Kathará

kathara lab

basic IPv4 configuration, ping, traceroute and arp

Version	1.1
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Web	http://www.kathara.org/
Description	basic IPv4 configuration commands, usage of ping and traceroute, arp behaviour

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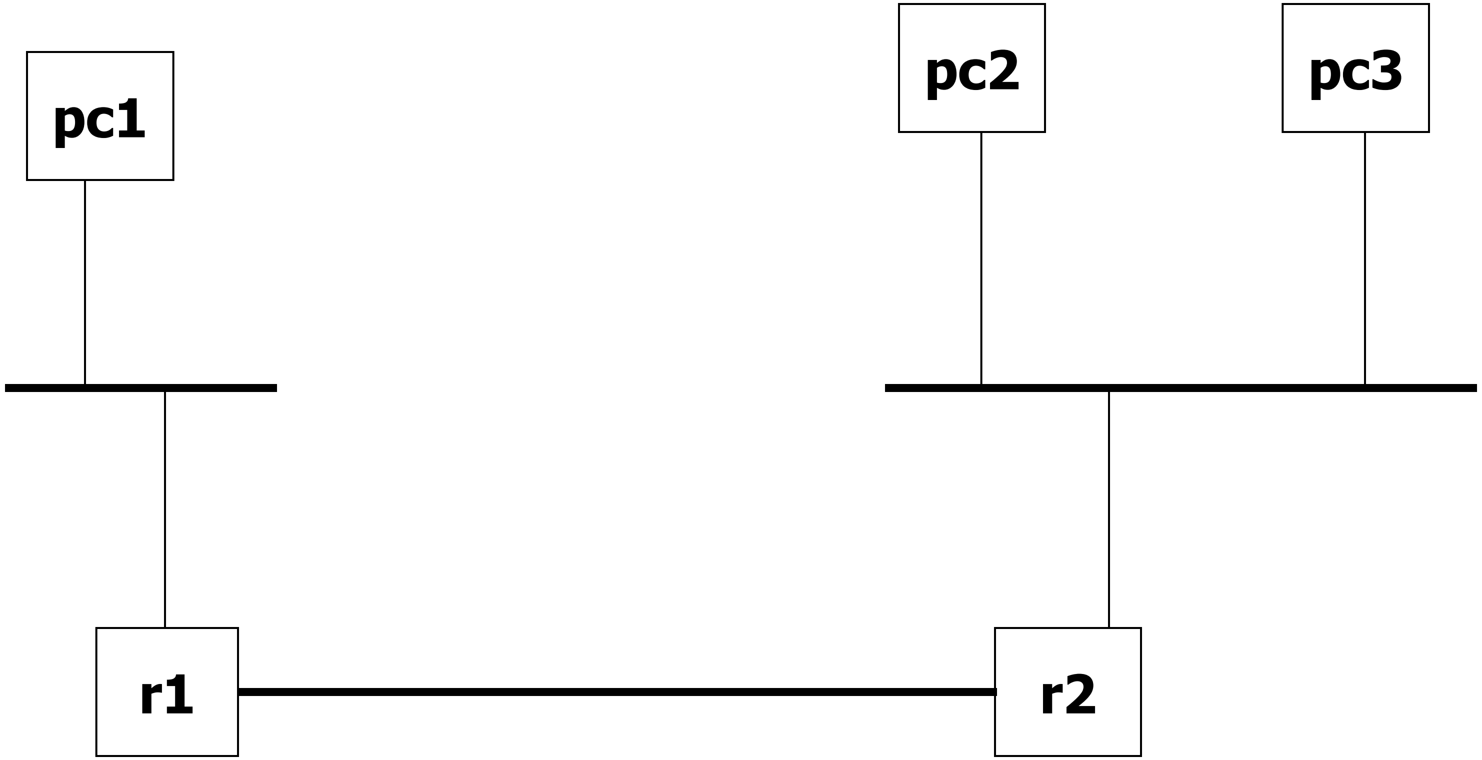
content of the lab

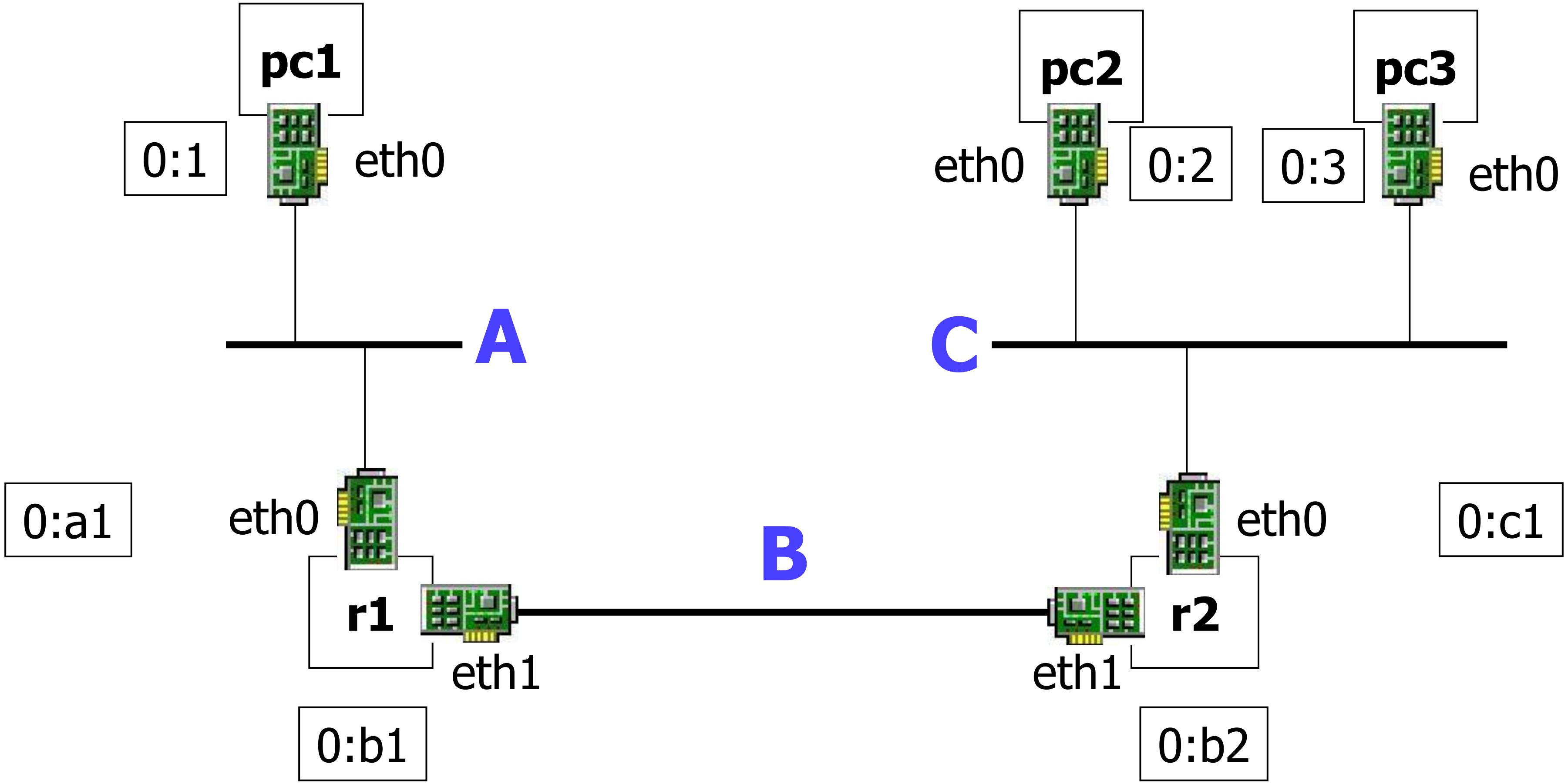
- there are two routers, called r1 and r2, and three hosts, called pc1, pc2, and pc3
  - they are connected via three LANs
  - we force their MAC addresses to be easily readable
- we will learn how to:
  - assign an IPv4 address and a netmask to the interface of a host
  - assign a default gateway to 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

lab configuration

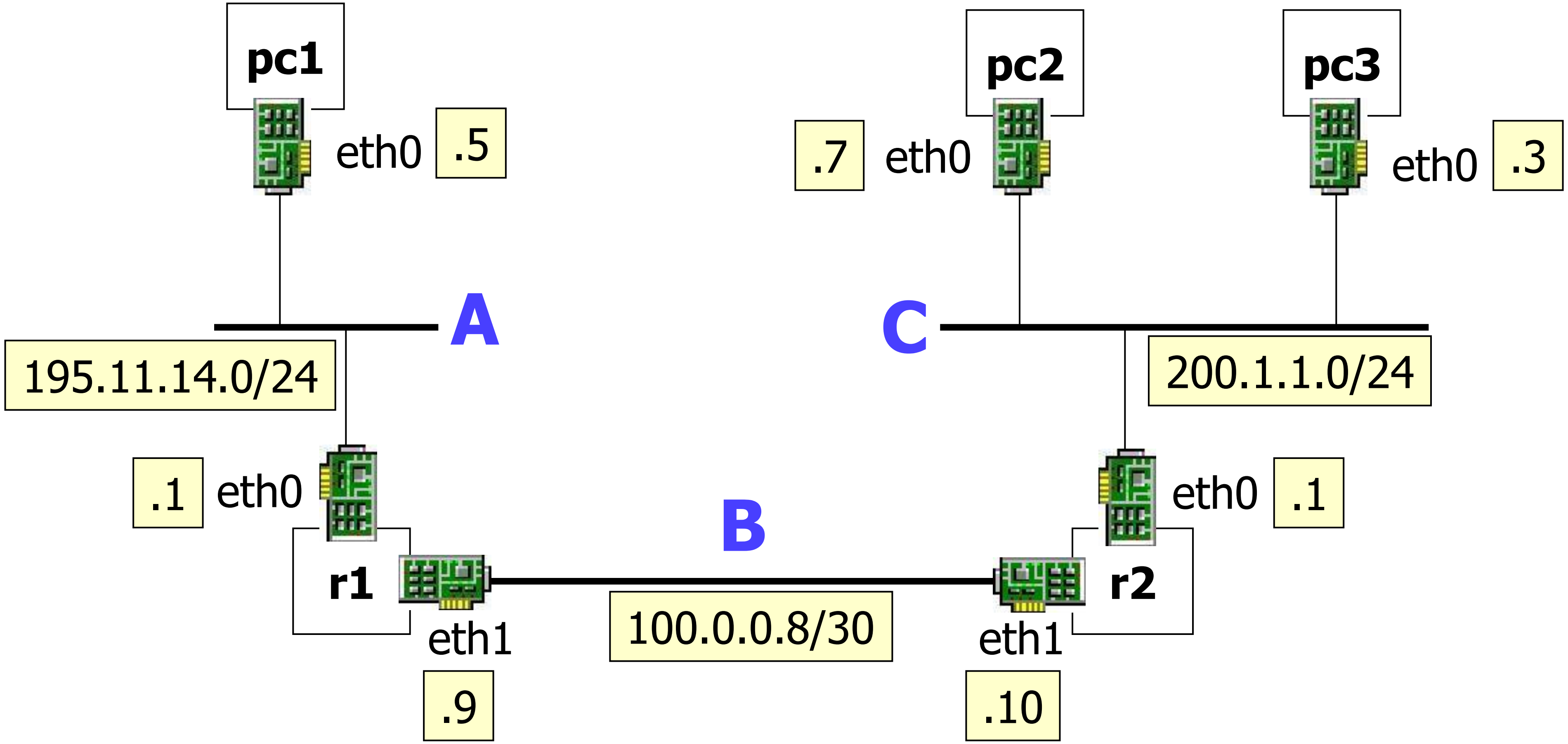
network topology – high level view



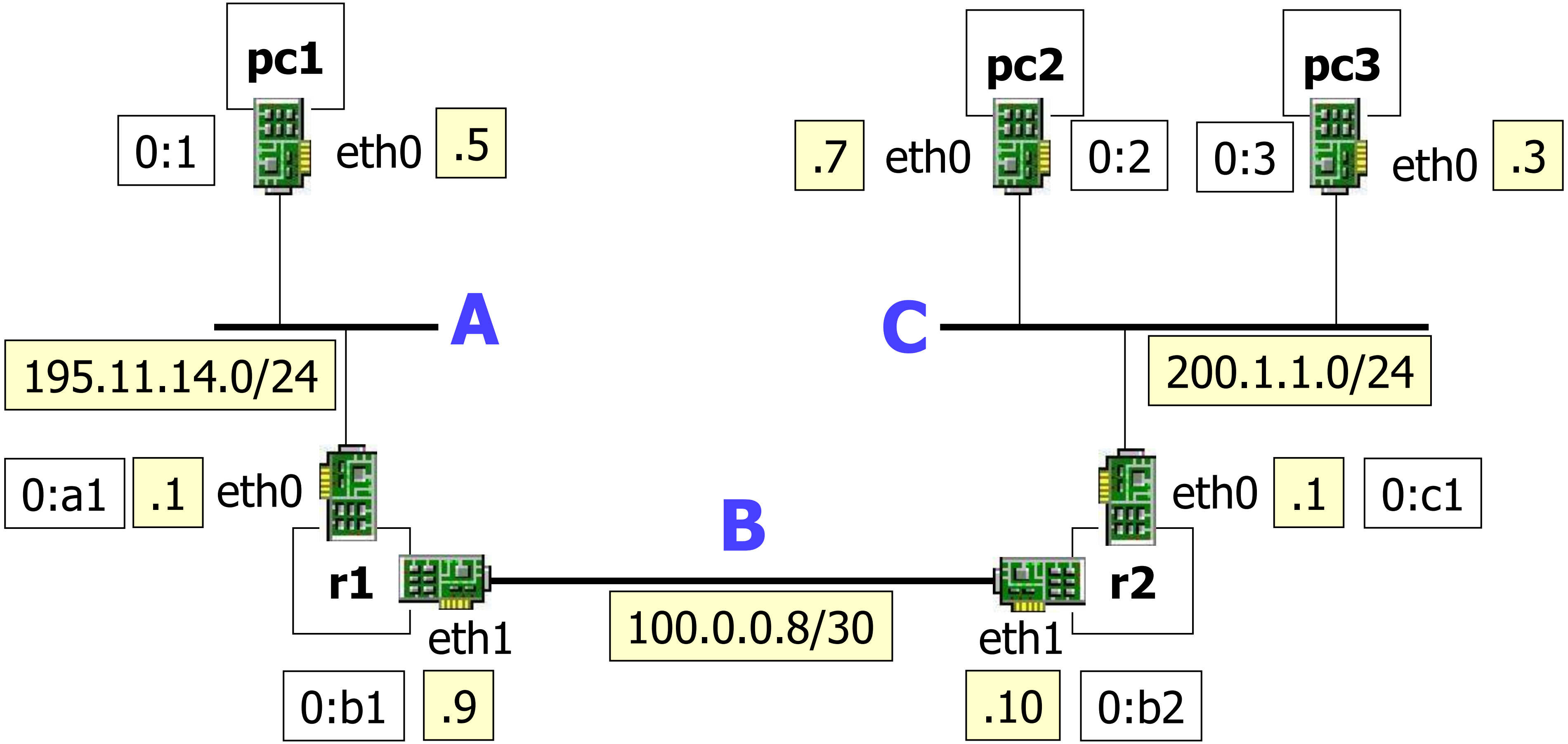
network topology – MAC addresses



network topology – IPv4 address plan



network topology – complete overview



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]="false"

