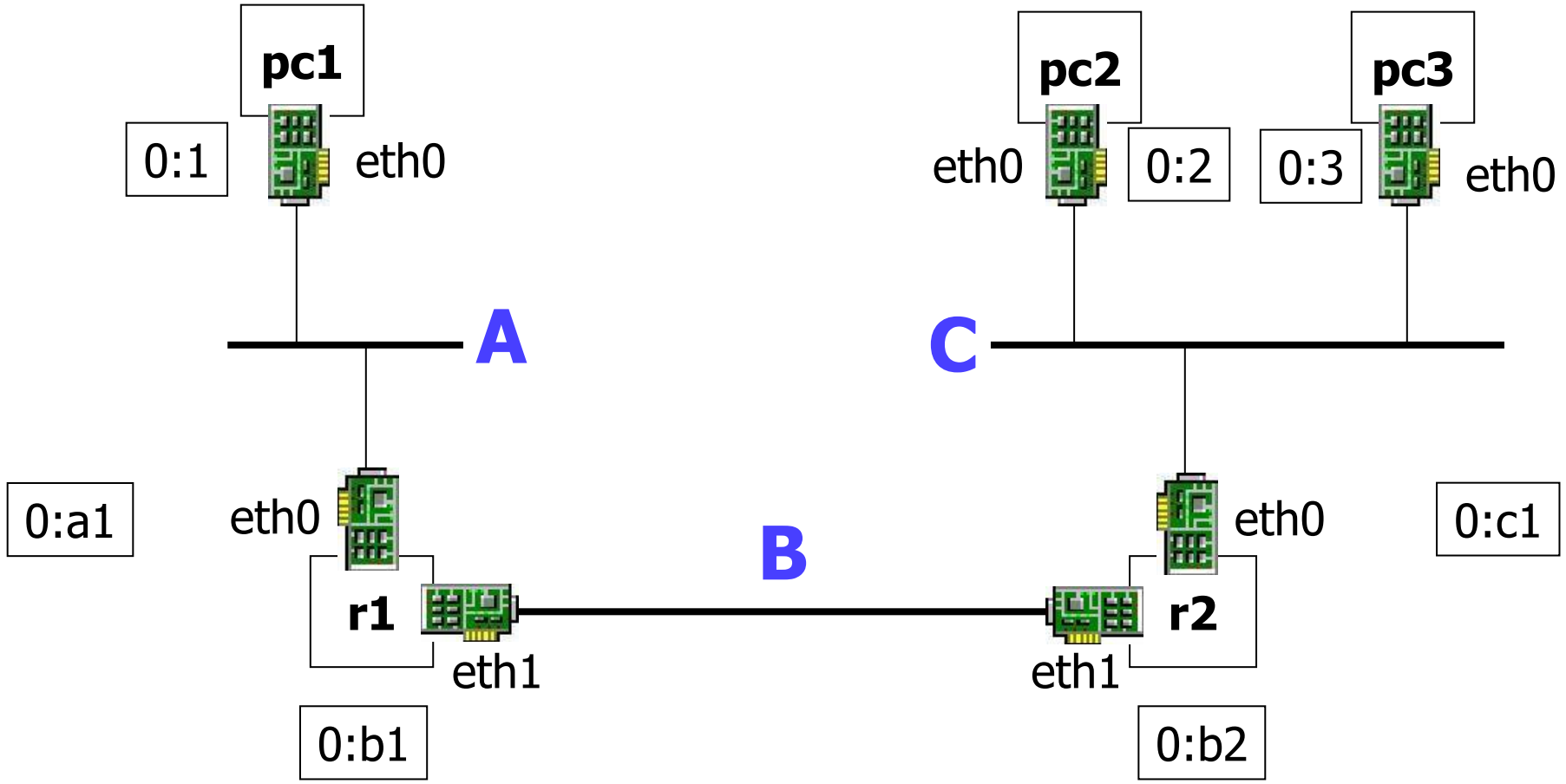
network topology – MAC addresses



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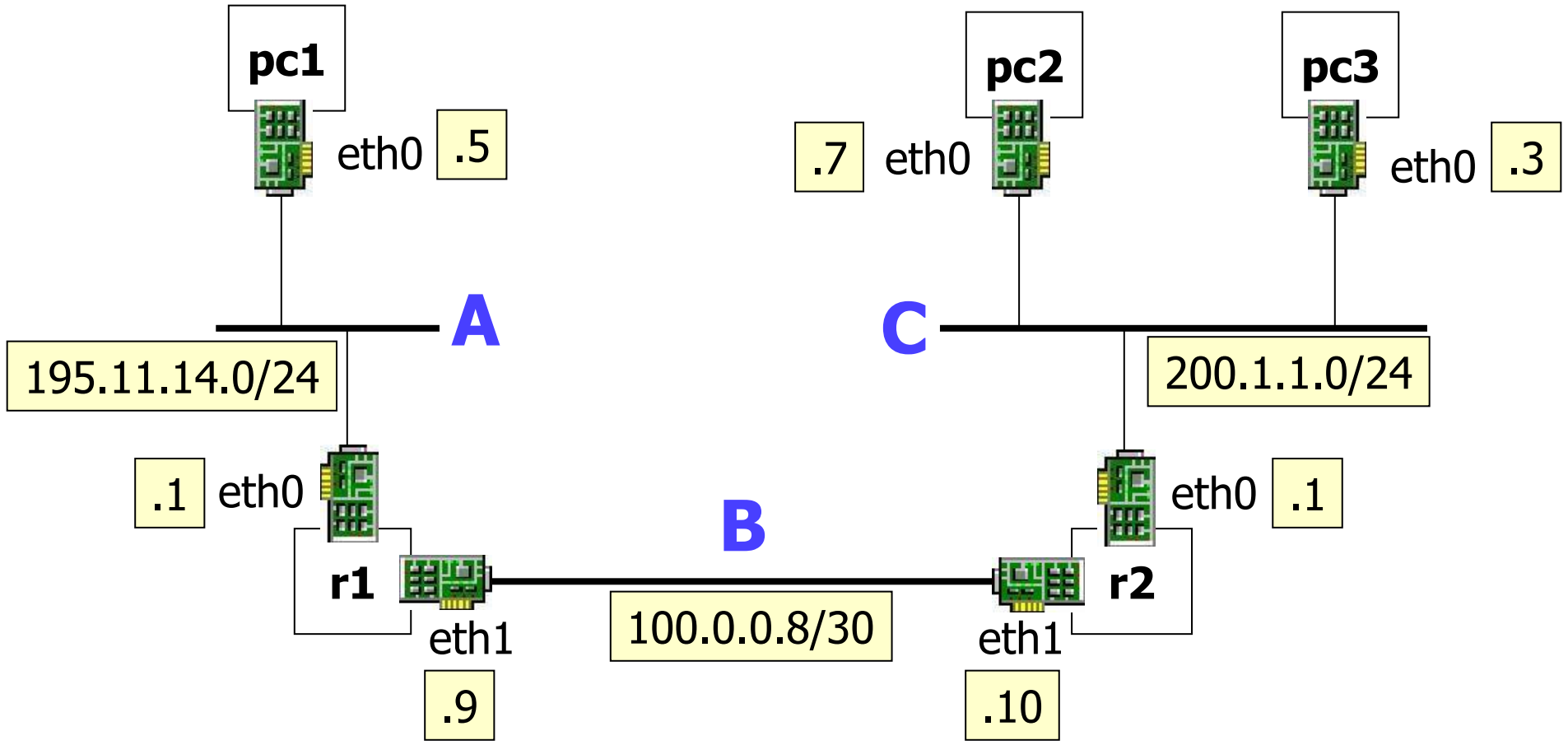
network topology – IPv4 address plan



