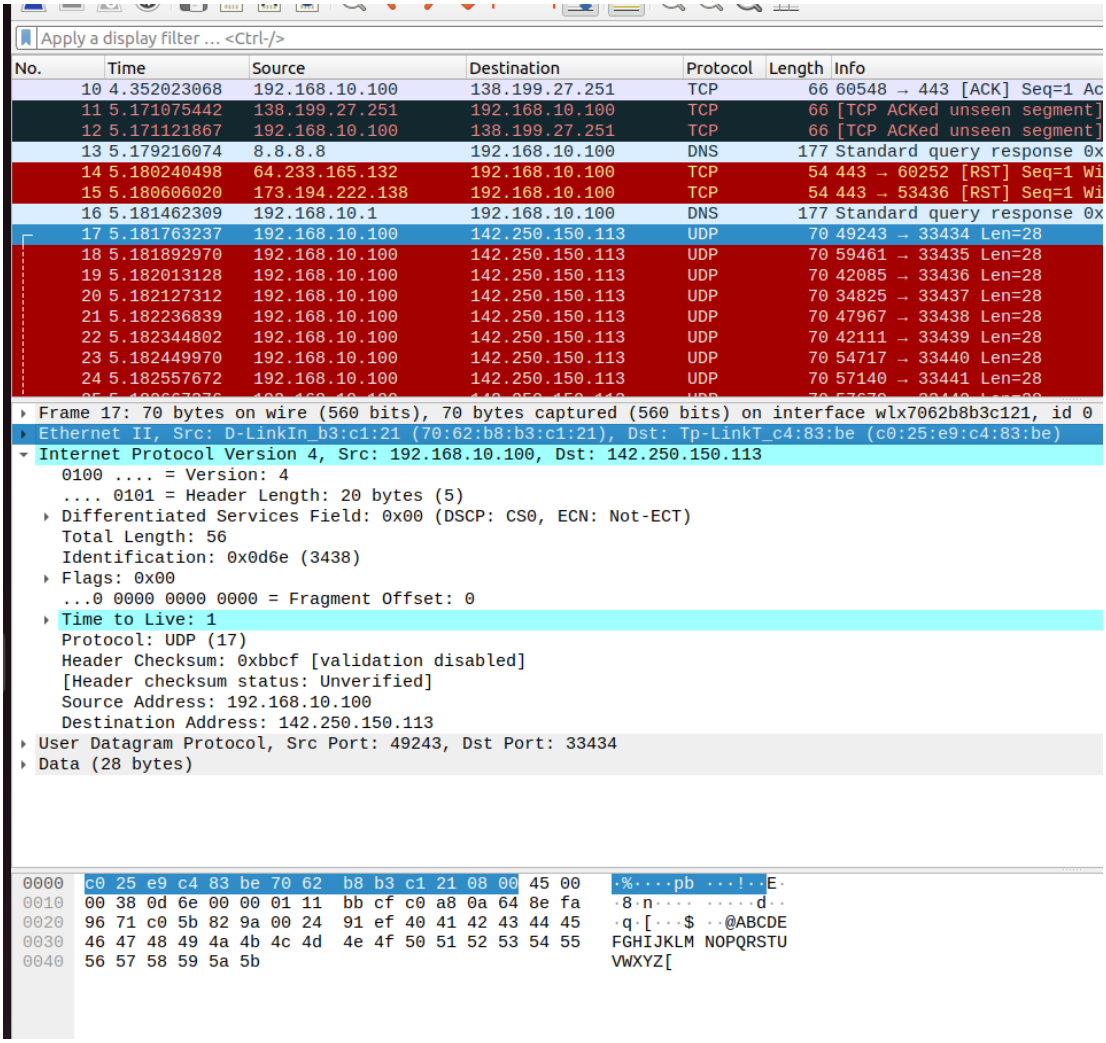
Курбатов Ярослав, РПО МКН

1. Wireshark. IP

1)

```
viralpraxis@primary:~$ traceroute google.com 56
traceroute to google.com (142.250.150.113), 30 hops max, 56 byte packets
 1  _gateway (192.168.10.1)  2.030 ms  2.001 ms  2.029 ms
 2  192.168.0.1 (192.168.0.1)  2.287 ms  2.383 ms  2.487 ms
 3  10.180.90.254 (10.180.90.254)  5.532 ms  7.229 ms  7.337 ms
 4  gw1.airnet.ru (93.92.200.254)  11.640 ms  11.750 ms  11.889 ms
 5  ae13-590.RT.KM.SPB.RU.retn.net (87.245.252.120)  15.999 ms  16.133 ms  16.252 ms
 6  ae1-14.RT.SL.SPB.RU.retn.net (139.45.243.6)  11.675 ms  3.221 ms  13.193 ms