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

pc1[0]="A/00:00:00:00:00:01"
pc1[image]="kathara/base"
pc1[ipv6]="false"
```

lab.conf

```
pc2[0]="C/00:00:00:00:00:02"
pc2[image]="kathara/base"
pc2[ipv6]="false"

pc3[0]="C/00:00:00:00:00:03"
pc3[image]="kathara/base"
pc3[ipv6]="false"

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

```
ip address add 195.11.14.5/24 dev eth0
ip route add default via 195.11.14.1
```

pc2.startup

```
ip address add 200.1.1.7/24 dev eth0
ip route add default via 200.1.1.1 dev eth0
```

pc3.startup

```
ip address add 200.1.1.3/24 dev eth0
ip route add default via 200.1.1.1 dev eth0
```

a quick look at the lab

an IPv4 address is assigned to the eth0 interfaces of hosts

pc1.startup

```
ip address add 195.11.14.5/24 dev eth0
ip route add default via 195.11.14.1
```

pc2.startup

```
ip address add 200.1.1.7/24 dev eth0
ip route add default via 200.1.1.1 dev eth0
```

pc3.startup

```
ip address add 200.1.1.3/24 dev eth0
ip route add default via 200.1.1.1 dev eth0
```

a quick look at the lab

an IPv4 address is assigned to the eth0 interfaces of hosts

a default gateway is set for all hosts

pc1.startup

```
ip address add 195.11.14.5/24 dev eth0
ip route add default via 195.11.14.1
```

pc2.startup

```
ip address add 200.1.1.7/24 dev eth0
ip route add default via 200.1.1.1 dev eth0
```

pc3.startup

```
ip address add 200.1.1.3/24 dev eth0
ip route add default via 200.1.1.1 dev eth0
```

a quick look at the lab

r1.startup

```
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
```

a quick look at the lab

r1.startup

```
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*

a quick look at the lab

r1.startup

```
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*

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

a quick look at the lab

r1.startup

```
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

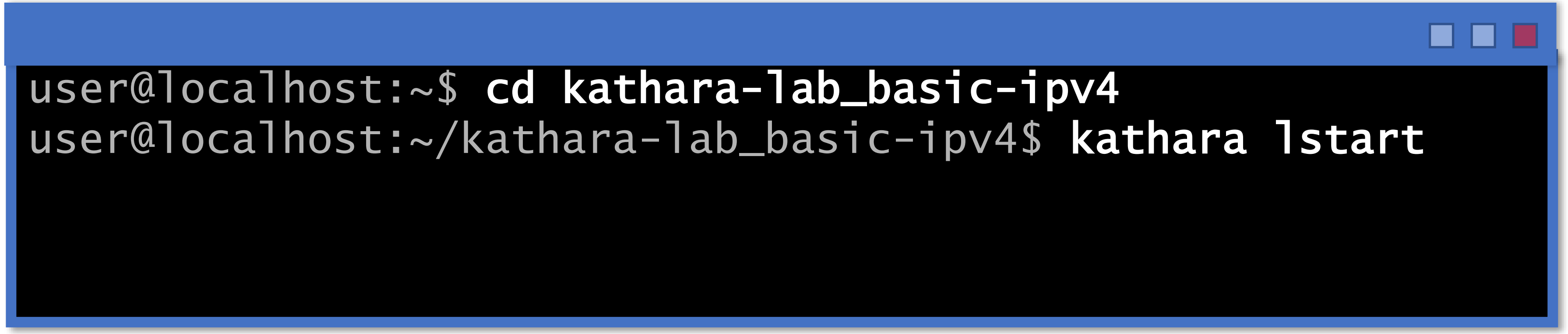
consequently, the corresponding LANs are considered *directly connected*

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

similar configuration for router r2

start the lab

- start the lab



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

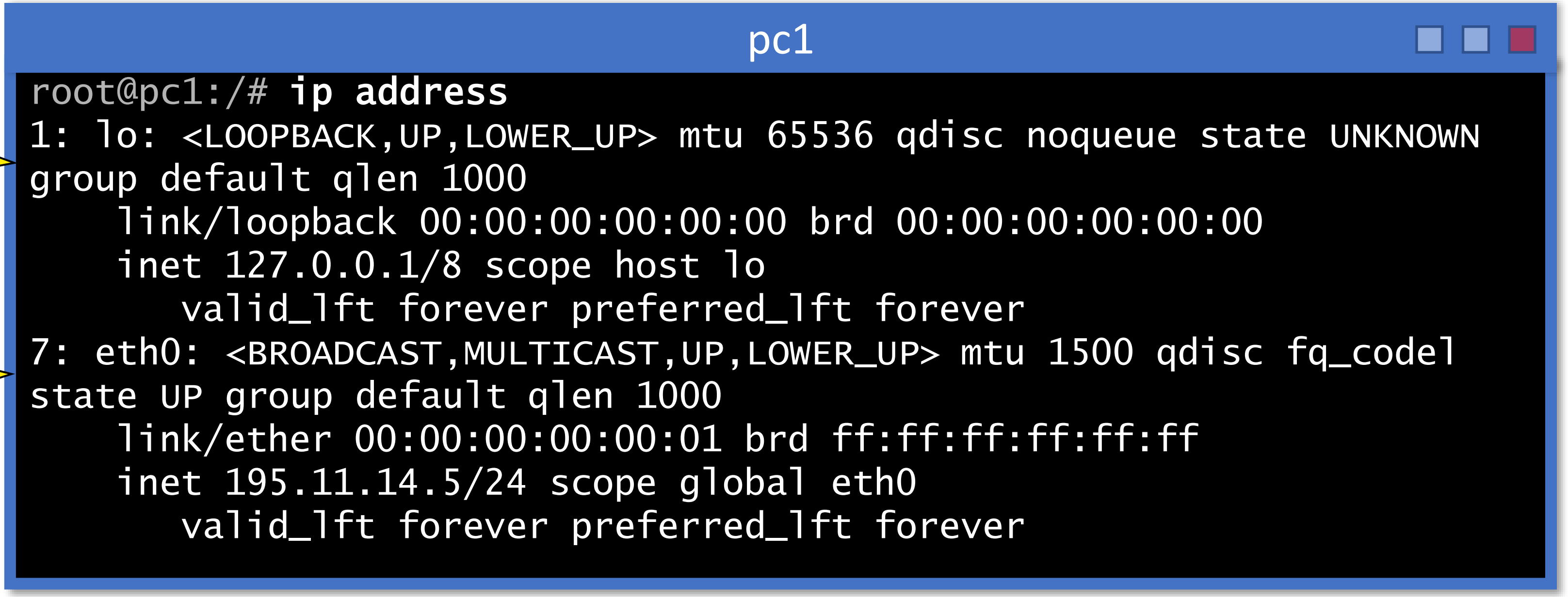
useful commands

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

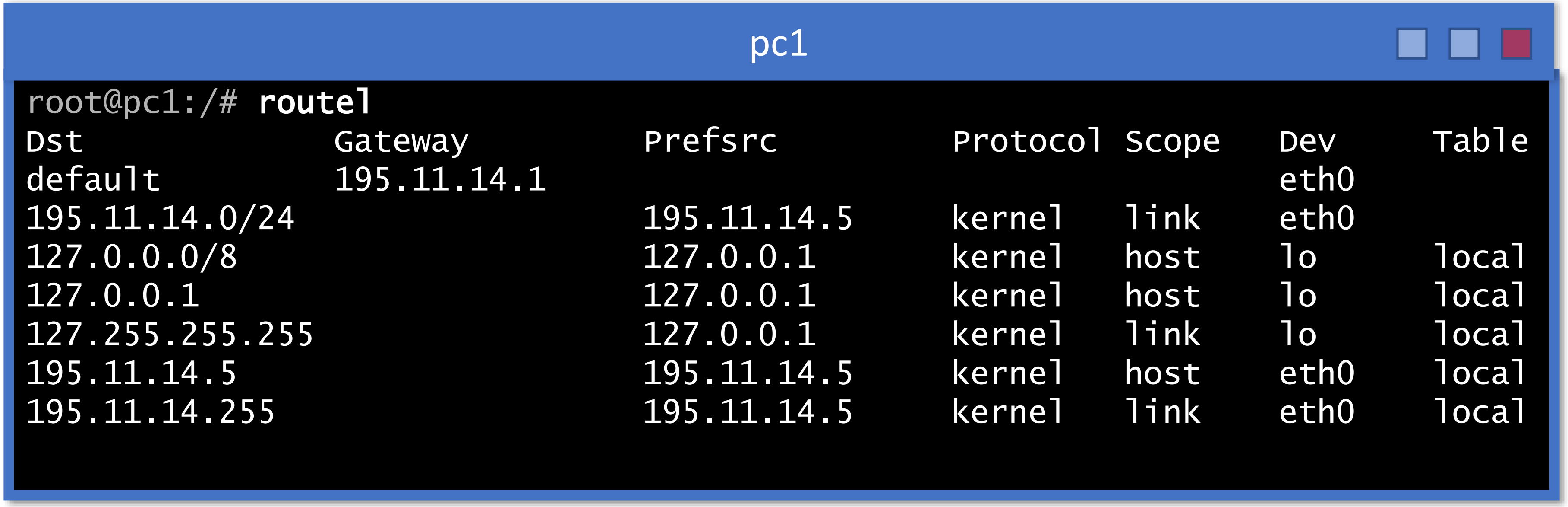
eth0
195.11.14.5/24



```
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
```

check the default route

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



```
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
```

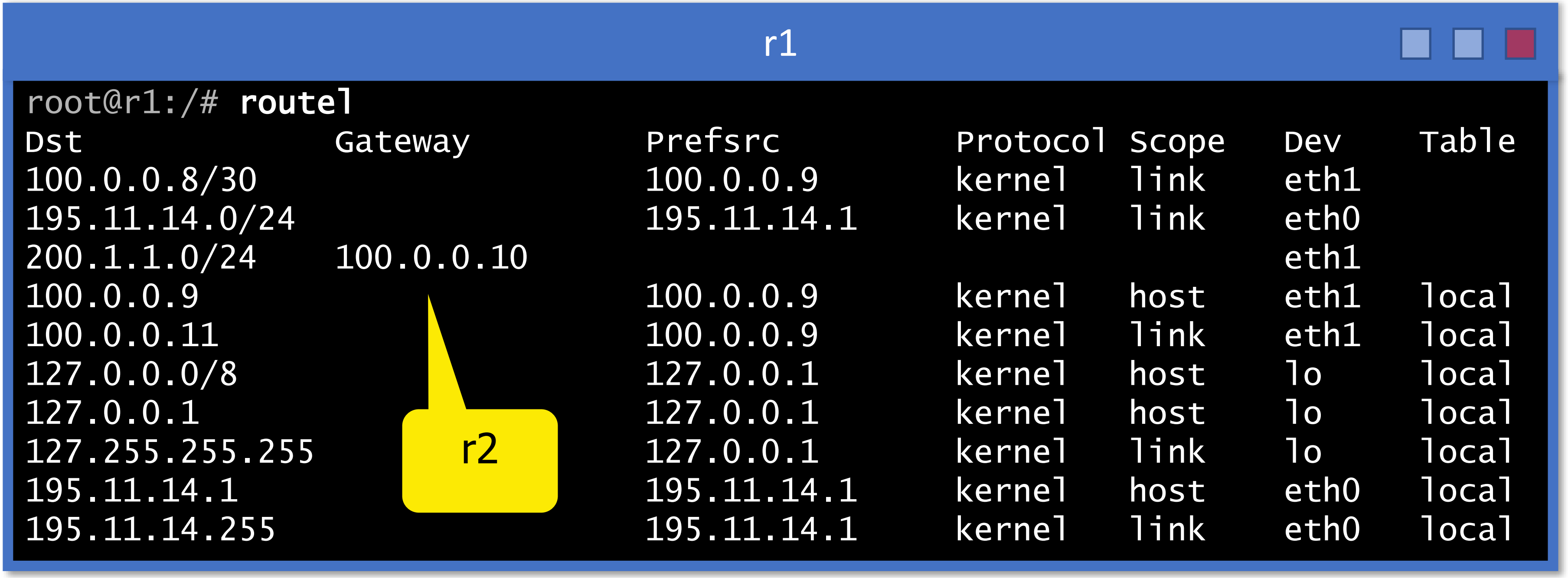
default route by r1

loopback prefix

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

check the router routing tables

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