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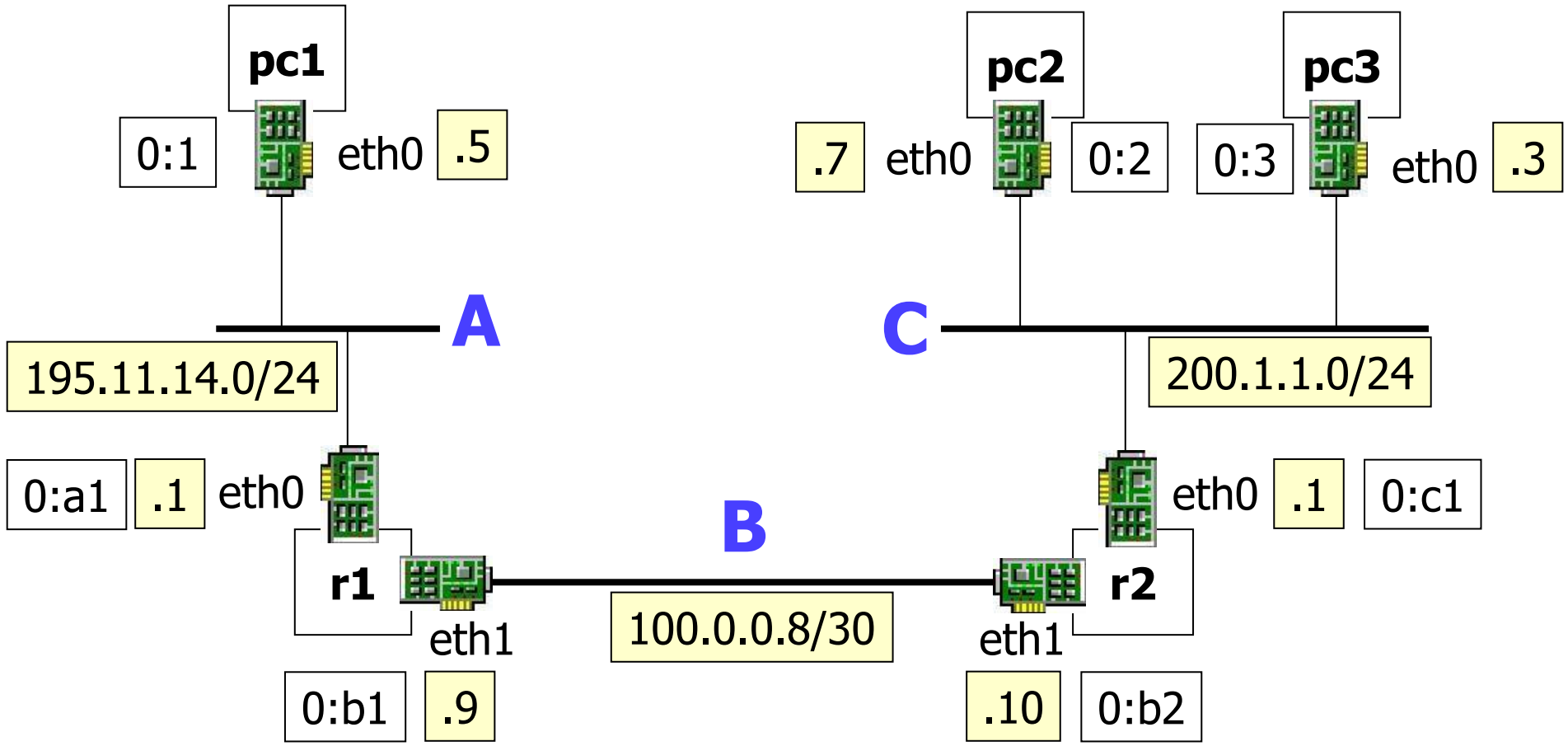
network topology – complete overview



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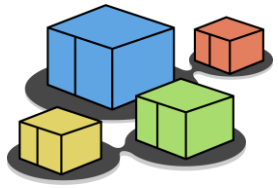

a quick look at the lab

lab.conf

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

r2[0]="C"
r2[1]="B"
r2[image]="kathara/base"
r2[ipv6]="false"

pc1[0]="A"
pc1[image]="kathara/base"
pc1[ipv6]="false"
```

lab.conf

```
pc2[0]="C"
pc2[image]="kathara/base"
pc2[ipv6]="false"

pc3[0]="C"
pc3[image]="kathara/base"
pc3[ipv6]="false"

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

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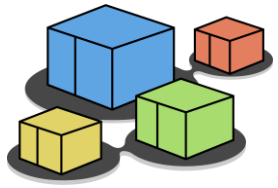

a quick look at the lab

pc1.startup

```
ip link set dev eth0 address 00:00:00:00:00:01
ip address add 195.11.14.5/24 dev eth0
ip route add default via 195.11.14.1
```

pc2.startup

```
ip link set dev eth0 address 00:00:00:00:00:02
ip address add 200.1.1.7/24 dev eth0
ip route add default via 200.1.1.1 dev eth0
```

pc3.startup

```
ip link set dev eth0 address 00:00:00:00:00:03
ip address add 200.1.1.3/24 dev eth0
ip route add default via 200.1.1.1 dev eth0
```

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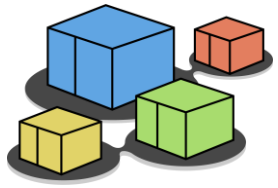

a quick look at the lab

an IPv4 address is assigned to the eth0 interfaces of hosts

pc1.startup

```
ip link set dev eth0 address 00:00:00:00:00:01
ip address add 195.11.14.5/24 dev eth0
ip route add default via 195.11.14.1
```

pc2.startup

```
ip link set dev eth0 address 00:00:00:00:00:02
ip address add 200.1.1.7/24 dev eth0
ip route add default via 200.1.1.1 dev eth0
```

pc3.startup

```
ip link set dev eth0 address 00:00:00:00:00:03
ip address add 200.1.1.3/24 dev eth0
ip route add default via 200.1.1.1 dev eth0
```

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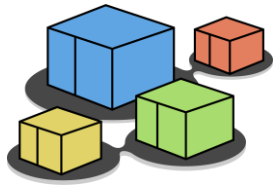

a quick look at the lab

an IPv4 address is added to the eth0 interfaces of hosts

a default gateway is set for all hosts

pc1.startup

```
ip link set dev eth0 address 00:00:00:00:00:01
ip address add 195.11.14.5/24 dev eth0
ip route add default via 195.11.14.1
```

pc2.startup

```
ip link set dev eth0 address 00:00:00:00:00:02
ip address add 200.1.1.7/24 dev eth0
ip route add default via 200.1.1.1 dev eth0
```

pc3.startup

```
ip link set dev eth0 address 00:00:00:00:00:03
ip address add 200.1.1.3/24 dev eth0
ip route add default via 200.1.1.1 dev eth0
```

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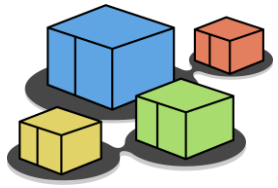

a quick look at the lab

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 address add 195.11.14.1/24 dev eth0
ip address add 100.0.0.9/30 dev eth1
ip route add 200.1.1.0/24 via 100.0.0.10 dev eth1
```

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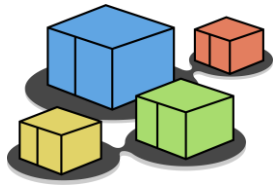

a quick look at the lab

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 address add 195.11.14.1/24 dev eth0
ip address add 100.0.0.9/30 dev eth1
ip route add 200.1.1.0/24 via 100.0.0.10 dev eth1
```

an IPv4 address is assigned to interfaces eth0 and eth1 of router r1

consequently, the corresponding LANs are considered *directly connected*

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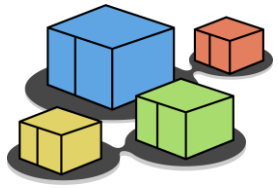

a quick look at the lab

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 address add 195.11.14.1/24 dev eth0
ip address add 100.0.0.9/30 dev eth1
ip route add 200.1.1.0/24 via 100.0.0.10 dev eth1
```

an IPv4 address is given to interfaces eth0 and eth1 of router r1

consequently, the corresponding LANs are considered *directly connected*

a row is added to the routing table on how to reach a LAN that is not directly connected

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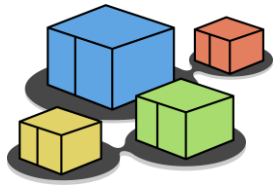

a quick look at the lab

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 address add 195.11.14.1/24 dev eth0
ip address add 100.0.0.9/30 dev eth1
ip route add 200.1.1.0/24 via 100.0.0.10 dev eth1
```

an IPv4 address is given to interfaces eth0 and eth1 of router r1

consequently, the corresponding LANs are considered *directly connected*

a row is added to the routing table on how to reach a LAN that is not directly connected

similar configuration for router r2

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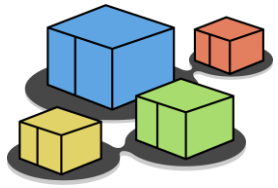

start the lab

- start the lab

```
user@localhost:~$ cd kathara-lab_basic-ipv4
user@localhost:~/kathara-lab_basic-ipv4$ lstart
```

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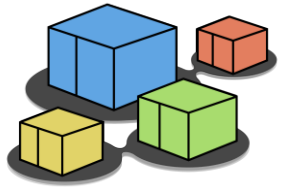

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useful commands

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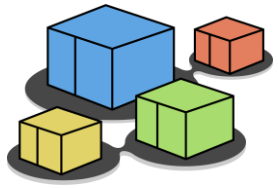

check the IPv4 addresses

- on pc1, pc2, pc3, r1, and r2
  - perform the `ip address` command, to check the IPv4 addresses assigned to the interfaces
    - look at eth and loopback interfaces

loopback interface
127.0.0.1/8

eth0
195.11.14.5/24

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
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
    inet 195.11.14.5/24 scope global eth0
       valid_lft forever preferred_lft forever
```

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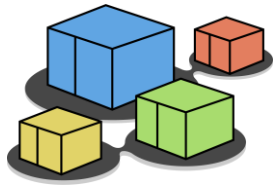

check the default route

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

default route by r1

loopback prefix

useful information:
for each d.c. network,
my address and
broadcast

pc1