 7  GW-Google.retn.net (87.245.228.199)  13.138 ms  13.316 ms  13.736 ms
 8  74.125.244.133 (74.125.244.133)  15.731 ms  16.228 ms  14.235 ms
 9  72.14.232.84 (72.14.232.84)  14.847 ms  15.071 ms  15.216 ms
10  142.250.209.171 (142.250.209.171)  19.212 ms 216.239.48.163 (216.239.48.163)  21.819 ms 142.250.209.161 (142.250.209.161)  18.362 ms
11  * 142.250.238.179 (142.250.238.179)  21.452 ms *
12  * * *
13  * * *
14  * * *
15  * * *
16  * * *
17  * * *
18  * la-in-f113.1e100.net (142.250.150.113)  7.974 ms *
viralpraxis@primary:~$
```

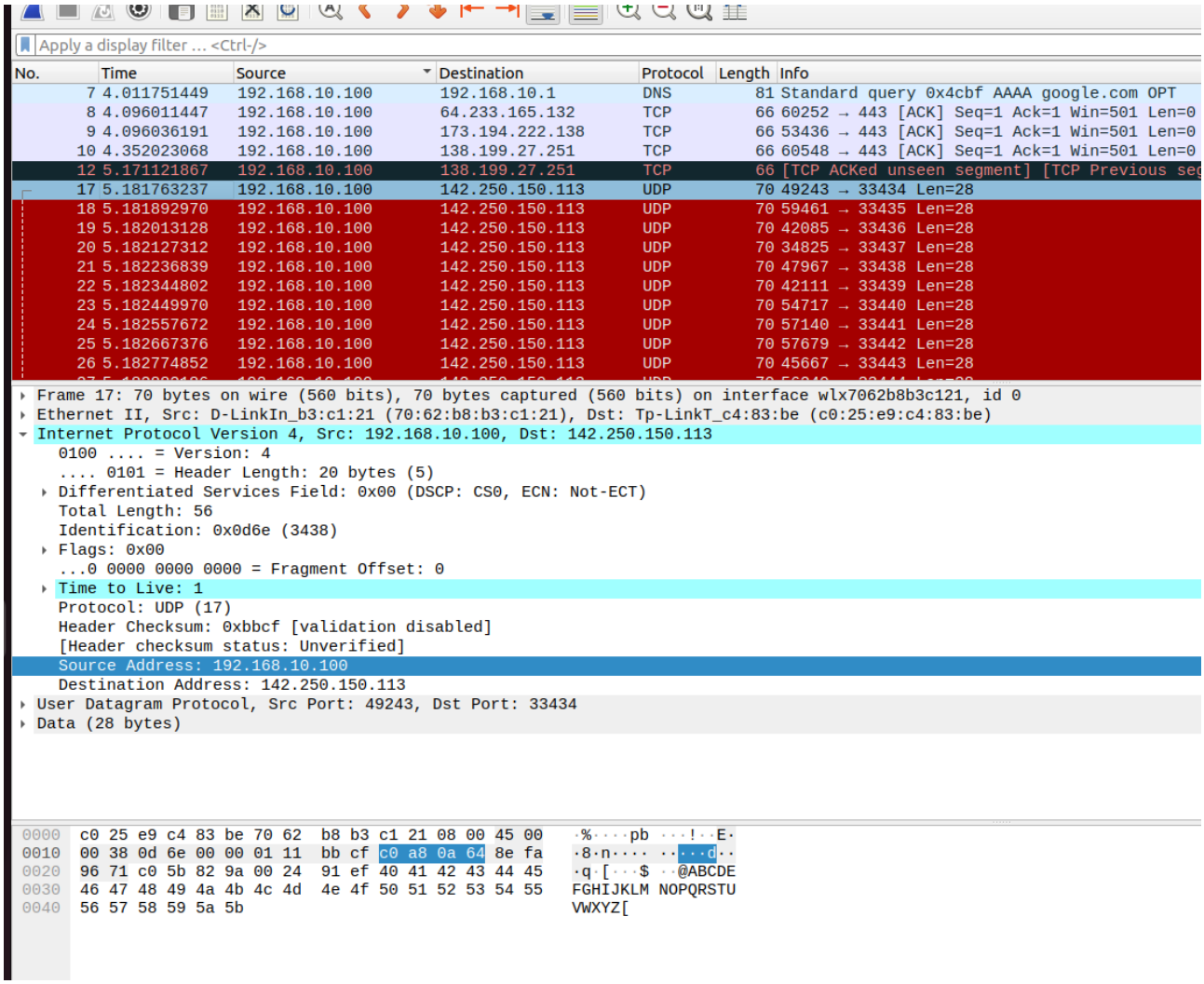


IP-адрес: 192.168.10.100

2) Значение поля Protocol – 17 (UDP).