```
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
```

Lan B

Lan A

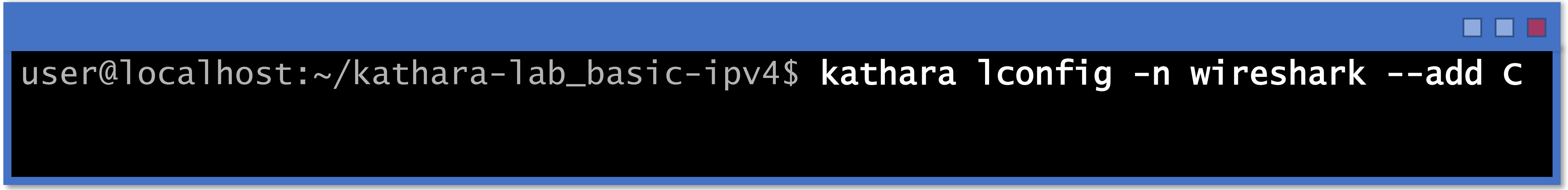
Lan C

r2

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

sniff the traffic

- connect the wireshark device to collision domain C



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

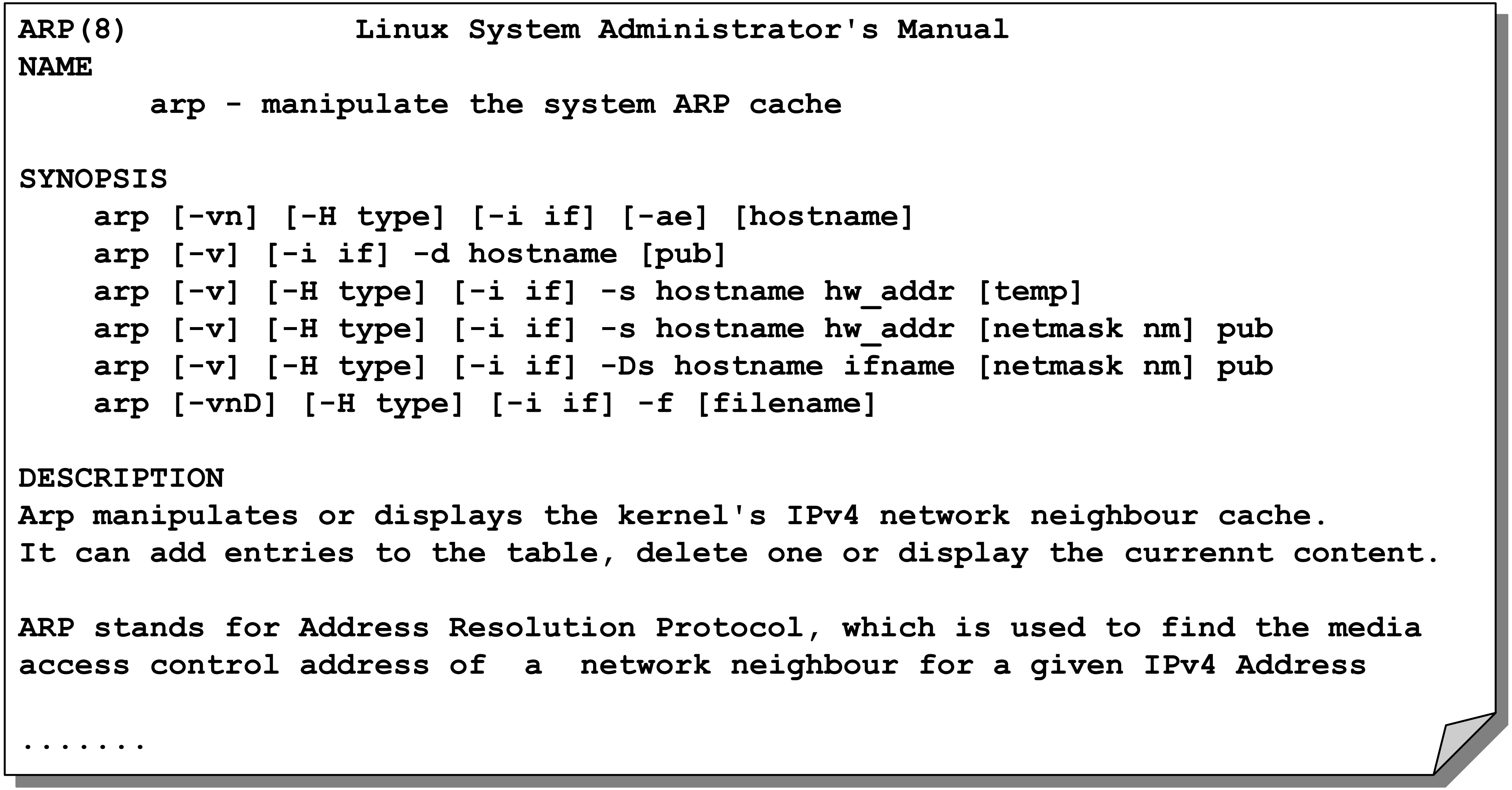
- open any browser on the host machine
  - on **localhost:3000**
  - sniff eth1

ping from pc3 to pc2 and related arp behavior

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

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]

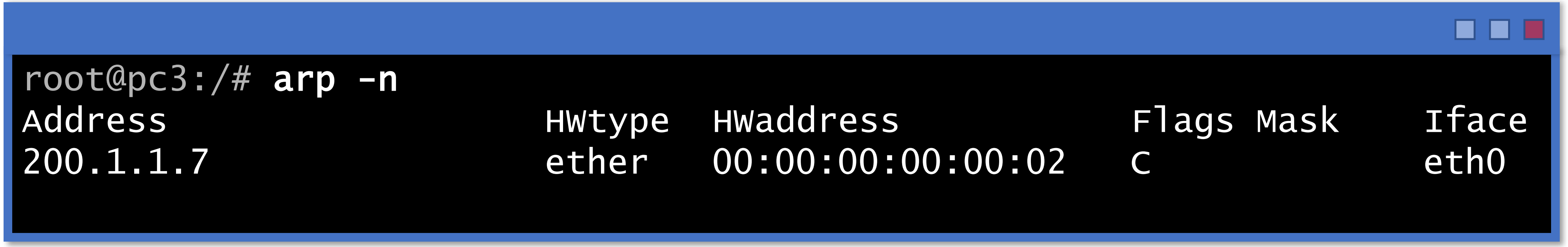
DESCRIPTION
Arp manipulates or displays the kernel's IPv4 network neighbour cache.
It can add entries to the table, delete one or display the currennt content.

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


.......
```

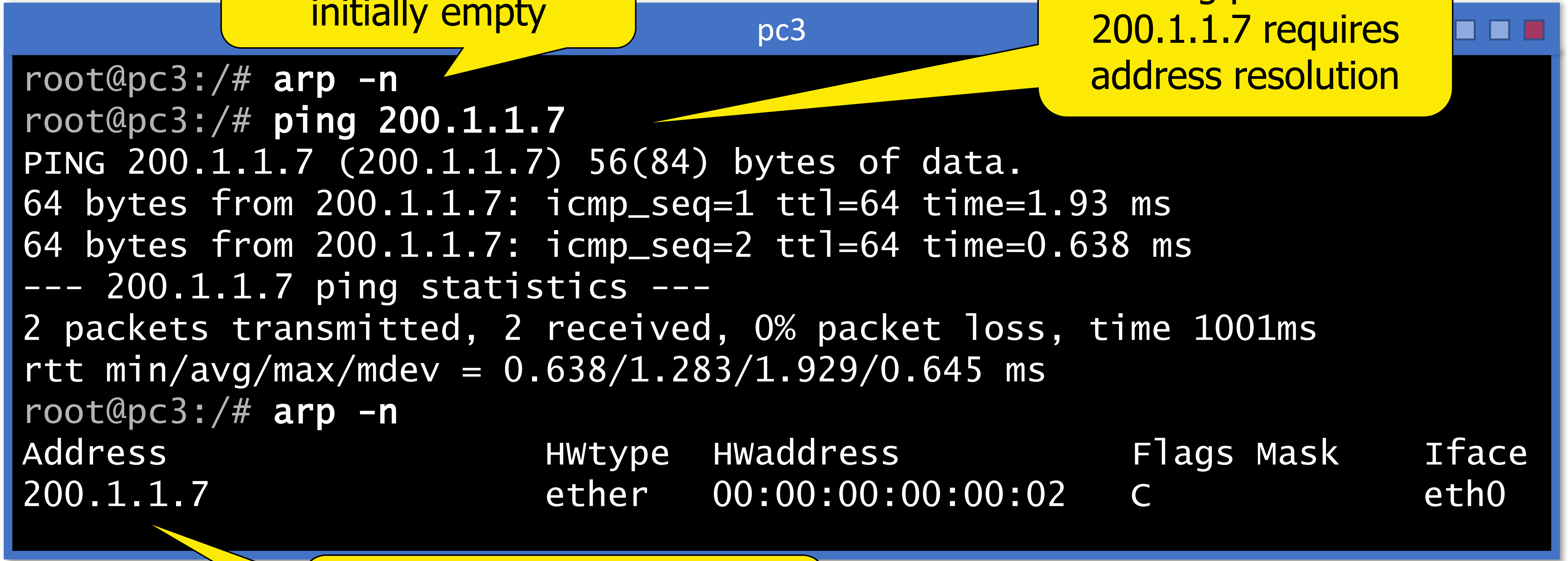
inspecting the arp cache

- arp is the command to inspect the arp cache
- the –n parameter tells arp to not resolve the IP addresses with DNS names



```
root@pc3:/# arp -n
Address                  HWtype  HWaddress           Flags Mask      Iface
200.1.1.7                ether   00:00:00:00:00:02   C               eth0
```

inspecting the arp cache



```
root@pc3:/# arp -n
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 -n
Address                  HWtype  HWaddress           Flags Mask     Iface
200.1.1.7                ether   00:00:00:00:00:02   C              eth0
```