```
root@pc1:/# routel
Dst              Gateway          Prefsrc          Protocol Scope   Dev     Table
default          195.11.14.1                                        eth0
195.11.14.0/24                    195.11.14.5      kernel   link    eth0
127.0.0.0/8                       127.0.0.1        kernel   host    lo      local
127.0.0.1                         127.0.0.1        kernel   host    lo      local
127.255.255.255                   127.0.0.1        kernel   link    lo      local
195.11.14.5                       195.11.14.5      kernel   host    eth0    local
195.11.14.255                     195.11.14.5      kernel   link    eth0    local
```

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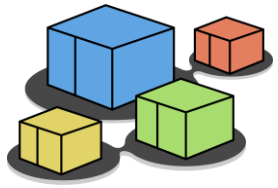

check the router routing tables

- on r1, and r2
  - perform the `routel` command, to check the routing table

Lan B

Lan A

Lan C

useful information:
for each d.c. network,
my address and
broadcast

r1

```
root@r1:/# routel
Dst                 Gateway          Prefsrc          Protocol Scope   Dev    Table
100.0.0.8/30                         100.0.0.9        kernel   link    eth1
195.11.14.0/24                       195.11.14.1      kernel   link    eth0
200.1.1.0/24        100.0.0.10                                        eth1
100.0.0.9                            100.0.0.9        kernel   host    eth1   local
100.0.0.11                           100.0.0.9        kernel   link    eth1   local
127.0.0.0/8                          127.0.0.1        kernel   host    lo     local
127.0.0.1                            127.0.0.1        kernel   host    lo     local
127.255.255.255                      127.0.0.1        kernel   link    lo     local
195.11.14.1                          195.11.14.1      kernel   host    eth0   local
195.11.14.255                        195.11.14.1      kernel   link    eth0   local
```

r2

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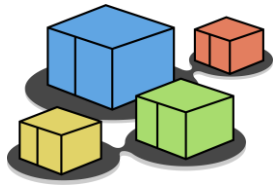

snif the traffic

- connect the wireshark device to collision domain C

```
user@localhost:~/kathara-lab_basic-ipv4$ kathara lconfig -n wireshark --add C
```

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

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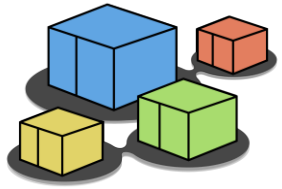

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ping from pc3 to pc2 and related arp behavior

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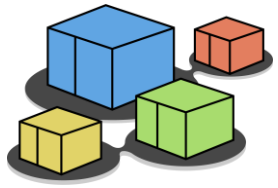

on pc3

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

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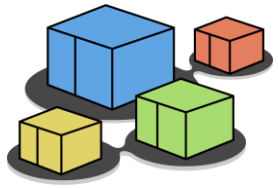

inspecting the arp cache of pc3

```
ARP(8)              Linux System Administrator's Manual
NAME
       arp - manipulate the system ARP cache

SYNOPSIS
    arp [-vn] [-H type] [-i if] [-ae] [hostname]
    arp [-v] [-i if] -d hostname [pub]
    arp [-v] [-H type] [-i if] -s hostname hw_addr [temp]
    arp [-v] [-H type] [-i if] -s hostname hw_addr [netmask nm] pub
    arp [-v] [-H type] [-i if] -Ds hostname ifname [netmask nm] pub
    arp [-vnD] [-H type] [-i if] -f [filename]

DESCRIPTION
Arp manipulates or displays the kernel's IPv4 network neighbour cache.
It can add entries to the table, delete one or display the currennt content.

ARP stands for Address Resolution Protocol, which is used to find the media
access control address of  a  network neighbour for a given IPv4 Address

.......
```

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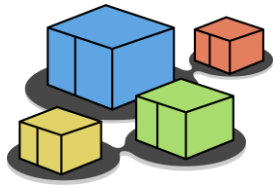

inspecting the arp cache

the arp cache is initially empty

sending packets to 200.1.1.7 requires address resolution

pc3

```
root@pc3:/# arp
root@pc3:/# ping 200.1.1.7
PING 200.1.1.7 (200.1.1.7) 56(84) bytes of data.
64 bytes from 200.1.1.7: icmp_seq=1 ttl=64 time=1.93 ms
64 bytes from 200.1.1.7: icmp_seq=2 ttl=64 time=0.638 ms
--- 200.1.1.7 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1001ms
rtt min/avg/max/mdev = 0.638/1.283/1.929/0.645 ms
root@pc3:/# arp
Address                  HWtype  HWaddress           Flags Mask    Iface
200.1.1.7                ether   00:00:00:00:00:02   C             eth0
```

address resolution results are stored in the arp cache

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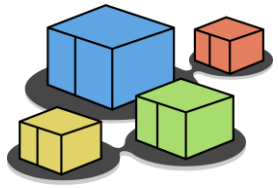
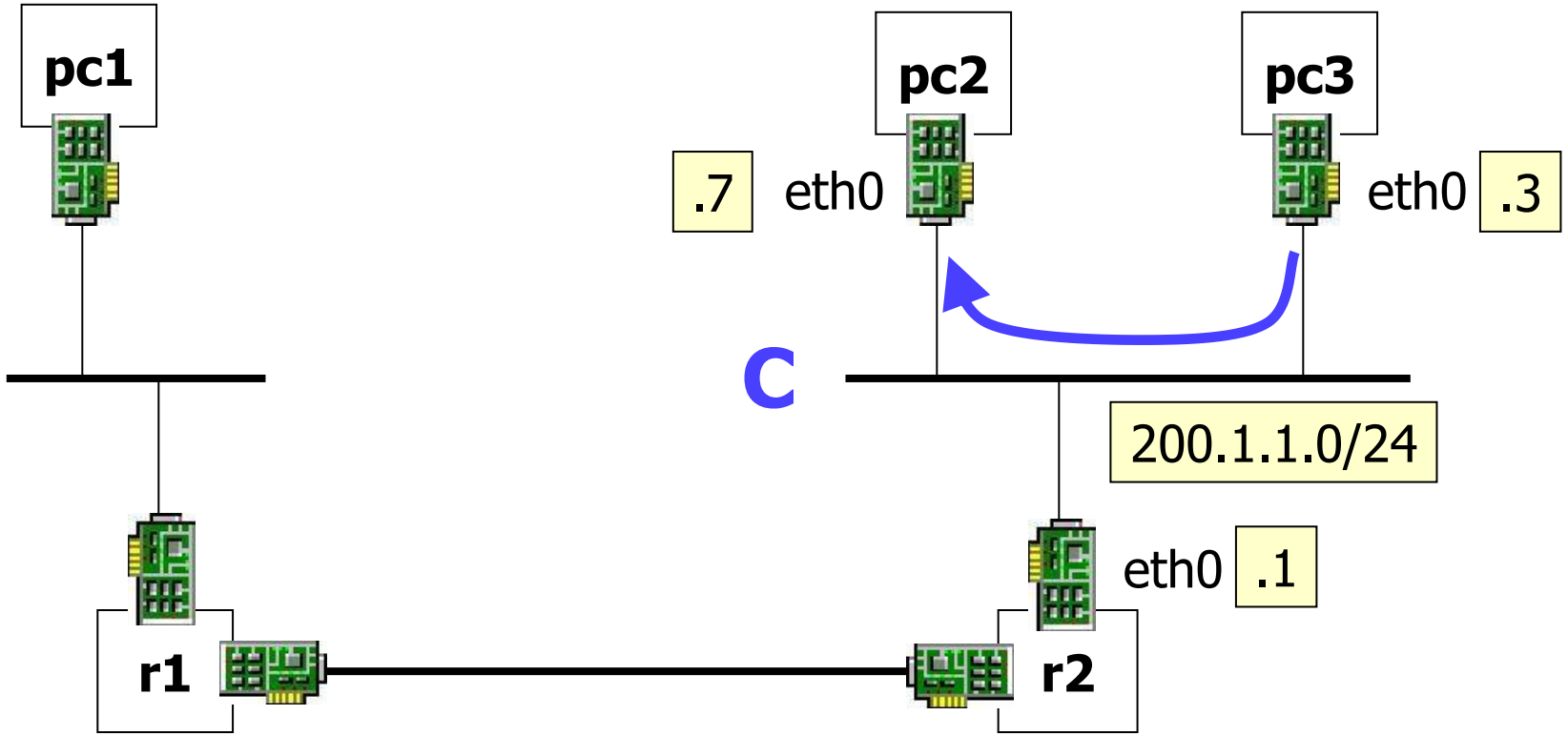


inspecting the arp cache

- traffic within the same network does not traverse routers



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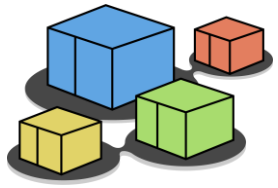
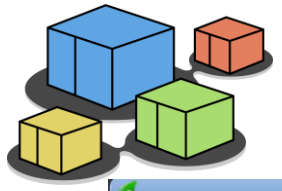


inspecting the arp cache

- communications are usually bi-directional
- the receiver of the arp request learns the mac address of the other party, to avoid a new arp in opposite direction (standard behavior, see rfc 826)

pc2