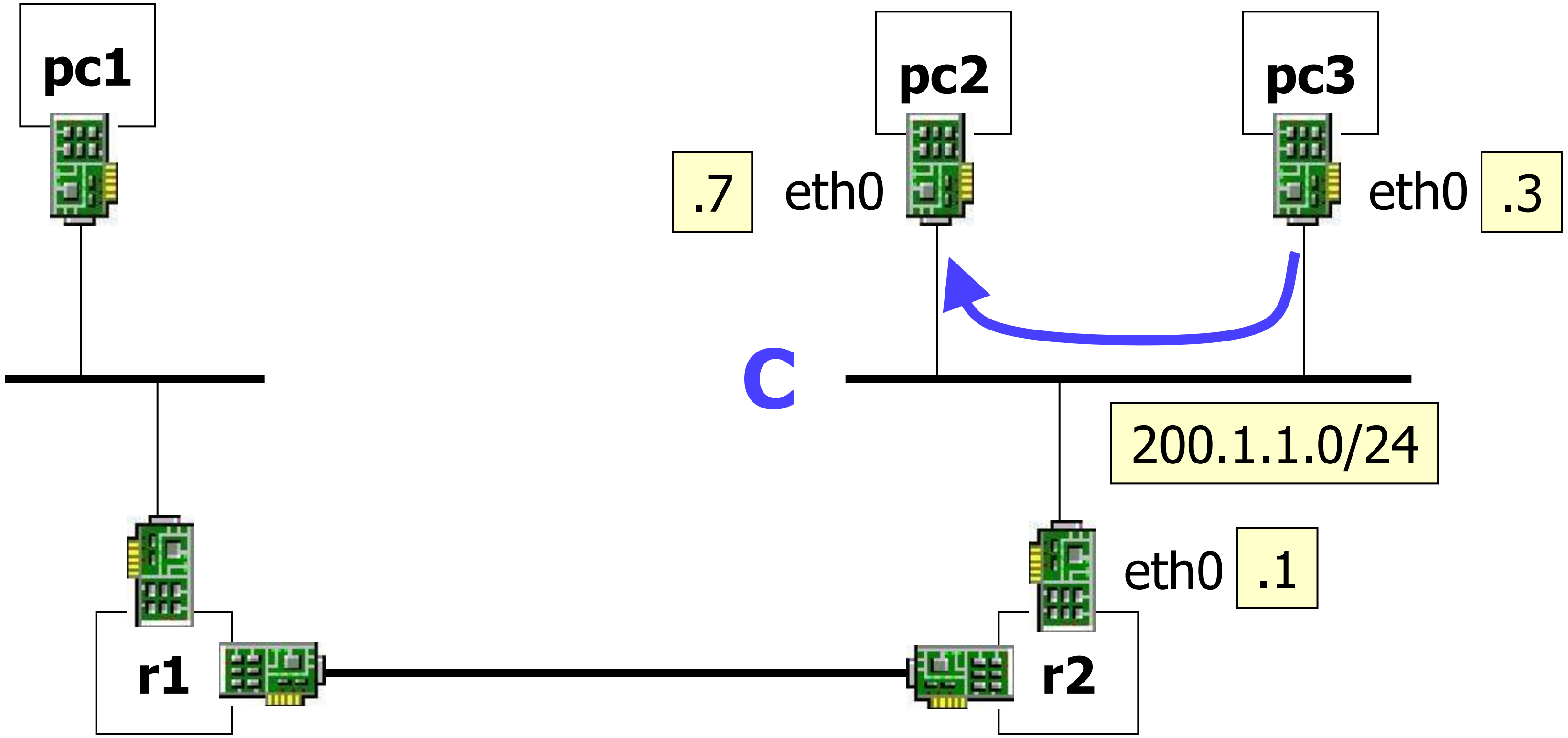
the arp cache is initially empty

sending packets to 200.1.1.7 requires address resolution

address resolution results are stored in the arp cache

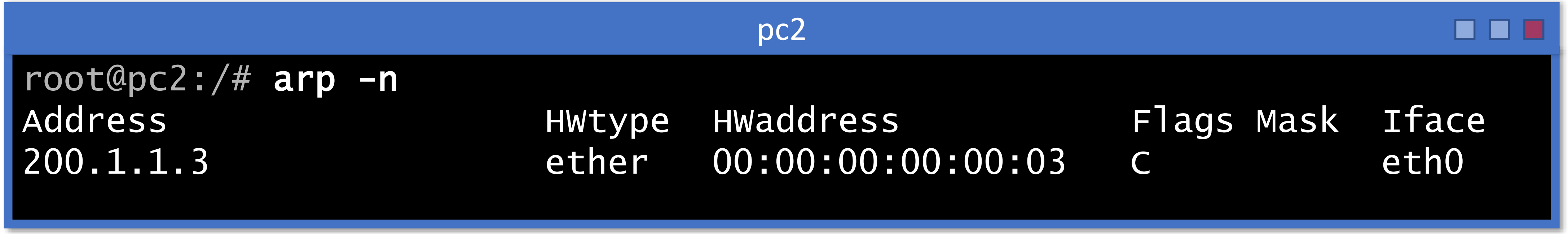
inspecting the arp cache

- traffic within the same network does not traverse routers



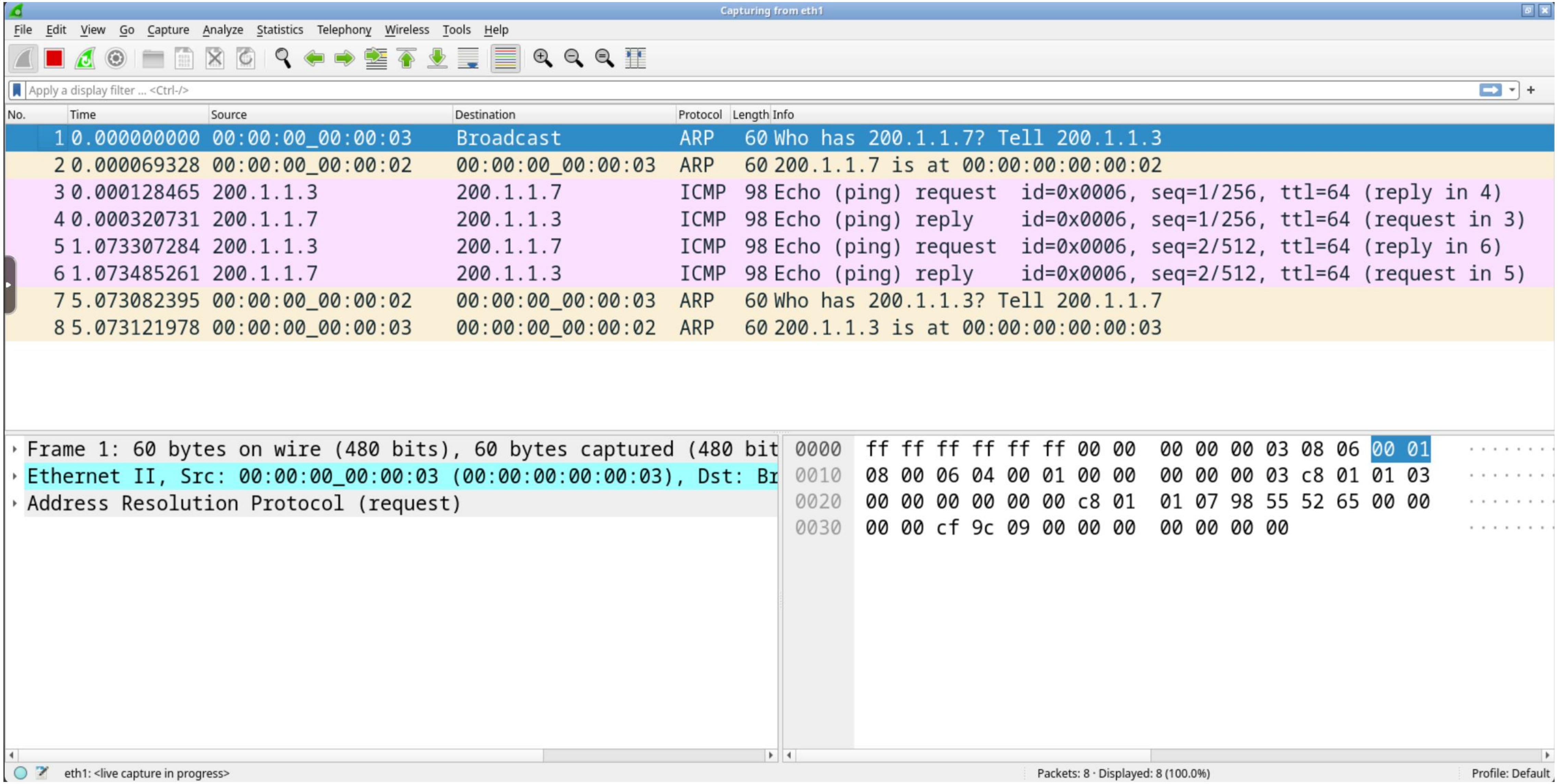
inspecting the arp cache

- 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)



```
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
```

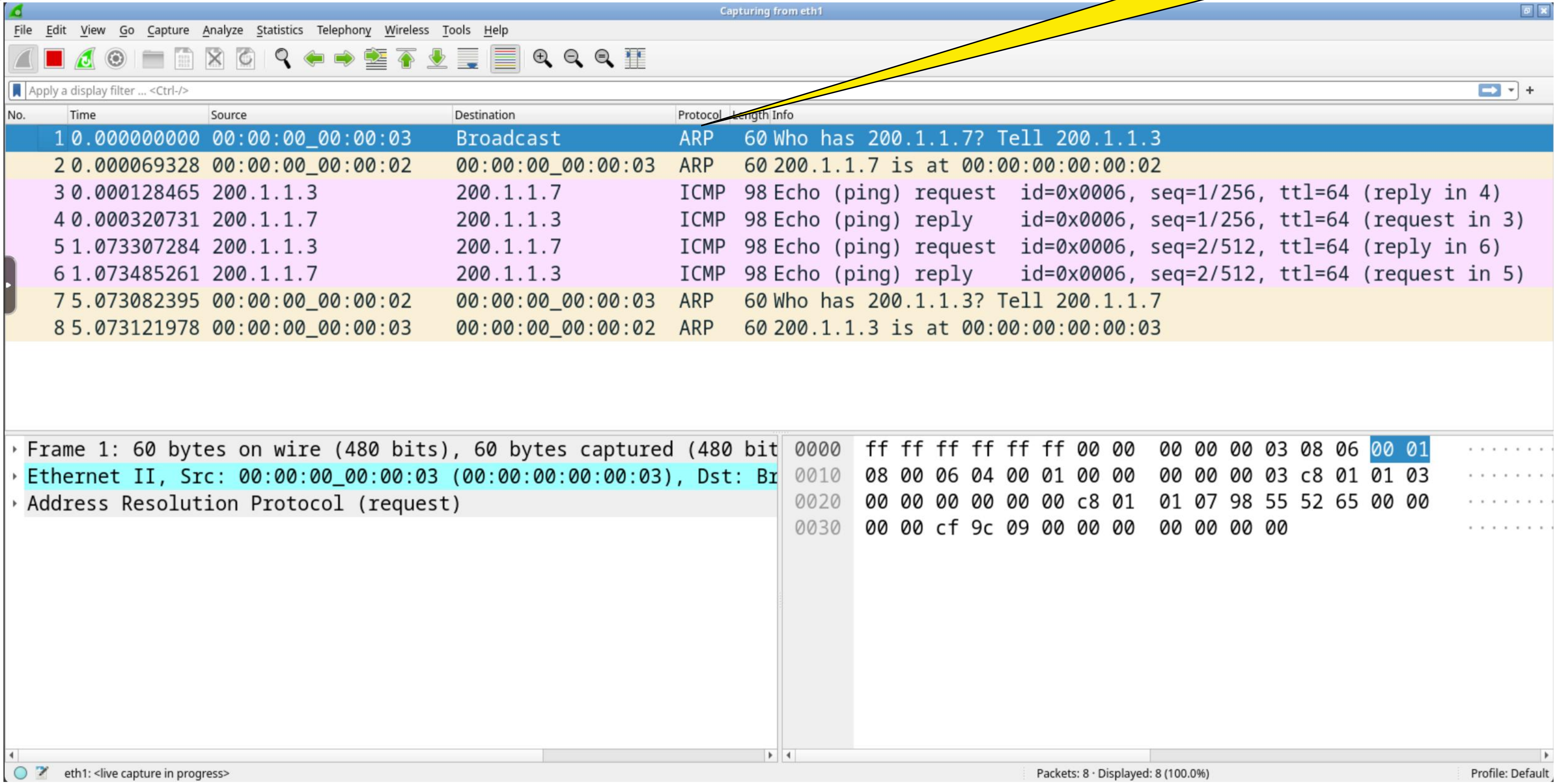
```
› Frame 1: 60 bytes on wire (480 bits), 60 bytes captured (480 bit
› Ethernet II, Src: 00:00:00_00:00:03 (00:00:00:00:00:03), Dst: Br
› Address Resolution Protocol (request)
```

```
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   ........
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

wireshark

arp request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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)
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  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
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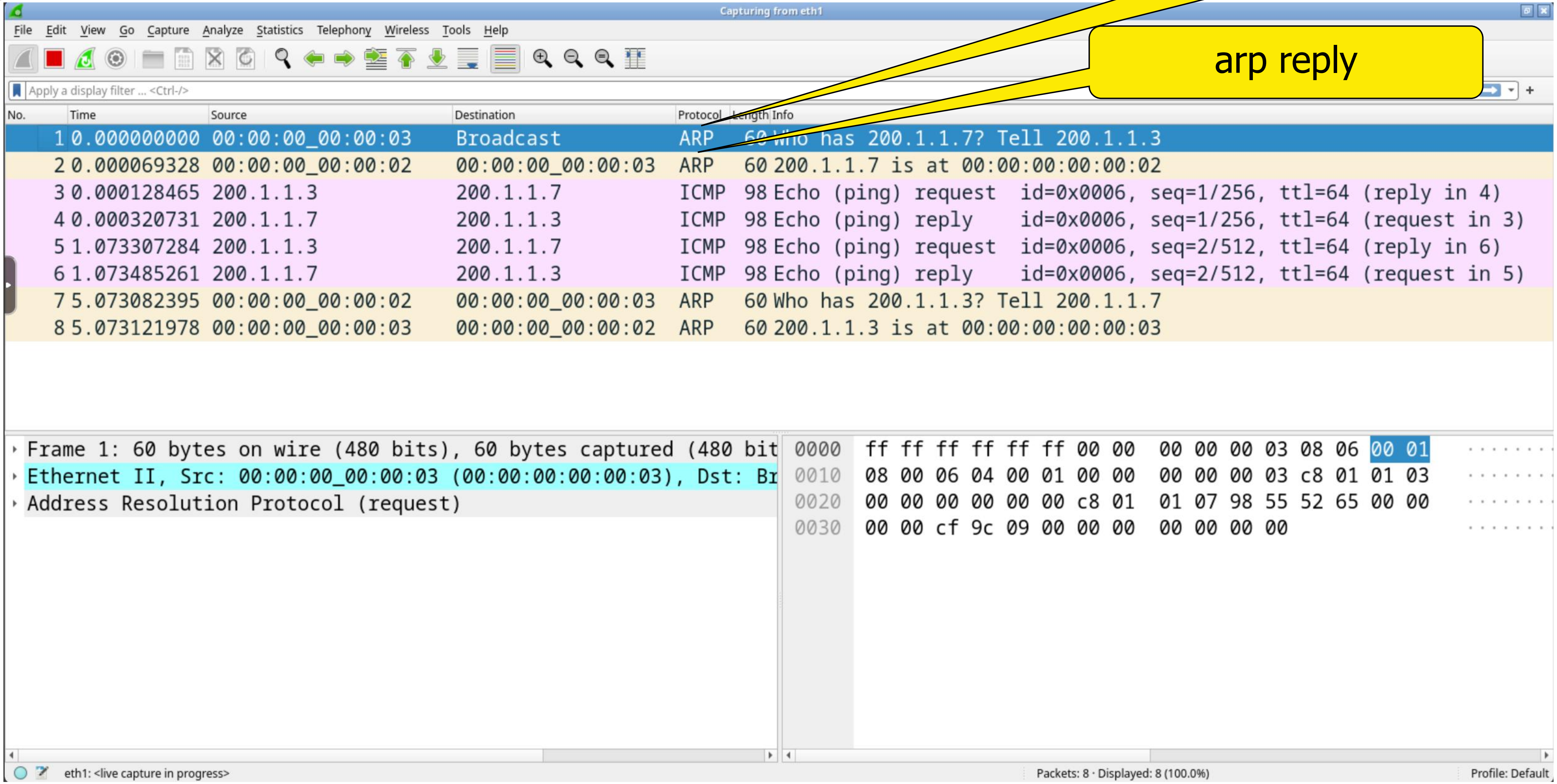
```

```
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   ........
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
```

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
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```
› Frame 1: 60 bytes on wire (480 bits), 60 bytes captured (480 bit
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› Address Resolution Protocol (request)
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```
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   ........
0030  00 00 cf 9c 09 00 00 00  00 00 00 00              ........
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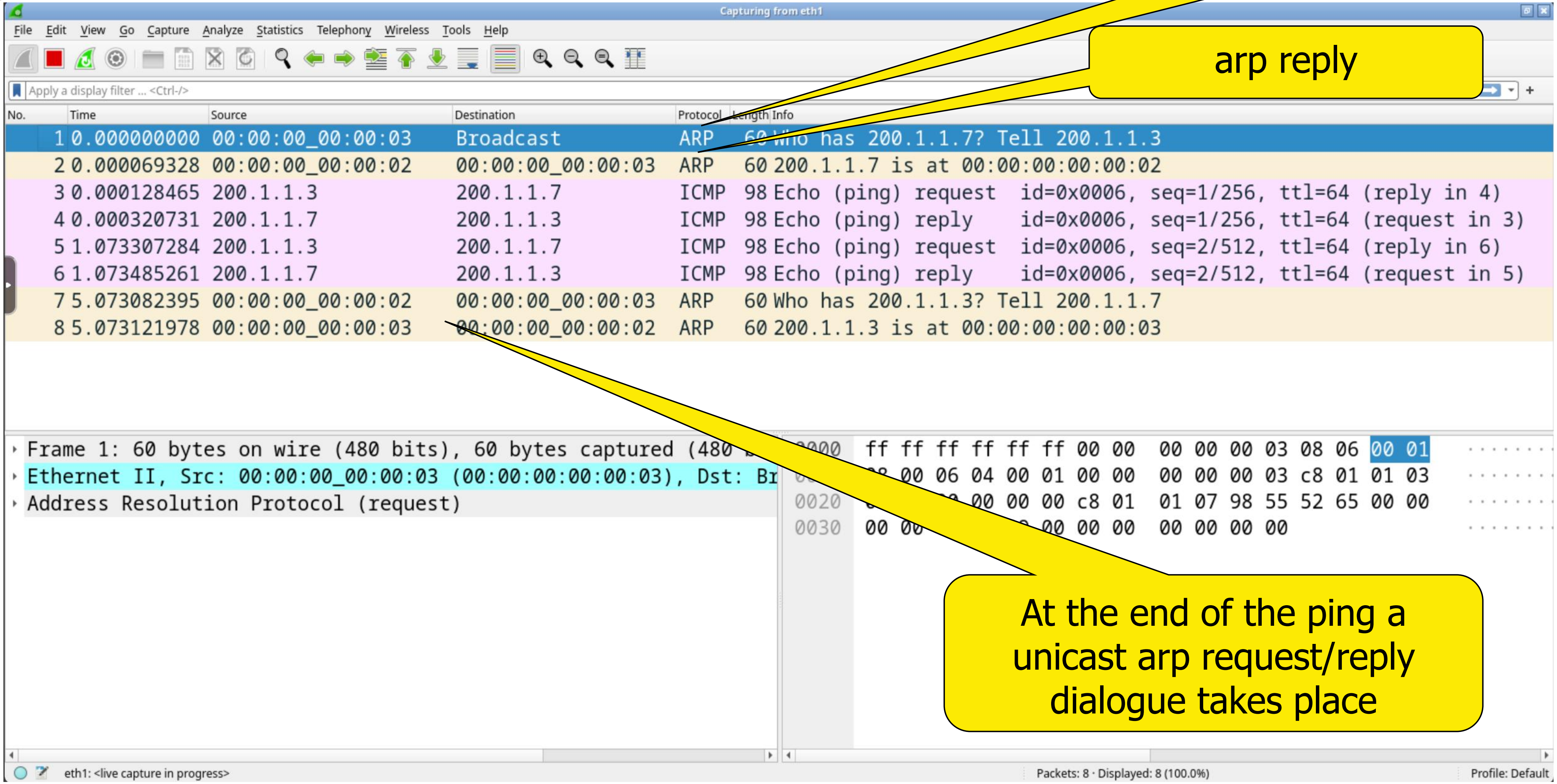
wireshark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```
No. Time        Source               Destination          Protocol Length Info
  1 0.000000000 00:00:00_00:00:03    Broadcast            ARP      60 Who has 200.1.1.7? Tell 200.1.1.3
  2 0.000069328 00:00:00_00:00:02    00:00:00_00:00:03    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)
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```

```
› Frame 1: 60 bytes on wire (480 bits), 60 bytes captured (480 b
› 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   ........
      08 00 06 04 00 01 00 00  00 00 00 03 c8 01 01 03   ........
0020                 00 00 00 c8 01  01 07 98 55 52 65 00 00   ........
0030  00 00                00 00 00  00 00 00 00             ........
```

arp request

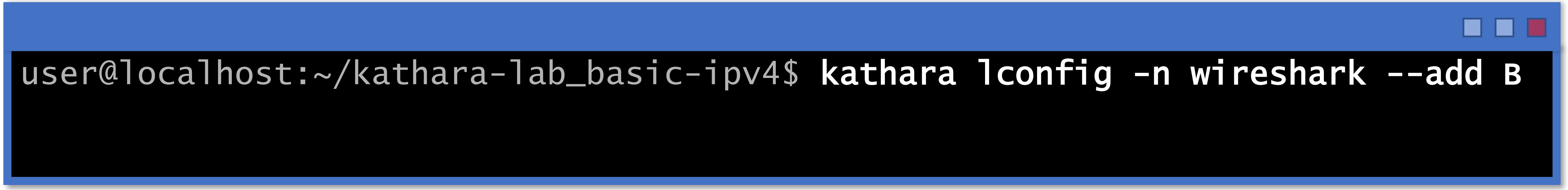
arp reply

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

ping from pc2 to pc1 and related arp behavior

sniff the traffic

- connect the wireshark device to collision domain B

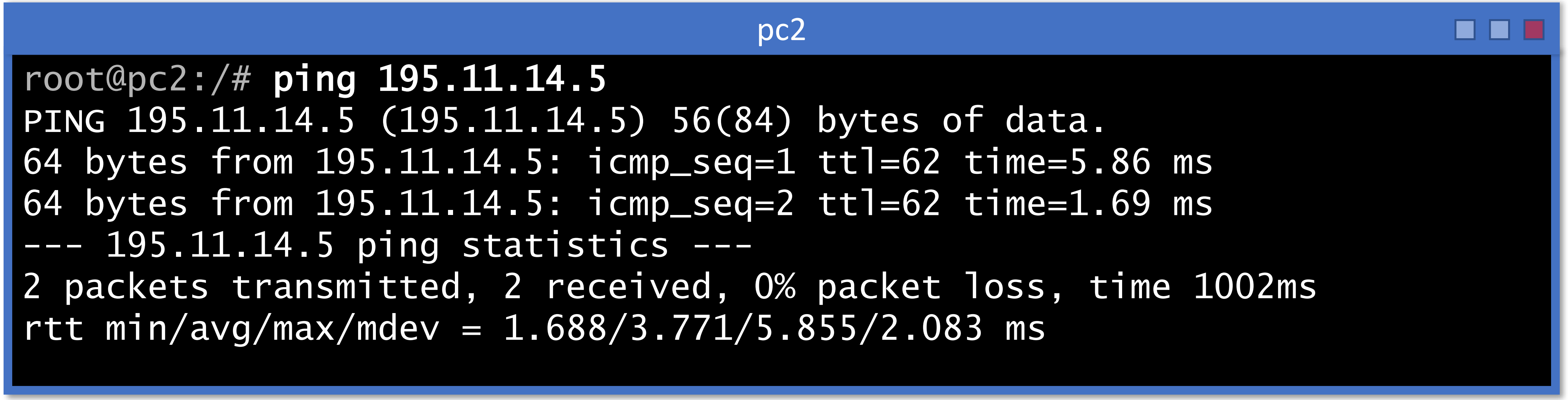


```
user@localhost:~/kathara-lab_basic-ipv4$ kathara lconfig -n wireshark --add B
```

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

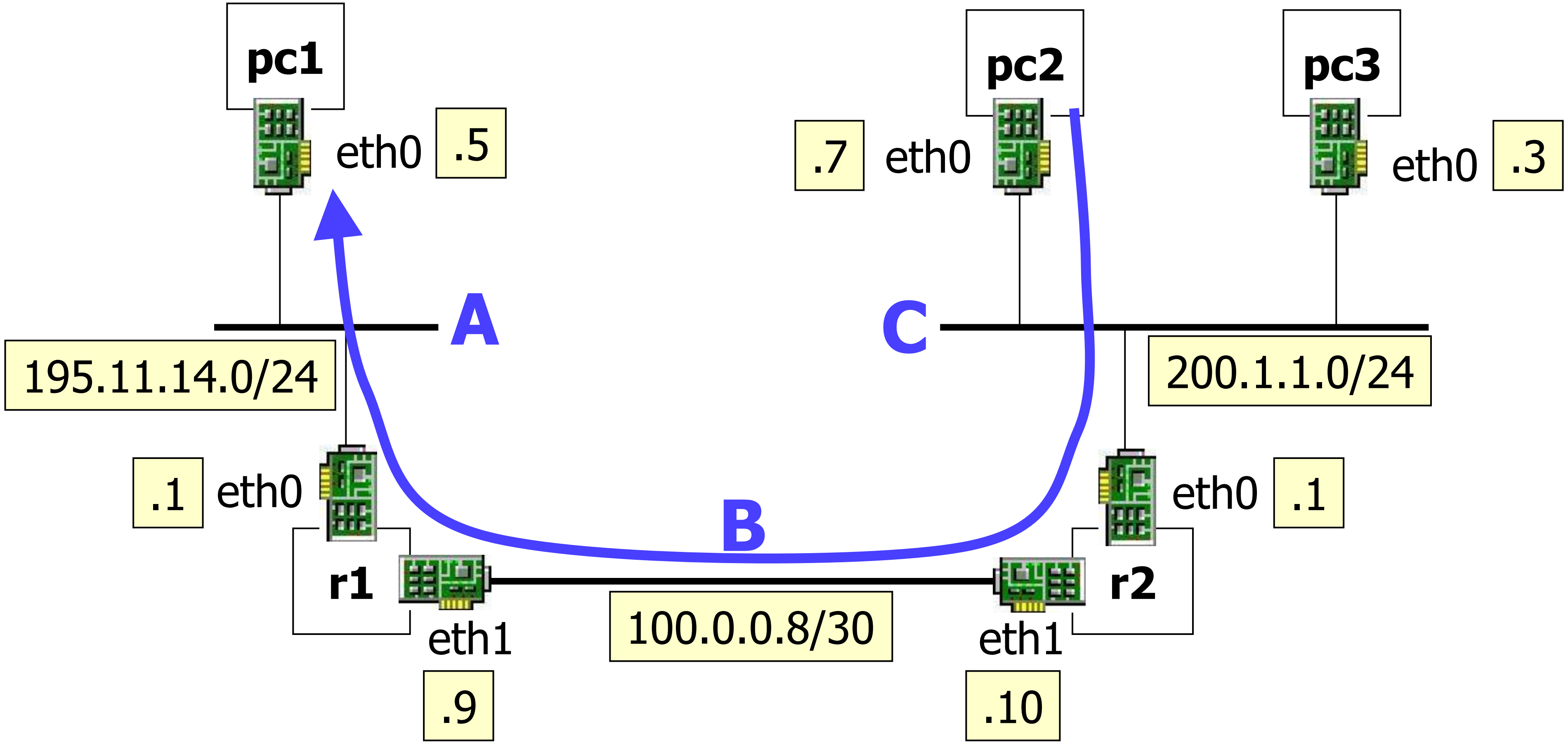
on pc2

- execute a ping command towards pc1



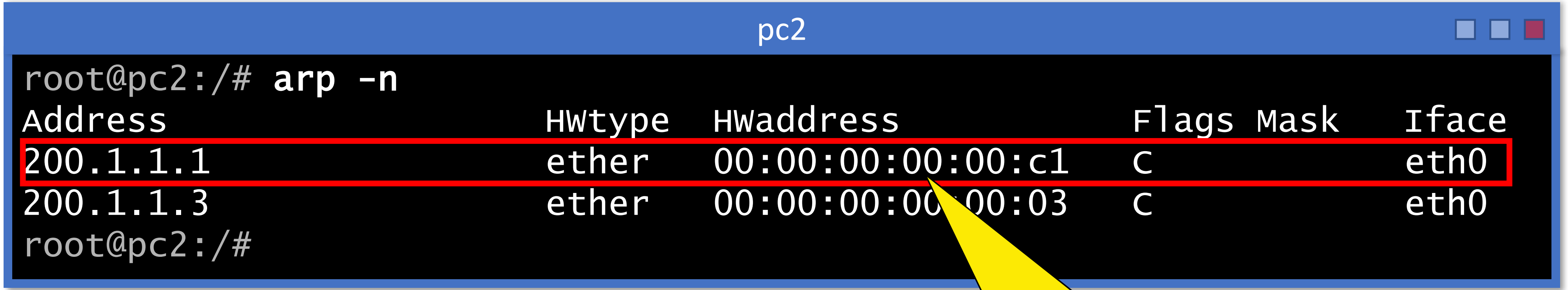
```
root@pc2:/# ping 195.11.14.5
PING 195.11.14.5 (195.11.14.5) 56(84) bytes of data.
64 bytes from 195.11.14.5: icmp_seq=1 ttl=62 time=5.86 ms
64 bytes from 195.11.14.5: icmp_seq=2 ttl=62 time=1.69 ms
--- 195.11.14.5 ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1002ms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

inspecting the arp cache (non local traffic)



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

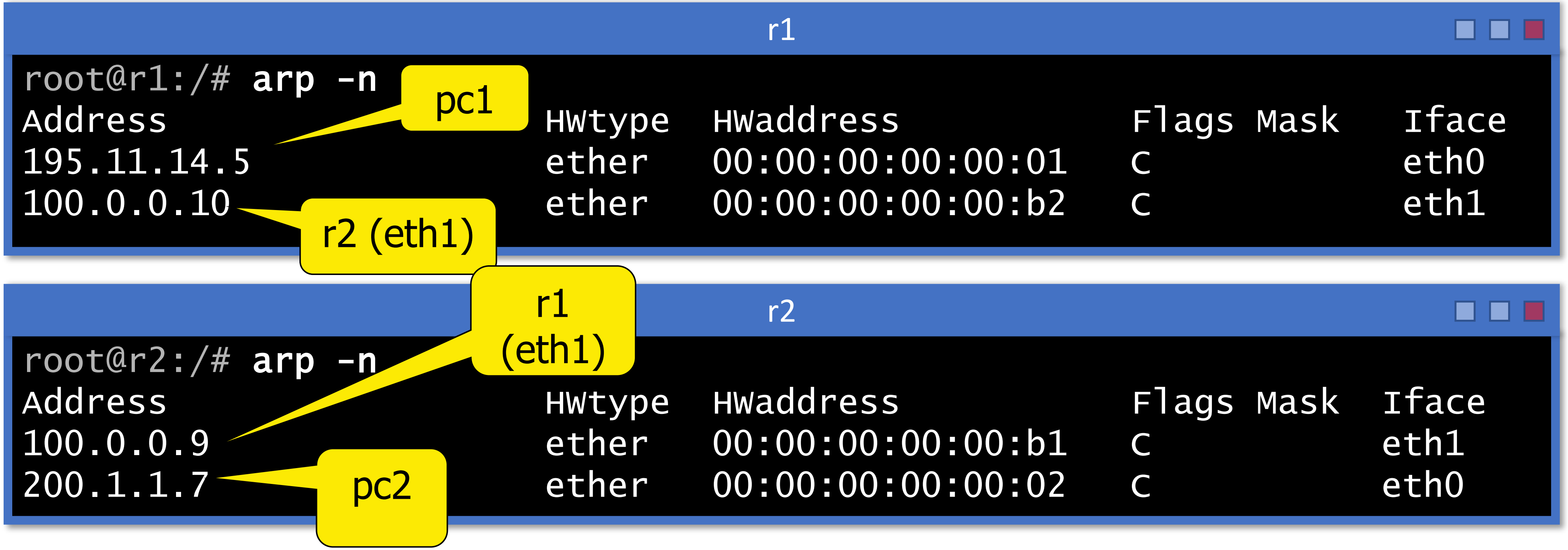