```
root@pc2:/# arp -n
Address                  HWtype  HWaddress           Flags Mask  Iface
200.1.1.3                ether   00:00:00:00:00:03   C           eth0
```



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	0.000000000	00:00:00_00:00:03	Broadcast	ARP	60	Who has 200.1.1.7? Tell 200.1.1.3
2	0.000069328	00:00:00_00:00:02	00:00:00_00:00:03	ARP	60	200.1.1.7 is at 00:00:00:00:00:02
3	0.000128465	200.1.1.3	200.1.1.7	ICMP	98	Echo (ping) request id=0x0006, seq=1/256, ttl=64 (reply in 4)
4	0.000320731	200.1.1.7	200.1.1.3	ICMP	98	Echo (ping) reply id=0x0006, seq=1/256, ttl=64 (request in 3)
5	1.073307284	200.1.1.3	200.1.1.7	ICMP	98	Echo (ping) request id=0x0006, seq=2/512, ttl=64 (reply in 6)
6	1.073485261	200.1.1.7	200.1.1.3	ICMP	98	Echo (ping) reply id=0x0006, seq=2/512, ttl=64 (request in 5)
7	5.073082395	00:00:00_00:00:02	00:00:00_00:00:03	ARP	60	Who has 200.1.1.3? Tell 200.1.1.7
8	5.073121978	00:00:00_00:00:03	00:00:00_00:00:02	ARP	60	200.1.1.3 is at 00:00:00:00:00:03

```
▸ Frame 1: 60 bytes on wire (480 bits), 60 bytes captured (480 bit
▸ Ethernet II, Src: 00:00:00_00:00:03 (00:00:00:00:00:03), Dst: Br
▸ Address Resolution Protocol (request)
```

```
0000  ff ff ff ff ff ff 00 00  00 00 00 03 08 06 00 01  ........ ........
0010  08 00 06 04 00 01 00 00  00 00 00 03 c8 01 01 03  ........ ........
0020  00 00 00 00 00 00 c8 01  01 07 98 55 52 65 00 00  ........ ...URe..
0030  00 00 cf 9c 09 00 00 00  00 00 00 00              ........ ....
```

eth1: <live capture in progress> Packets: 8 · Displayed: 8 (100.0%) Profile: Default

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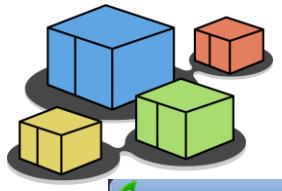

wireshark

arp request

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	0.000000000	00:00:00_00:00:03	Broadcast	ARP	60	Who has 200.1.1.7? Tell 200.1.1.3
2	0.000069328	00:00:00_00:00:02	00:00:00_00:00:03	ARP	60	200.1.1.7 is at 00:00:00:00:00:02
3	0.000128465	200.1.1.3	200.1.1.7	ICMP	98	Echo (ping) request id=0x0006, seq=1/256, ttl=64 (reply in 4)
4	0.000320731	200.1.1.7	200.1.1.3	ICMP	98	Echo (ping) reply id=0x0006, seq=1/256, ttl=64 (request in 3)
5	1.073307284	200.1.1.3	200.1.1.7	ICMP	98	Echo (ping) request id=0x0006, seq=2/512, ttl=64 (reply in 6)
6	1.073485261	200.1.1.7	200.1.1.3	ICMP	98	Echo (ping) reply id=0x0006, seq=2/512, ttl=64 (request in 5)
7	5.073082395	00:00:00_00:00:02	00:00:00_00:00:03	ARP	60	Who has 200.1.1.3? Tell 200.1.1.7
8	5.073121978	00:00:00_00:00:03	00:00:00_00:00:02	ARP	60	200.1.1.3 is at 00:00:00:00:00:03

```
▸ Frame 1: 60 bytes on wire (480 bits), 60 bytes captured (480 bit
▸ Ethernet II, Src: 00:00:00_00:00:03 (00:00:00:00:00:03), Dst: Br
▸ Address Resolution Protocol (request)
```

```
0000  ff ff ff ff ff ff 00 00  00 00 00 03 08 06 00 01  ........ ........
0010  08 00 06 04 00 01 00 00  00 00 00 03 c8 01 01 03  ........ ........
0020  00 00 00 00 00 00 c8 01  01 07 98 55 52 65 00 00  ........ ...URe..
0030  00 00 cf 9c 09 00 00 00  00 00 00 00              ........ ....
```

eth1: <live capture in progress> Packets: 8 · Displayed: 8 (100.0%) Profile: Default

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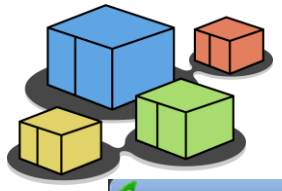

wireshark

arp request

arp reply

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	0.000000000	00:00:00_00:00:03	Broadcast	ARP	60	Who has 200.1.1.7? Tell 200.1.1.3
2	0.000069328	00:00:00_00:00:02	00:00:00_00:00:03	ARP	60	200.1.1.7 is at 00:00:00:00:00:02
3	0.000128465	200.1.1.3	200.1.1.7	ICMP	98	Echo (ping) request id=0x0006, seq=1/256, ttl=64 (reply in 4)
4	0.000320731	200.1.1.7	200.1.1.3	ICMP	98	Echo (ping) reply id=0x0006, seq=1/256, ttl=64 (request in 3)
5	1.073307284	200.1.1.3	200.1.1.7	ICMP	98	Echo (ping) request id=0x0006, seq=2/512, ttl=64 (reply in 6)
6	1.073485261	200.1.1.7	200.1.1.3	ICMP	98	Echo (ping) reply id=0x0006, seq=2/512, ttl=64 (request in 5)
7	5.073082395	00:00:00_00:00:02	00:00:00_00:00:03	ARP	60	Who has 200.1.1.3? Tell 200.1.1.7
8	5.073121978	00:00:00_00:00:03	00:00:00_00:00:02	ARP	60	200.1.1.3 is at 00:00:00:00:00:03

```
▸ Frame 1: 60 bytes on wire (480 bits), 60 bytes captured (480 bit
▸ Ethernet II, Src: 00:00:00_00:00:03 (00:00:00:00:00:03), Dst: Br
▸ Address Resolution Protocol (request)
```