```
root@pc2:/# arp -n
Address                  HWtype  HWaddress           Flags Mask   Iface
200.1.1.1                ether   00:00:00:00:00:c1   C            eth0
200.1.1.3                ether   00:00:00:00:00:03   C            eth0
root@pc2:/#
```

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

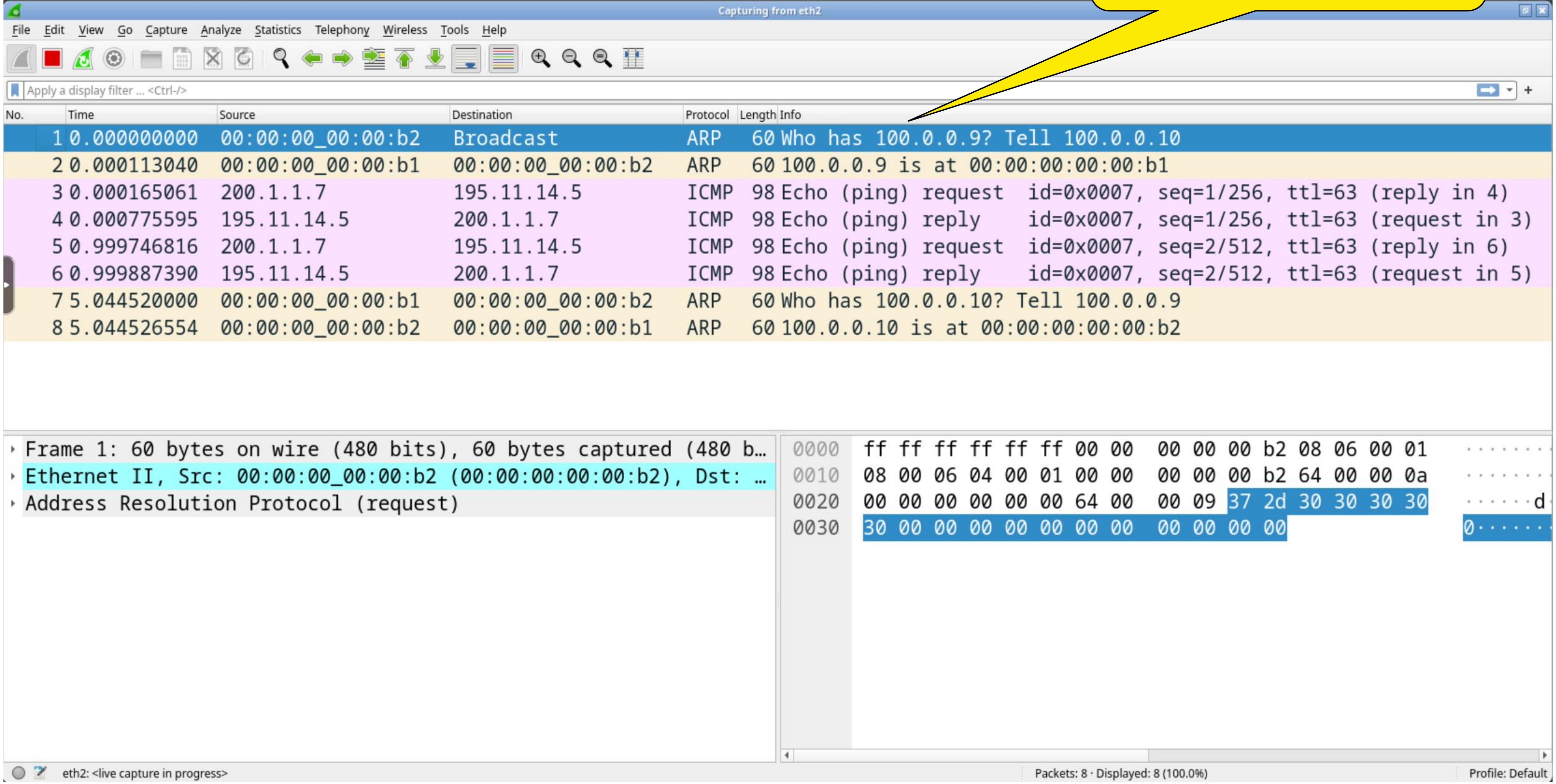


```
root@r1:/# arp -n
Address                  HWtype  HWaddress           Flags Mask    Iface
195.11.14.5              ether   00:00:00:00:00:01   C             eth0
100.0.0.10               ether   00:00:00:00:00:b2   C             eth1
```

```
root@r2:/# arp -n
Address                  HWtype  HWaddress           Flags Mask   Iface
100.0.0.9                ether   00:00:00:00:00:b1   C            eth1
200.1.1.7                ether   00:00:00:00:00:02   C            eth0
```

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-/>

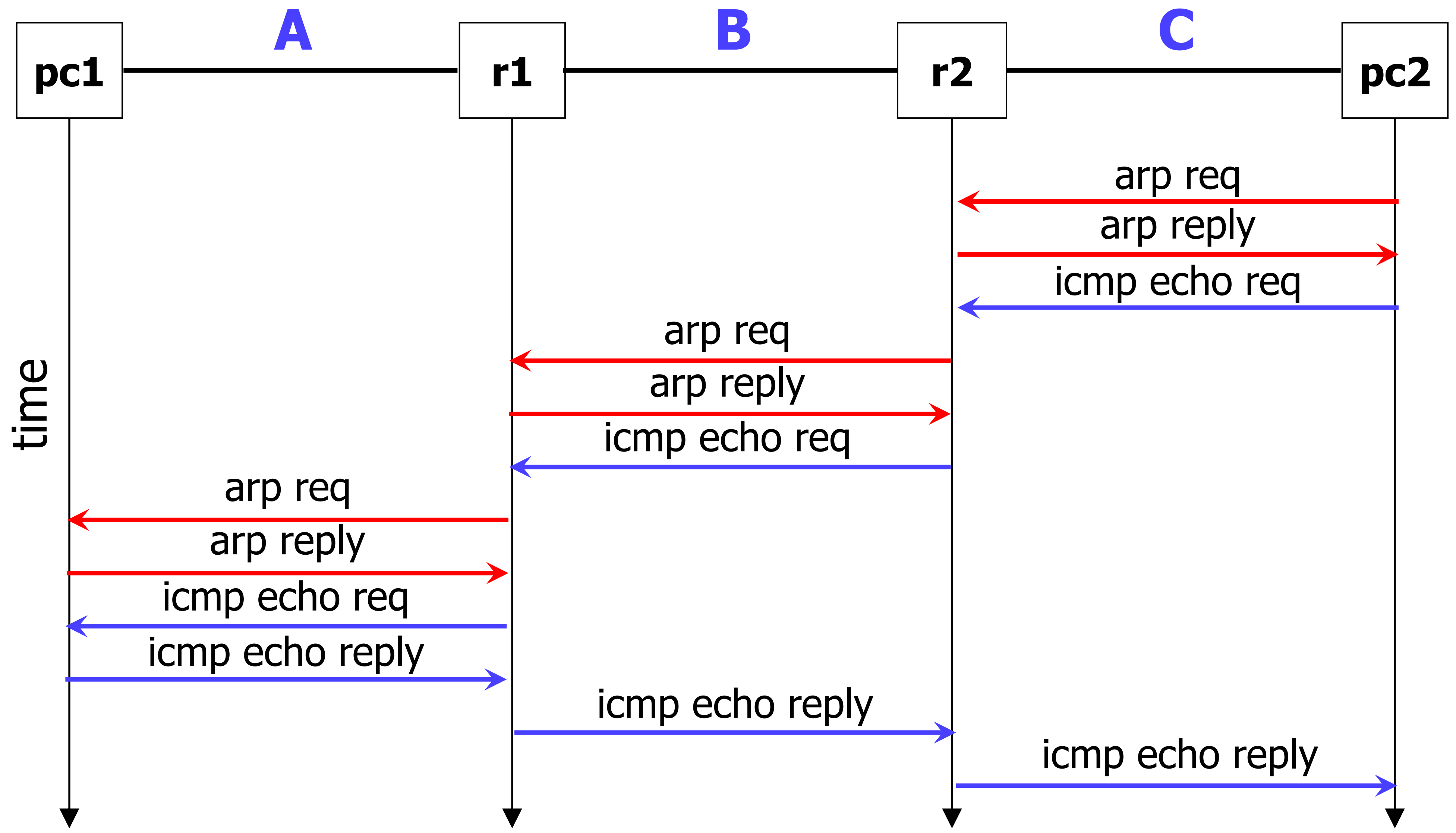
```
No. Time         Source              Destination         Protocol Length Info
  1 0.000000000  00:00:00_00:00:b2   Broadcast           ARP      60 Who has 100.0.0.9? Tell 100.0.0.10
  2 0.000113040  00:00:00_00:00:b1   00:00:00_00:00:b2   ARP      60 100.0.0.9 is at 00:00:00:00:00:b1
  3 0.000165061  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   ········
0020  00 00 00 00 00 00 64 00  00 09 37 2d 30 30 30 30   ······d·
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

ping: understanding the whole picture



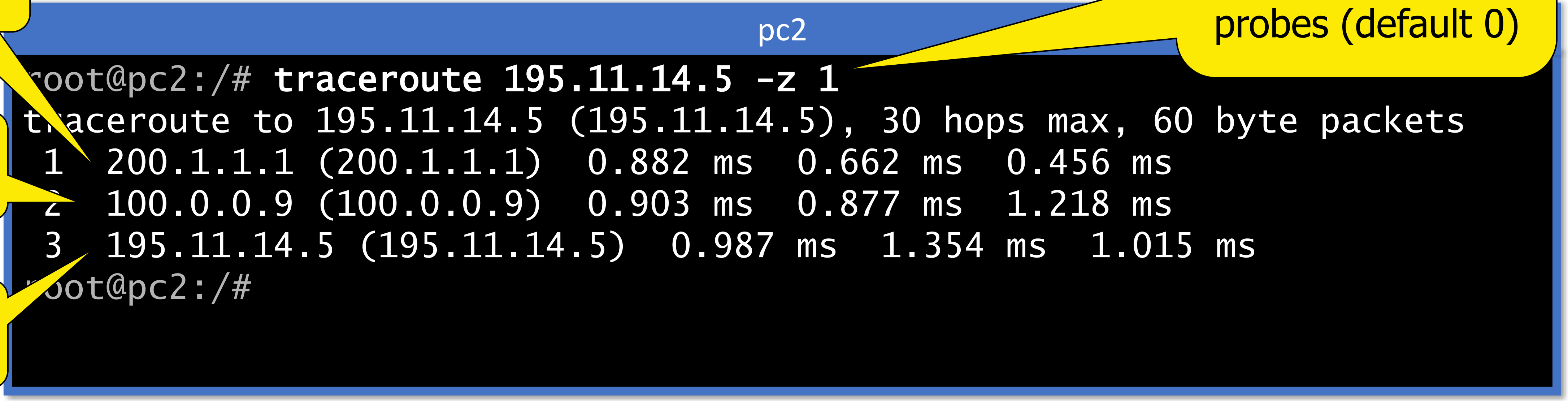
traceroute from pc2 to pc1 and related arp behavior

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



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:/#
```

eth0 of r2

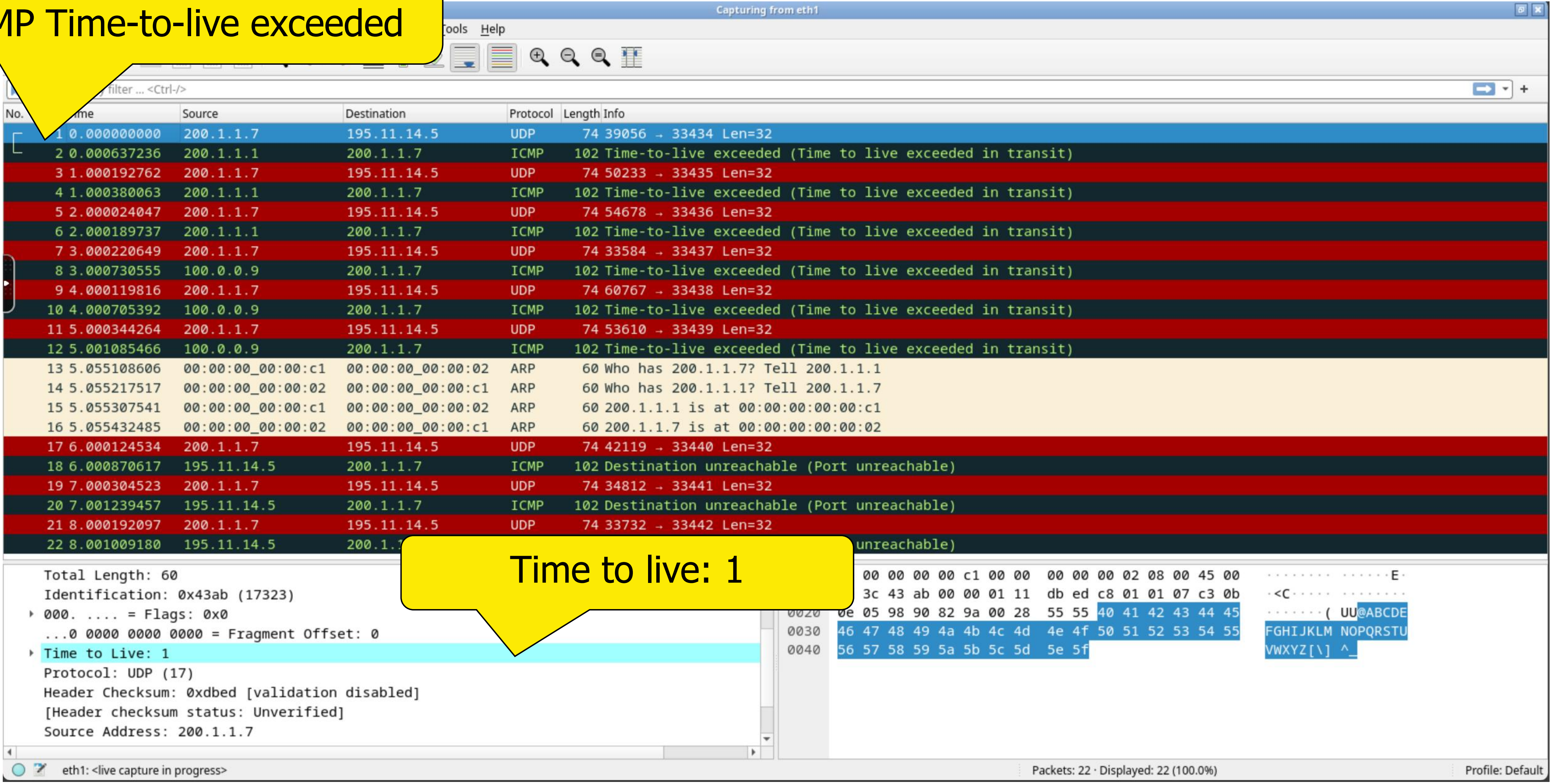
eth1 of r1

eth0 of pc1

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

wireshark

udp packet and corresponding ICMP Time-to-live exceeded



```
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.                                                   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
```

```
      00 00 00 00 c1 00 00  00 00 00 02 08 00 45 00   ········ ······E·
      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[\] ^_
```

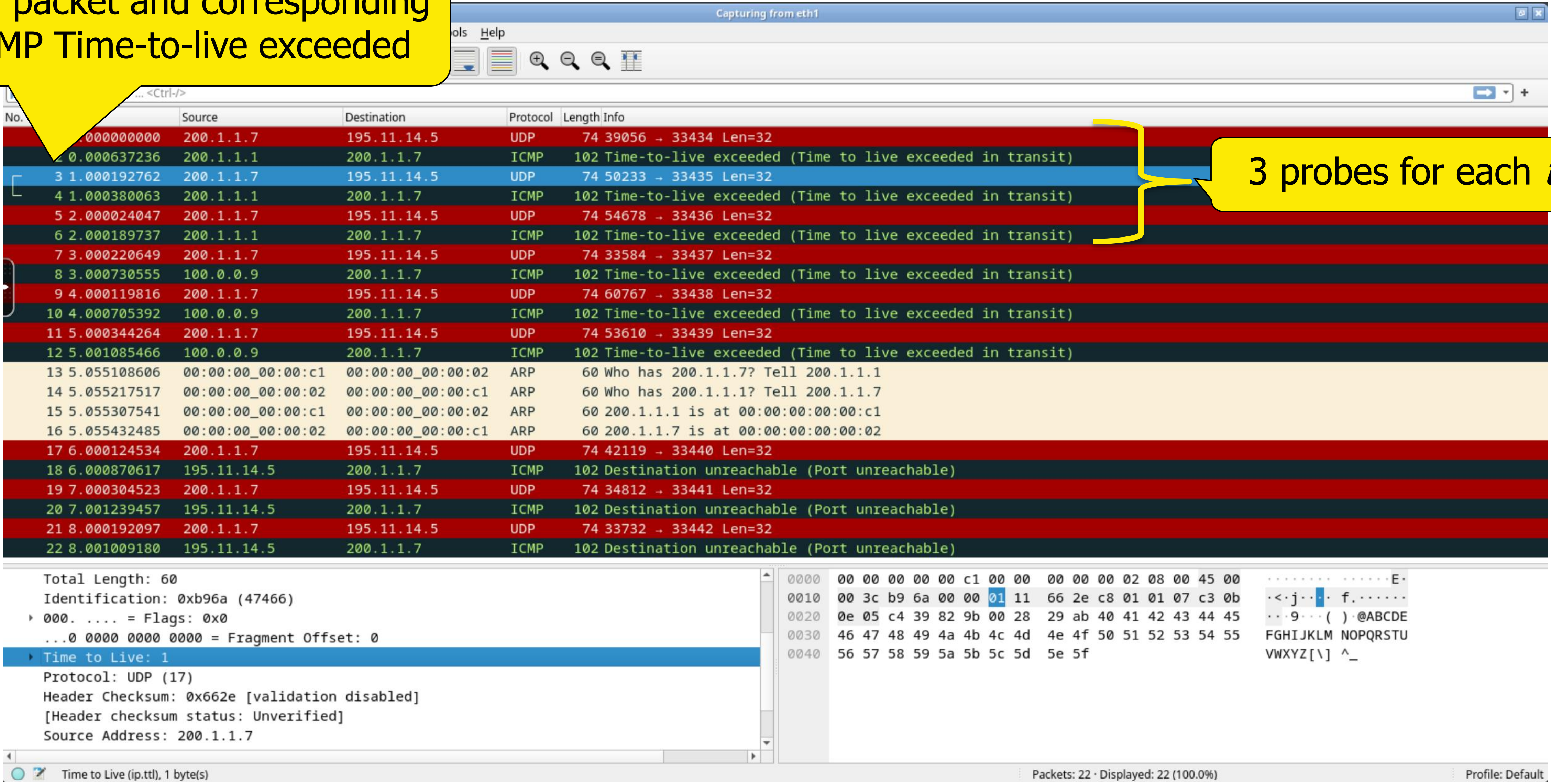
eth1: <live capture in progress>   Packets: 22 · Displayed: 22 (100.0%)   Profile: Default

Time to live: 1

wireshark

udp packet and corresponding ICMP Time-to-live exceeded

3 probes for each *ttl*



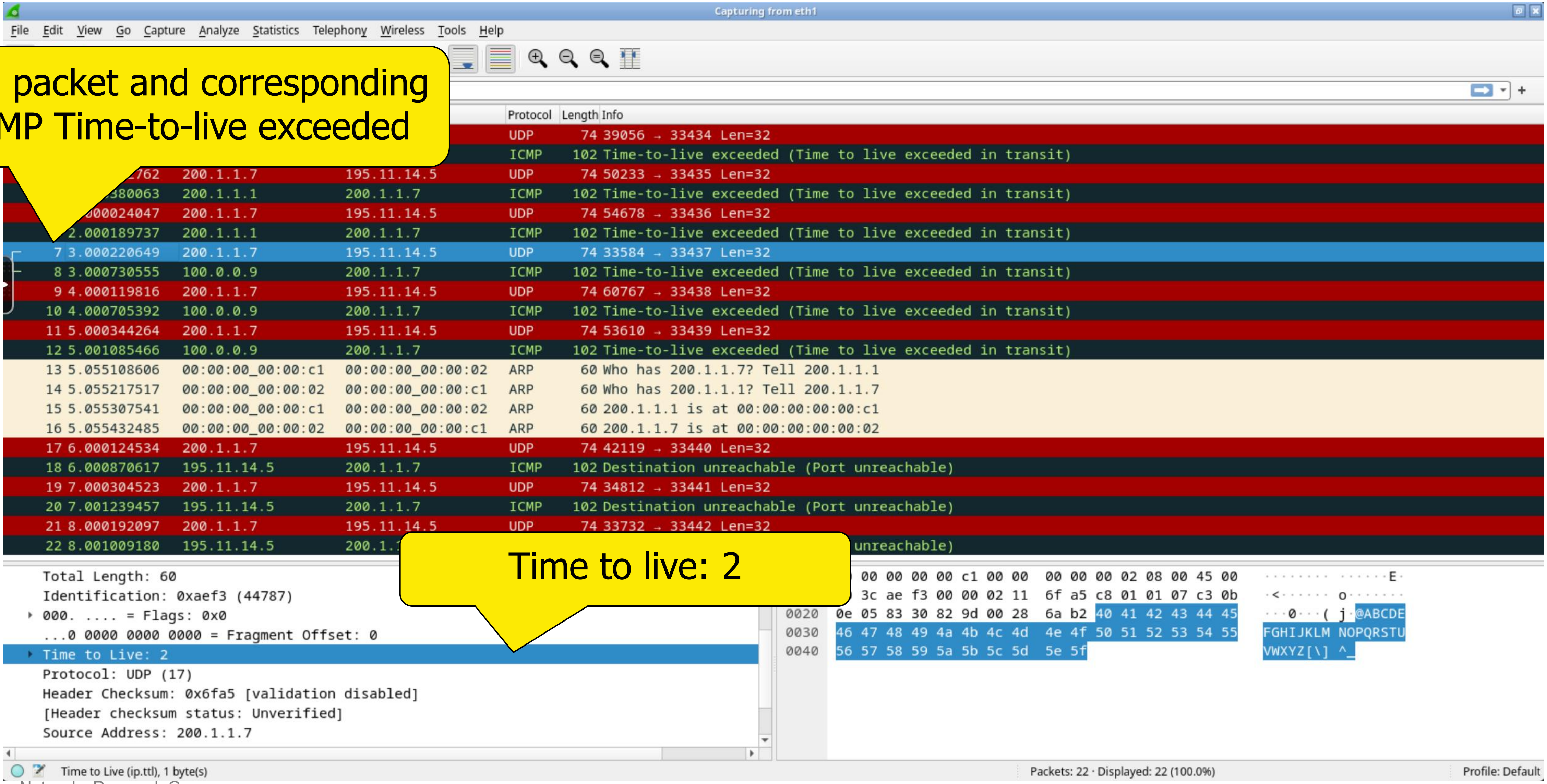
```
No.        Source             Destination        Protocol Length Info
 .000000000 200.1.1.7          195.11.14.5        UDP        74 39056 → 33434 Len=32
 2 0.000637236 200.1.1.1       200.1.1.7          ICMP      102 Time-to-live exceeded (Time to live exceeded in transit)
 3 1.000192762 200.1.1.7       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 Destination unreachable (Port unreachable)
```

```
    Total Length: 60
    Identification: 0xb96a (47466)
  ▸ 000. .... = Flags: 0x0
    ...0 0000 0000 0000 = Fragment Offset: 0
  ▸ Time to Live: 1
    Protocol: UDP (17)
    Header Checksum: 0x662e [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 200.1.1.7
```

```
0000  00 00 00 00 00 c1 00 00  00 00 00 02 08 00 45 00   ········ ······E·
0010  00 3c b9 6a 00 00 01 11  66 2e c8 01 01 07 c3 0b   ·<·j···· f.······
0020  0e 05 c4 39 82 9b 00 28  29 ab 40 41 42 43 44 45   ···9···( )·@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[\] ^_
```

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

wireshark


Capturing from eth1
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

udp packet and corresponding ICMP Time-to-live exceeded

```
                                                 Protocol Length Info
                                                 UDP       74 39056 → 33434 Len=32
                                                 ICMP     102 Time-to-live exceeded (Time to live exceeded in transit)
     762      200.1.1.7       195.11.14.5        UDP       74 50233 → 33435 Len=32
     380063   200.1.1.1       200.1.1.7          ICMP     102 Time-to-live exceeded (Time to live exceeded in transit)
    000024047 200.1.1.7       195.11.14.5        UDP       74 54678 → 33436 Len=32
    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.                                   unreachable)
```

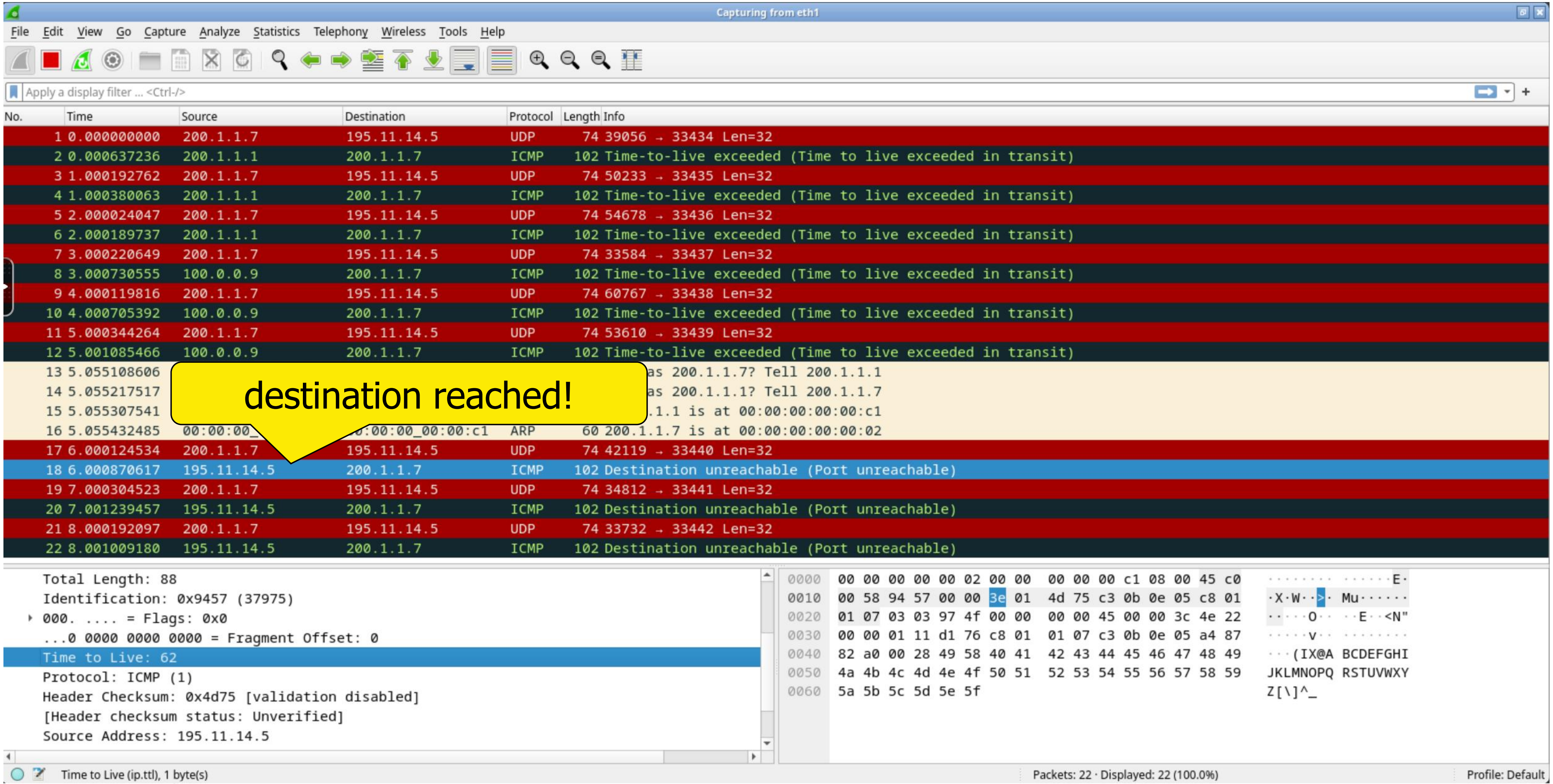
Time to live: 2