```
0000  ff ff ff ff ff ff 00 00  00 00 00 03 08 06 00 01  ........ ........
0010  08 00 06 04 00 01 00 00  00 00 00 03 c8 01 01 03  ........ ........
0020  00 00 00 00 00 00 c8 01  01 07 98 55 52 65 00 00  ........ ...URe..
0030  00 00 cf 9c 09 00 00 00  00 00 00 00              ........ ....
```

eth1: <live capture in progress> Packets: 8 · Displayed: 8 (100.0%) Profile: Default

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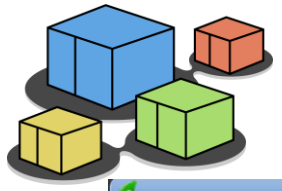
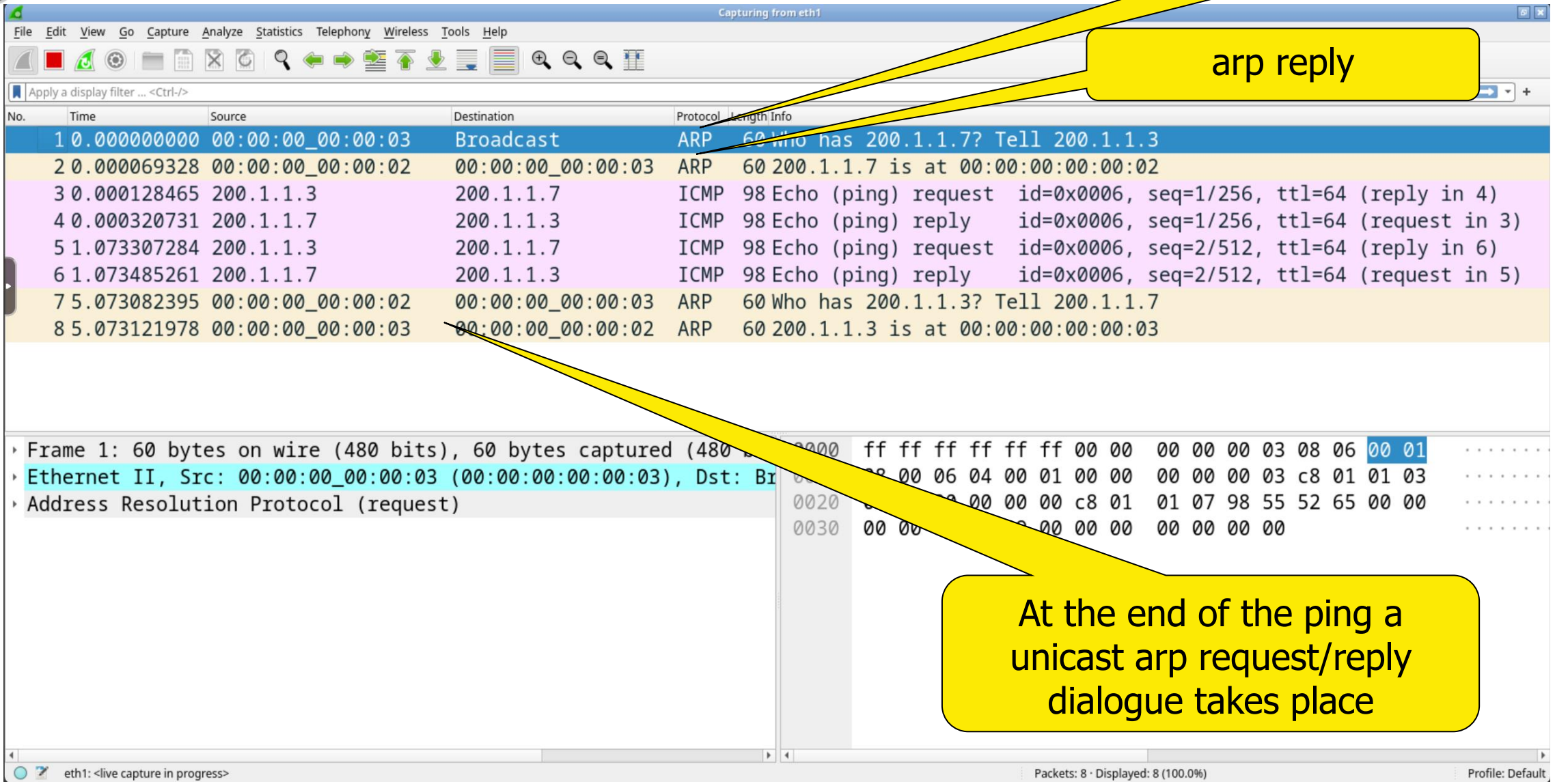


wireshark

arp request

arp reply



At the end of the ping a unicast arp request/reply dialogue takes place

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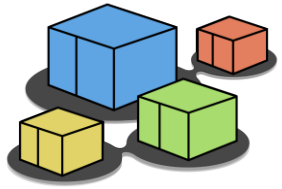

Kathará

ping from pc2 to pc1 and related arp behavior

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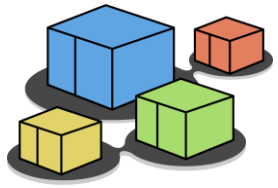

sniff the traffic

- connect the wireshark host to collision domain B

```
user@localhost:~/kathara-lab_basic-ipv4$ kathara lconfig -n wireshark
--add B
```

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

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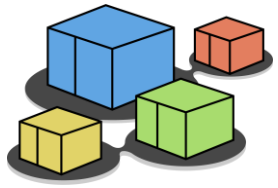

on pc2

- execute a ping command towards pc1

pc2

```
root@pc2:/# ping 195.11.14.5
PING 195.11.14.5 (195.11.14.5) 56(84) bytes of data.
64 bytes from 195.11.14.5: icmp_seq=1 ttl=62 time=5.86 ms
64 bytes from 195.11.14.5: icmp_seq=2 ttl=62 time=1.69 ms
--- 195.11.14.5 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1002ms
rtt min/avg/max/mdev = 1.688/3.771/5.855/2.083 ms
```

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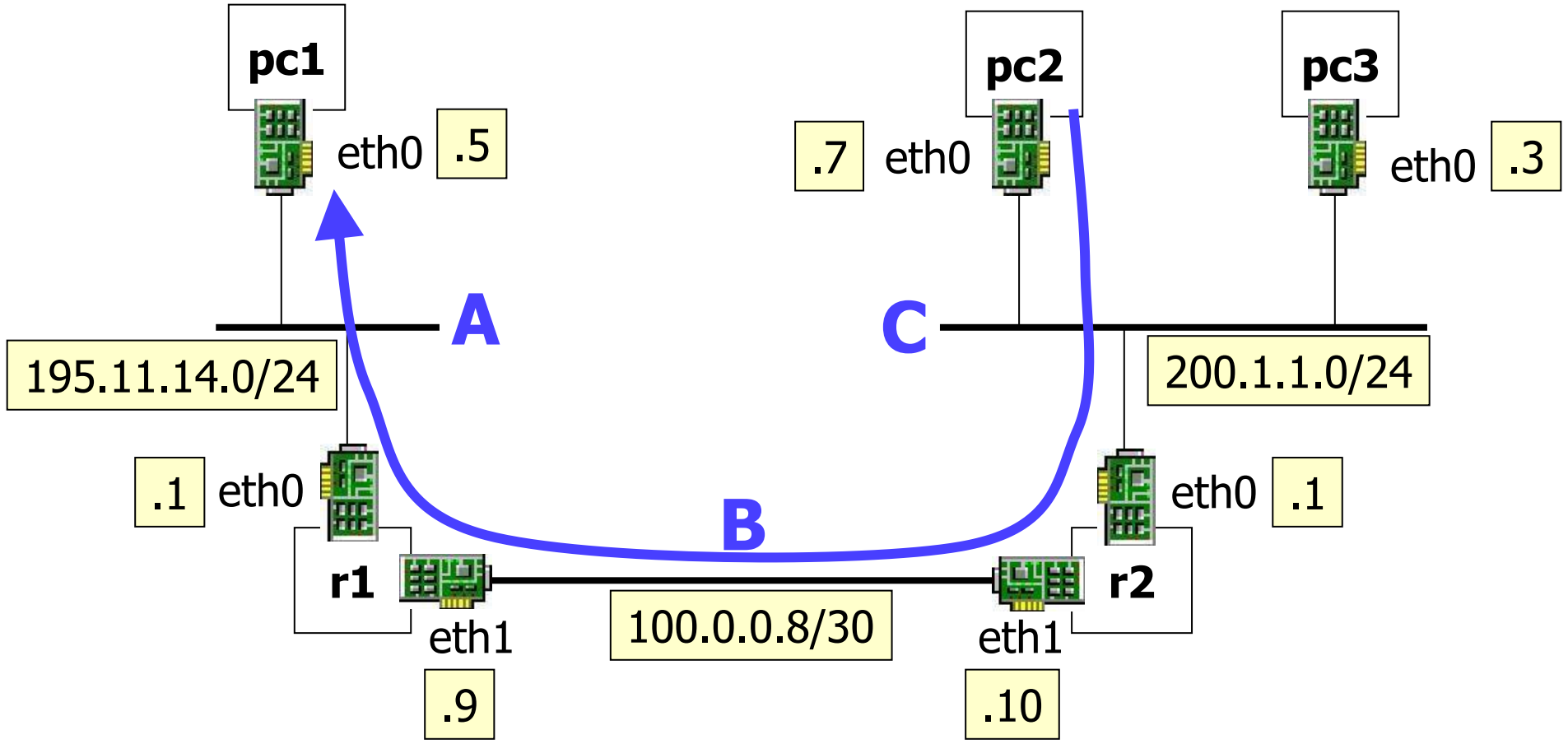
inspecting the arp cache (non local traffic)



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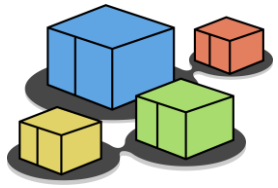


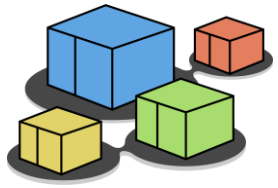
inspecting the arp cache (non local traffic)

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

pc2

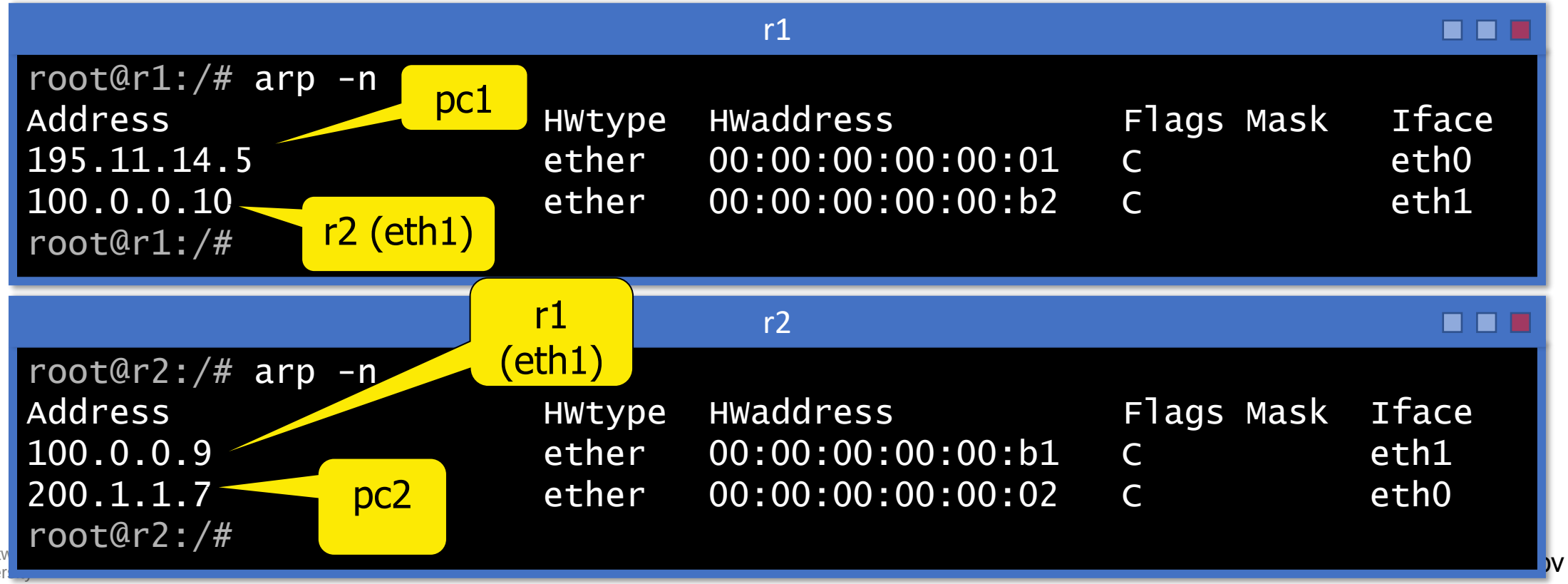
```
root@pc2:/# arp -n
Address                  HWtype  HWaddress           Flags Mask   Iface
200.1.1.1                ether   00:00:00:00:00:c1   C            eth0
200.1.1.3                ether   00:00:00:00:00:03   C            eth0
root@pc2:/#
```

mac address of eth0 on r2



inspecting the arp cache
(non local traffic)

- what about routers?
- routers perform arp too (hence have arp caches) anytime they have to send ip packets on an ethernet lan



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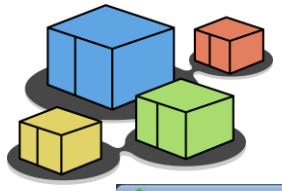

wireshark

which is the mac address of r1

Capturing from eth2

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	00:00:00_00:00:b2	Broadcast	ARP	60	Who has 100.0.0.9? Tell 100.0.0.10
2	0.000113040	00:00:00_00:00:b1	00:00:00_00:00:b2	ARP	60	100.0.0.9 is at 00:00:00:00:00:b1
3	0.000165061	200.1.1.7	195.11.14.5	ICMP	98	Echo (ping) request id=0x0007, seq=1/256, ttl=63 (reply in 4)
4	0.000775595	195.11.14.5	200.1.1.7	ICMP	98	Echo (ping) reply id=0x0007, seq=1/256, ttl=63 (request in 3)
5	0.999746816	200.1.1.7	195.11.14.5	ICMP	98	Echo (ping) request id=0x0007, seq=2/512, ttl=63 (reply in 6)
6	0.999887390	195.11.14.5	200.1.1.7	ICMP	98	Echo (ping) reply id=0x0007, seq=2/512, ttl=63 (request in 5)
7	5.044520000	00:00:00_00:00:b1	00:00:00_00:00:b2	ARP	60	Who has 100.0.0.10? Tell 100.0.0.9
8	5.044526554	00:00:00_00:00:b2	00:00:00_00:00:b1	ARP	60	100.0.0.10 is at 00:00:00:00:00:b2