```
    Total Length: 60
    Identification: 0xaef3 (44787)
  ▸ 000. .... = Flags: 0x0
    ...0 0000 0000 0000 = Fragment Offset: 0
  ▸ Time to Live: 2
    Protocol: UDP (17)
    Header Checksum: 0x6fa5 [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 200.1.1.7
```

```
      00 00 00 00 c1 00 00  00 00 00 02 08 00 45 00   ········ ······E·
      3c ae f3 00 00 02 11  6f a5 c8 01 01 07 c3 0b   ·<······ o·······
0020  0e 05 83 30 82 9d 00 28  6a b2 40 41 42 43 44 45   ···0···( j·@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[\] ^_
```

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

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_        0:00:00_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)
```

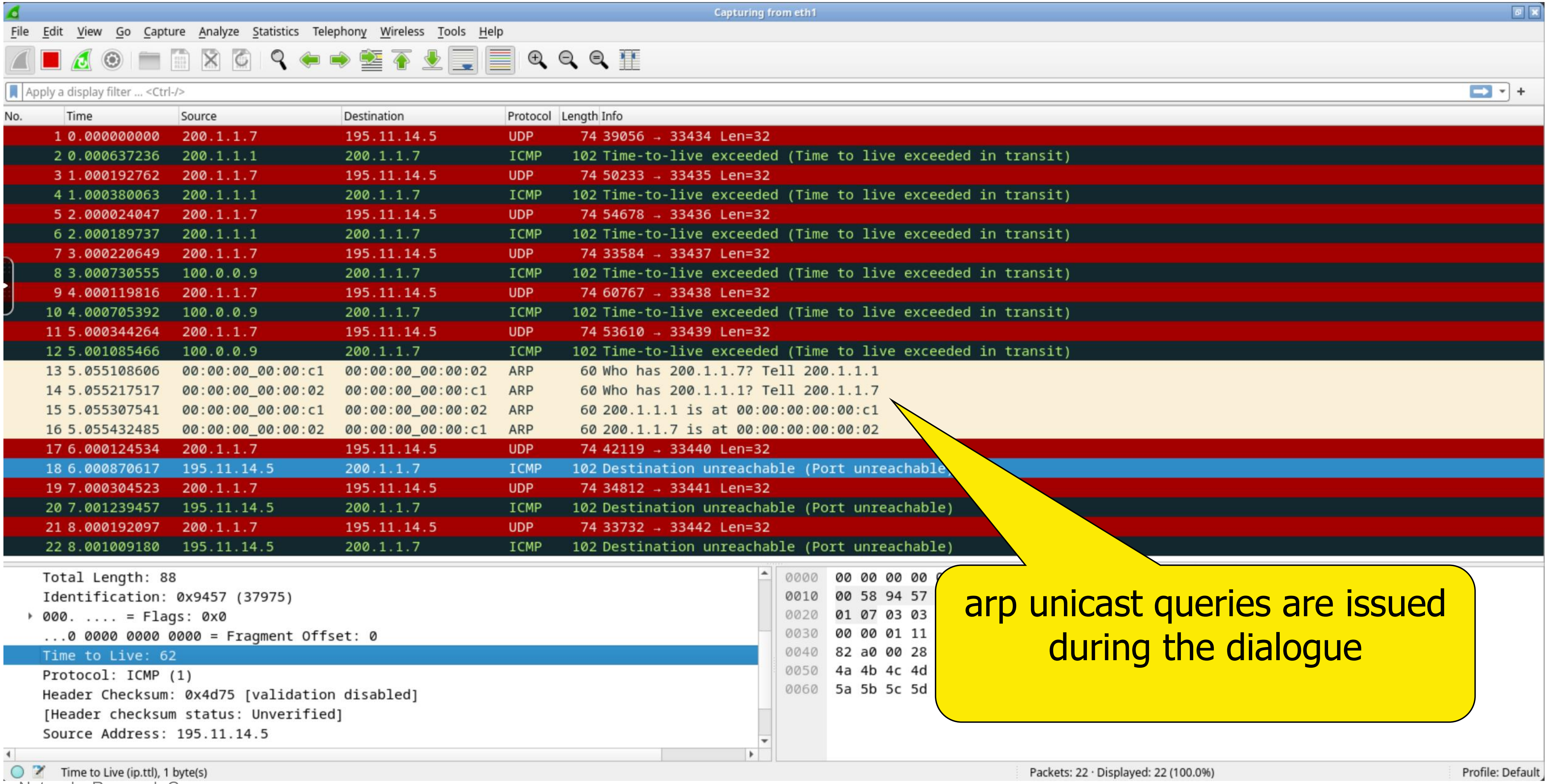
destination reached!

```
    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

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  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 Destination unreachable (Port unreachable)
```

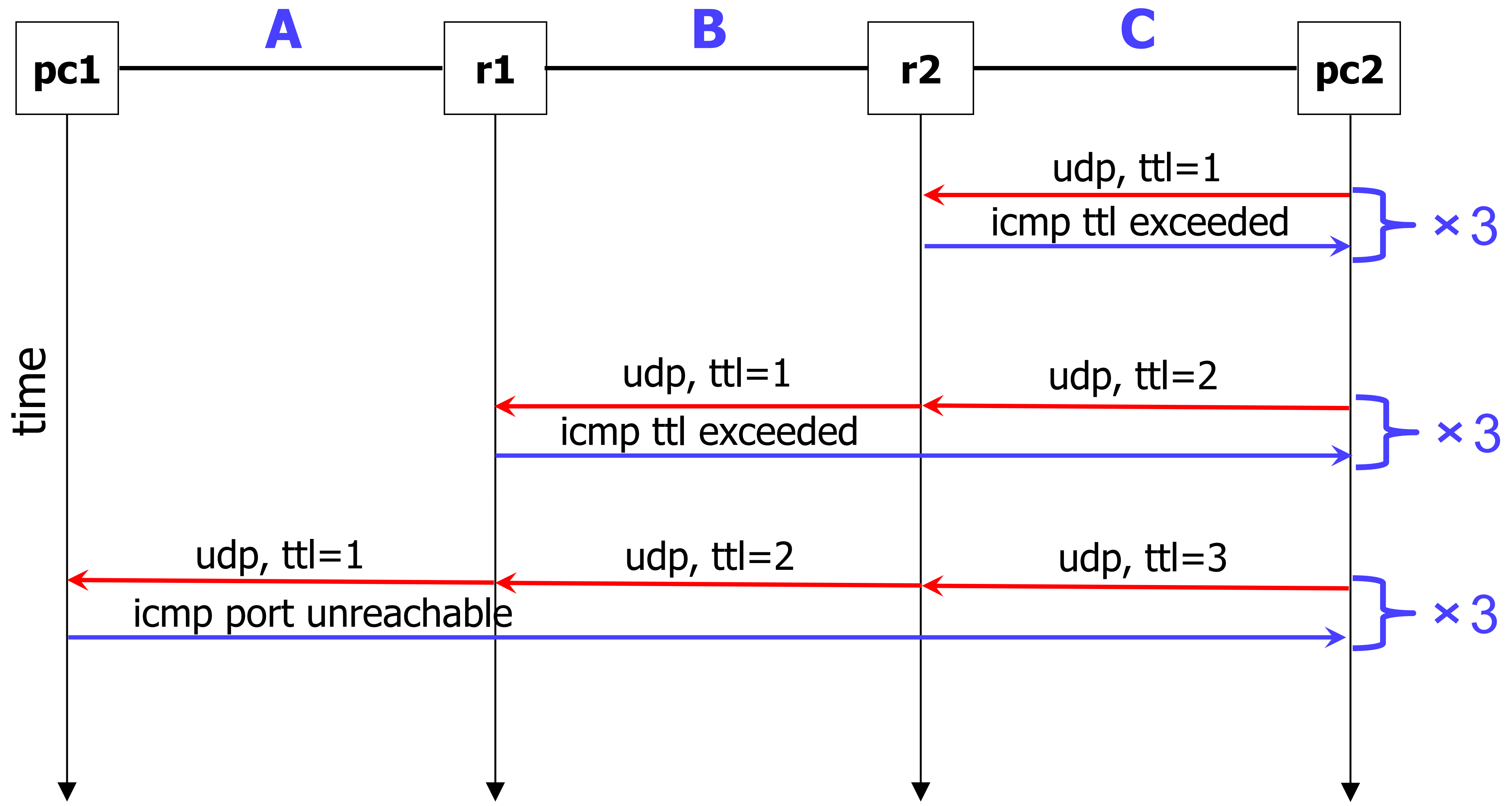
```
    Total Length: 88
    Identification: 0x9457 (37975)
  ▸ 000. .... = Flags: 0x0
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 62
    Protocol: ICMP (1)
    Header Checksum: 0x4d75 [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 195.11.14.5
```

```
0000  00 00 00 00
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
```

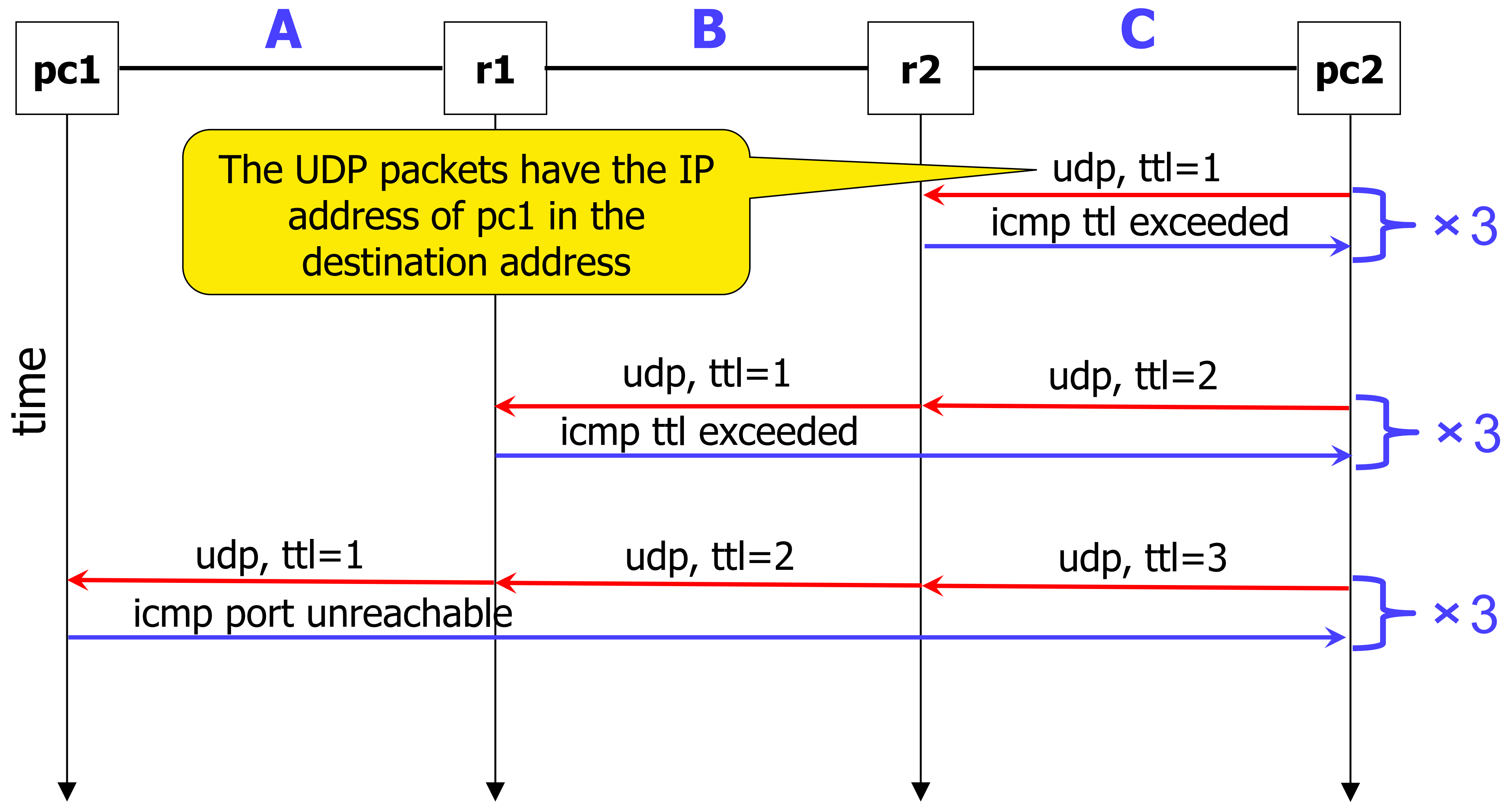
Time to Live (ip.ttl), 1 byte(s)   Packets: 22 · Displayed: 22 (100.0%)   Profile: Default

arp unicast queries are issued during the dialogue

traceroute: understanding the whole picture



traceroute: understanding the whole picture



The UDP packets have the IP address of pc1 in the destination address

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?