```
▸ Frame 1: 60 bytes on wire (480 bits), 60 bytes captured (480 b…
▸ Ethernet II, Src: 00:00:00_00:00:b2 (00:00:00:00:00:b2), Dst: …
▸ Address Resolution Protocol (request)
```

```
0000  ff ff ff ff ff ff 00 00  00 00 00 b2 08 06 00 01  ........ ........
0010  08 00 06 04 00 01 00 00  00 00 00 b2 64 00 00 0a  ........ ....d...
0020  00 00 00 00 00 00 64 00  00 09 37 2d 30 30 30 30  ......d. ..7-0000
0030  30 00 00 00 00 00 00 00  00 00 00 00              0....... ....
```

eth2: <live capture in progress> Packets: 8 · Displayed: 8 (100.0%) Profile: Default

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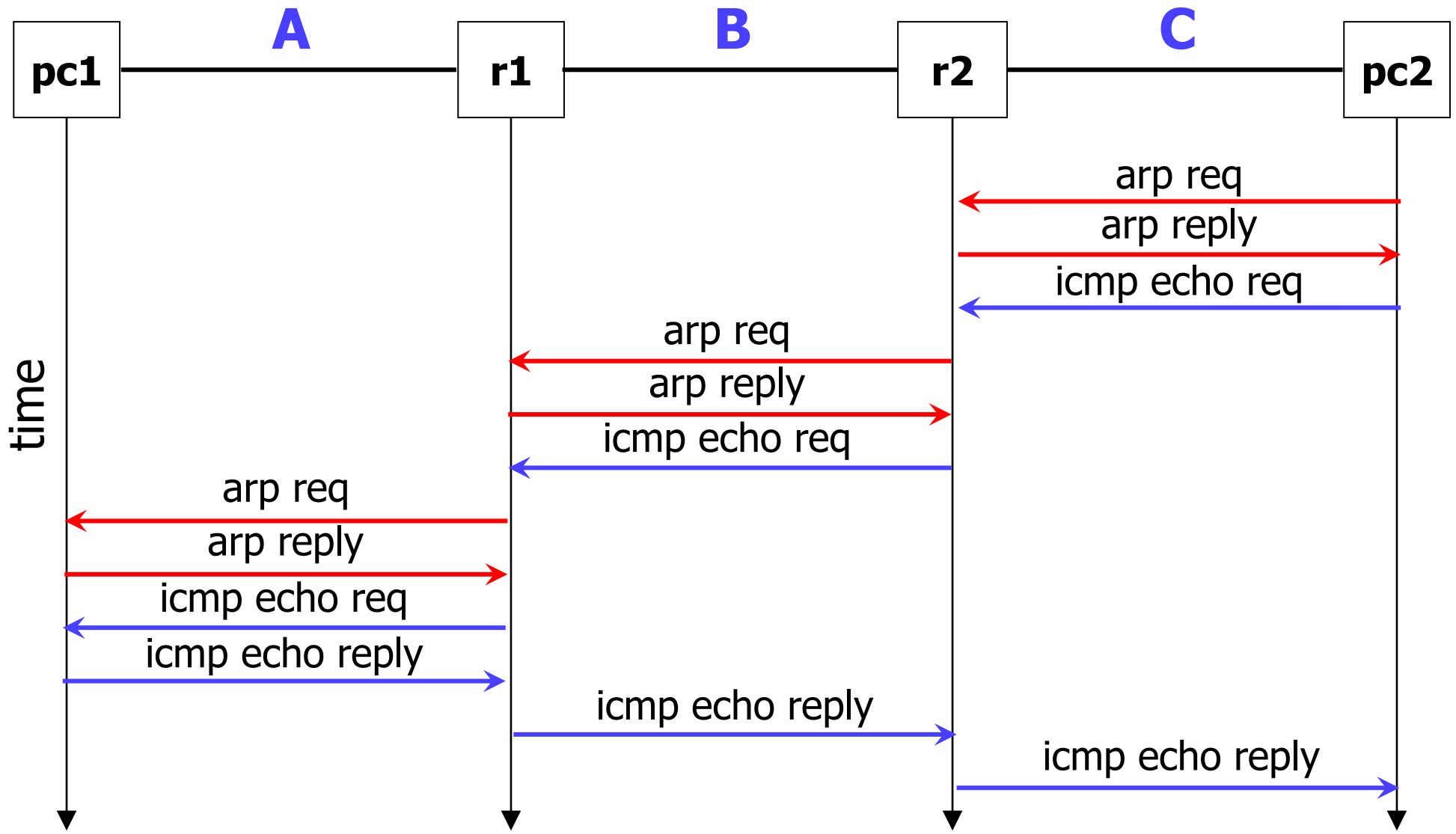
understanding the whole picture



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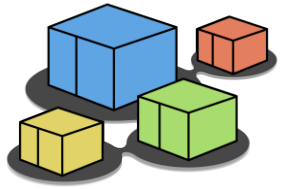

Kathará

traceroute from pc2 to pc1 and related arp behavior

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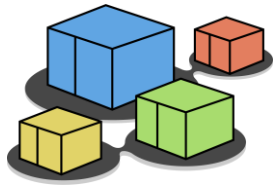

sniff the traffic

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

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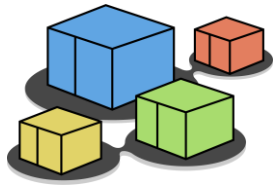

on pc2

- 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 195.11.14.5 -z 1
traceroute to 195.11.14.5 (195.11.14.5), 30 hops max, 60 byte packets
 1  200.1.1.1 (200.1.1.1)  0.882 ms  0.662 ms  0.456 ms
 2  100.0.0.9 (100.0.0.9)  0.903 ms  0.877 ms  1.218 ms
 3  195.11.14.5 (195.11.14.5)  0.987 ms  1.354 ms  1.015 ms
root@pc2:/#
```

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udp packet and corresponding ICMP Time-to-live exceeded

wireshark

Capturing from eth1

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

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	200.1.1.7	195.11.14.5	UDP	74	39056 → 33434 Len=32
2	0.000637236	200.1.1.1	200.1.1.7	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
3	1.000192762	200.1.1.7	195.11.14.5	UDP	74	50233 → 33435 Len=32
4	1.000380063	200.1.1.1	200.1.1.7	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
5	2.000024047	200.1.1.7	195.11.14.5	UDP	74	54678 → 33436 Len=32
6	2.000189737	200.1.1.1	200.1.1.7	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
7	3.000220649	200.1.1.7	195.11.14.5	UDP	74	33584 → 33437 Len=32
8	3.000730555	100.0.0.9	200.1.1.7	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
9	4.000119816	200.1.1.7	195.11.14.5	UDP	74	60767 → 33438 Len=32
10	4.000705392	100.0.0.9	200.1.1.7	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
11	5.000344264	200.1.1.7	195.11.14.5	UDP	74	53610 → 33439 Len=32
12	5.001085466	100.0.0.9	200.1.1.7	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
13	5.055108606	00:00:00_00:00:c1	00:00:00_00:00:02	ARP	60	Who has 200.1.1.7? Tell 200.1.1.1
14	5.055217517	00:00:00_00:00:02	00:00:00_00:00:c1	ARP	60	Who has 200.1.1.1? Tell 200.1.1.7
15	5.055307541	00:00:00_00:00:c1	00:00:00_00:00:02	ARP	60	200.1.1.1 is at 00:00:00:00:00:c1
16	5.055432485	00:00:00_00:00:02	00:00:00_00:00:c1	ARP	60	200.1.1.7 is at 00:00:00:00:00:02
17	6.000124534	200.1.1.7	195.11.14.5	UDP	74	42119 → 33440 Len=32
18	6.000870617	195.11.14.5	200.1.1.7	ICMP	102	Destination unreachable (Port unreachable)
19	7.000304523	200.1.1.7	195.11.14.5	UDP	74	34812 → 33441 Len=32
20	7.001239457	195.11.14.5	200.1.1.7	ICMP	102	Destination unreachable (Port unreachable)
21	8.000192097	200.1.1.7	195.11.14.5	UDP	74	33732 → 33442 Len=32
22	8.001009180	195.11.14.5	200.1.1.7	ICMP	102	unreachable)

```
Total Length: 60
Identification: 0x43ab (17323)
000. .... = Flags: 0x0
...0 0000 0000 0000 = Fragment Offset: 0
Time to Live: 1
Protocol: UDP (17)
Header Checksum: 0xdbed [validation disabled]
[Header checksum status: Unverified]
Source Address: 200.1.1.7
```

Time to live: 1

```
0000  00 00 00 00 c1 00 00  00 00 00 02 08 00 45 00   ·····E·
0010  3c 43 ab 00 00 01 11  db ed c8 01 01 07 c3 0b   <C·····
0020  0e 05 98 90 82 9a 00 28  55 55 40 41 42 43 44 45   ·····( UU@ABCDE
0030  46 47 48 49 4a 4b 4c 4d  4e 4f 50 51 52 53 54 55   FGHIJKLM NOPQRSTU
0040  56 57 58 59 5a 5b 5c 5d  5e 5f                     VWXYZ[\] ^_
```

eth1: <live capture in progress> Packets: 22 · Displayed: 22 (100.0%) Profile: Default

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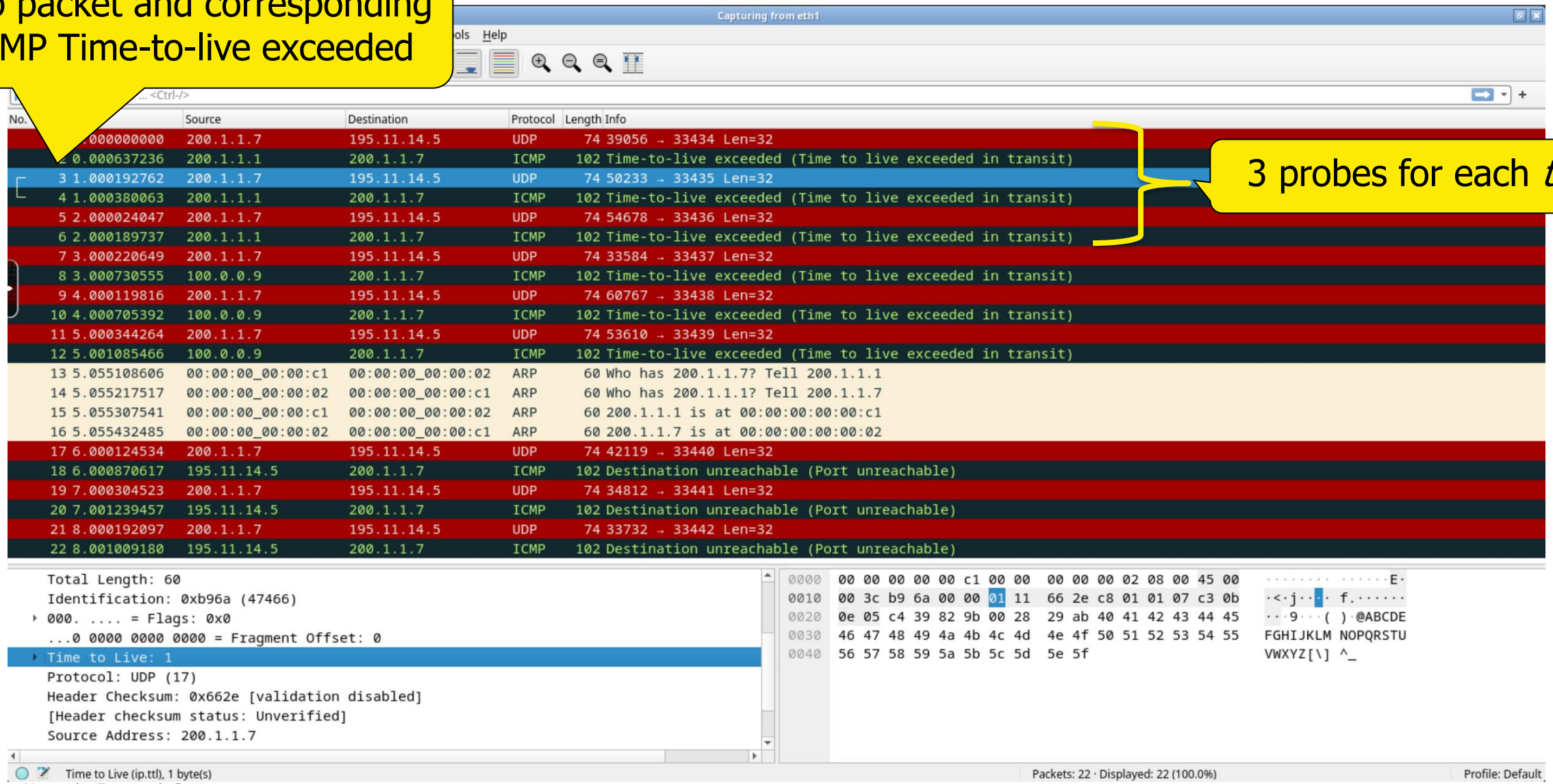
wireshark

udp packet and corresponding ICMP Time-to-live exceeded



3 probes for each *ttl*

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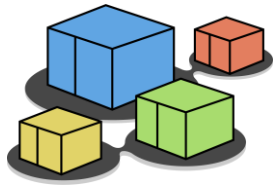
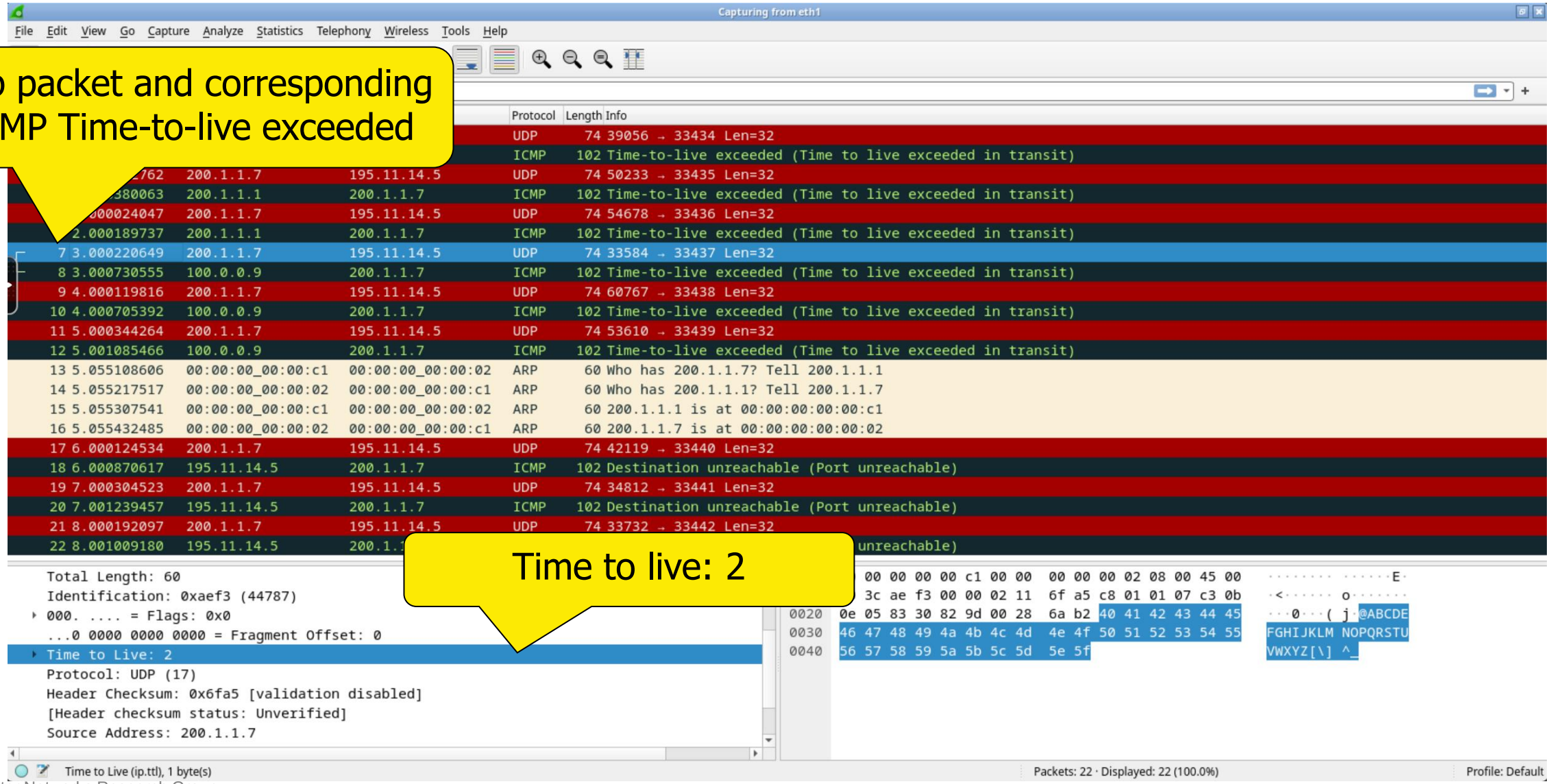


wireshark

udp packet and corresponding ICMP Time-to-live exceeded

Time to live: 2



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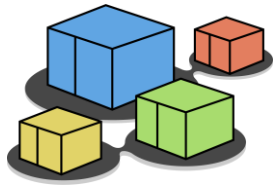

wireshark

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	0.000000000	200.1.1.7	195.11.14.5	UDP	74	39056 → 33434 Len=32
2	0.000637236	200.1.1.1	200.1.1.7	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
3	1.000192762	200.1.1.7	195.11.14.5	UDP	74	50233 → 33435 Len=32
4	1.000380063	200.1.1.1	200.1.1.7	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
5	2.000024047	200.1.1.7	195.11.14.5	UDP	74	54678 → 33436 Len=32
6	2.000189737	200.1.1.1	200.1.1.7	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
7	3.000220649	200.1.1.7	195.11.14.5	UDP	74	33584 → 33437 Len=32
8	3.000730555	100.0.0.9	200.1.1.7	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
9	4.000119816	200.1.1.7	195.11.14.5	UDP	74	60767 → 33438 Len=32
10	4.000705392	100.0.0.9	200.1.1.7	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
11	5.000344264	200.1.1.7	195.11.14.5	UDP	74	53610 → 33439 Len=32
12	5.001085466	100.0.0.9	200.1.1.7	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
13	5.055108606					as 200.1.1.7? Tell 200.1.1.1
14	5.055217517					as 200.1.1.1? Tell 200.1.1.7
15	5.055307541					.1.1 is at 00:00:00:00:00:c1
16	5.055432485	00:00:00_	:00:00_00:00:c1	ARP	60	200.1.1.7 is at 00:00:00:00:00:02
17	6.000124534	200.1.1.7	195.11.14.5	UDP	74	42119 → 33440 Len=32
18	6.000870617	195.11.14.5	200.1.1.7	ICMP	102	Destination unreachable (Port unreachable)
19	7.000304523	200.1.1.7	195.11.14.5	UDP	74	34812 → 33441 Len=32
20	7.001239457	195.11.14.5	200.1.1.7	ICMP	102	Destination unreachable (Port unreachable)
21	8.000192097	200.1.1.7	195.11.14.5	UDP	74	33732 → 33442 Len=32
22	8.001009180	195.11.14.5	200.1.1.7	ICMP	102	Destination unreachable (Port unreachable)

destination reached!

```
Total Length: 88
Identification: 0x9457 (37975)
▸ 000. .... = Flags: 0x0
...0 0000 0000 0000 = Fragment Offset: 0
Time to Live: 62
Protocol: ICMP (1)
Header Checksum: 0x4d75 [validation disabled]
[Header checksum status: Unverified]
Source Address: 195.11.14.5
```

```
0000  00 00 00 00 00 02 00 00  00 00 00 c1 08 00 45 c0   ·····E·
0010  00 58 94 57 00 00 3e 01  4d 75 c3 0b 0e 05 c8 01   ·X·W··>· Mu·····
0020  01 07 03 03 97 4f 00 00  00 00 45 00 00 3c 4e 22   ·····O·· ··E··<N"
0030  00 00 01 11 d1 76 c8 01  01 07 c3 0b 0e 05 a4 87   ·····v·· ·····
0040  82 a0 00 28 49 58 40 41  42 43 44 45 46 47 48 49   ···(IX@A BCDEFGHI
0050  4a 4b 4c 4d 4e 4f 50 51  52 53 54 55 56 57 58 59   JKLMNOPQ RSTUVWXY
0060  5a 5b 5c 5d 5e 5f                                  Z[\]^_
```

Time to Live (ip.ttl), 1 byte(s) Packets: 22 · Displayed: 22 (100.0%) Profile: Default

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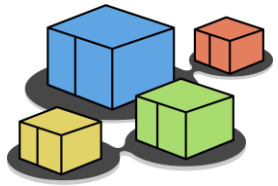

wireshark

Capturing from eth1

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

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

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1	0.000000000	200.1.1.7	195.11.14.5	UDP	74	39056 → 33434 Len=32
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12	5.001085466	100.0.0.9	200.1.1.7	ICMP	102	Time-to-live exceeded (Time to live exceeded in transit)
13	5.055108606	00:00:00_00:00:c1	00:00:00_00:00:02	ARP	60	Who has 200.1.1.7? Tell 200.1.1.1
14	5.055217517	00:00:00_00:00:02	00:00:00_00:00:c1	ARP	60	Who has 200.1.1.1? Tell 200.1.1.7
15	5.055307541	00:00:00_00:00:c1	00:00:00_00:00:02	ARP	60	200.1.1.1 is at 00:00:00:00:00:c1
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17	6.000124534	200.1.1.7	195.11.14.5	UDP	74	42119 → 33440 Len=32
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```
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▸ 000. .... = Flags: 0x0
...0 0000 0000 0000 = Fragment Offset: 0
Time to Live: 62
Protocol: ICMP (1)
Header Checksum: 0x4d75 [validation disabled]
[Header checksum status: Unverified]
Source Address: 195.11.14.5
```

```
0000  00 00 00 00
0010  00 58 94 57
0020  01 07 03 03
0030  00 00 01 11
0040  82 a0 00 28
0050  4a 4b 4c 4d
0060  5a 5b 5c 5d
```

arp unicast queries are issued during the dialogue

Time to Live (ip.ttl), 1 byte(s)

Packets: 22 · Displayed: 22 (100.0%)

Profile: Default

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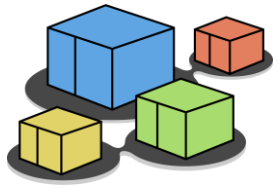

proposed exercises

- 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?

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