3) Размер заголовка IP-пакета: 20 байт. Размер пэйлоада – 56 – 20 = 36 (28 байт пэйлоада UDP + 8 заголовок UDP)

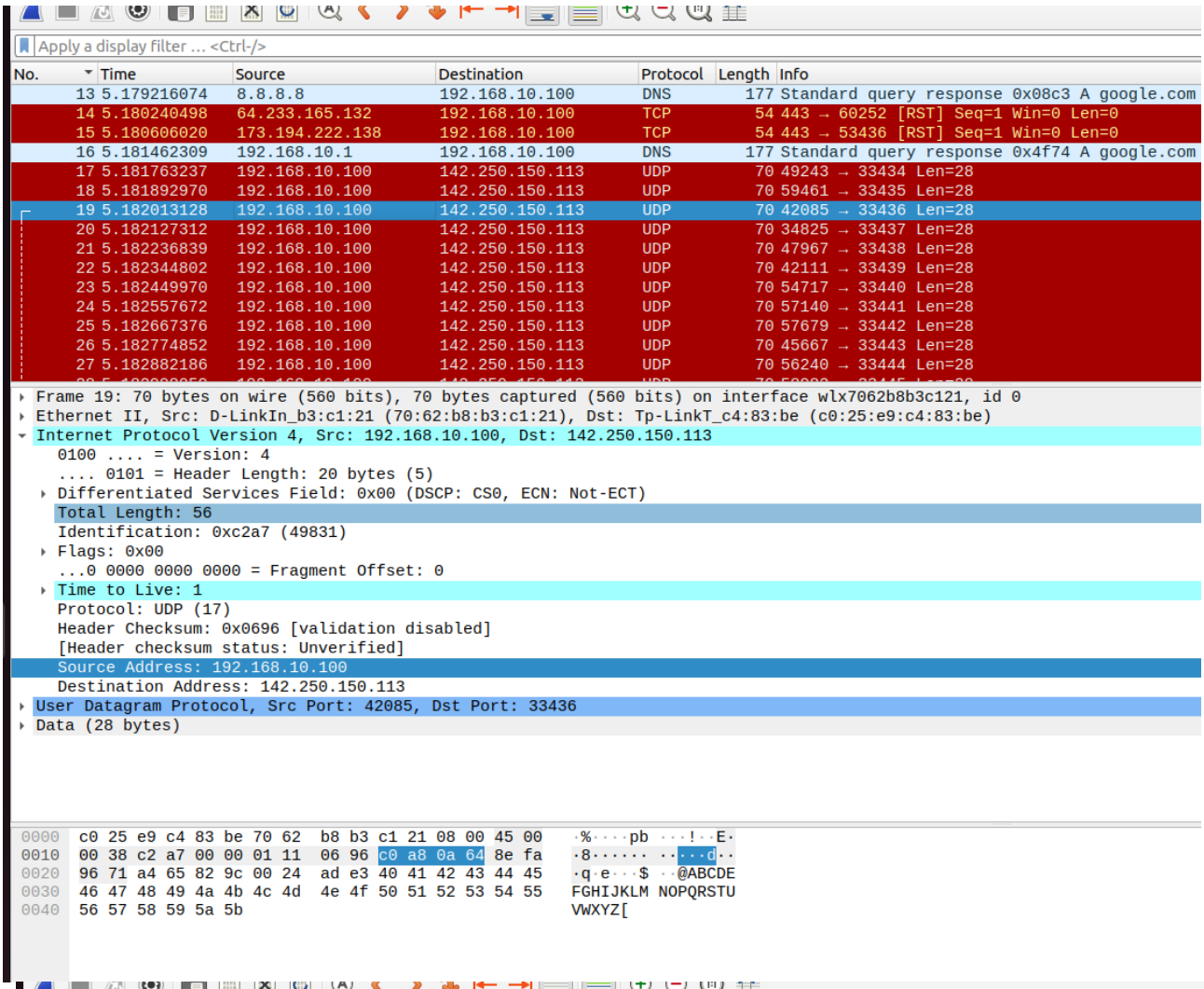
4)



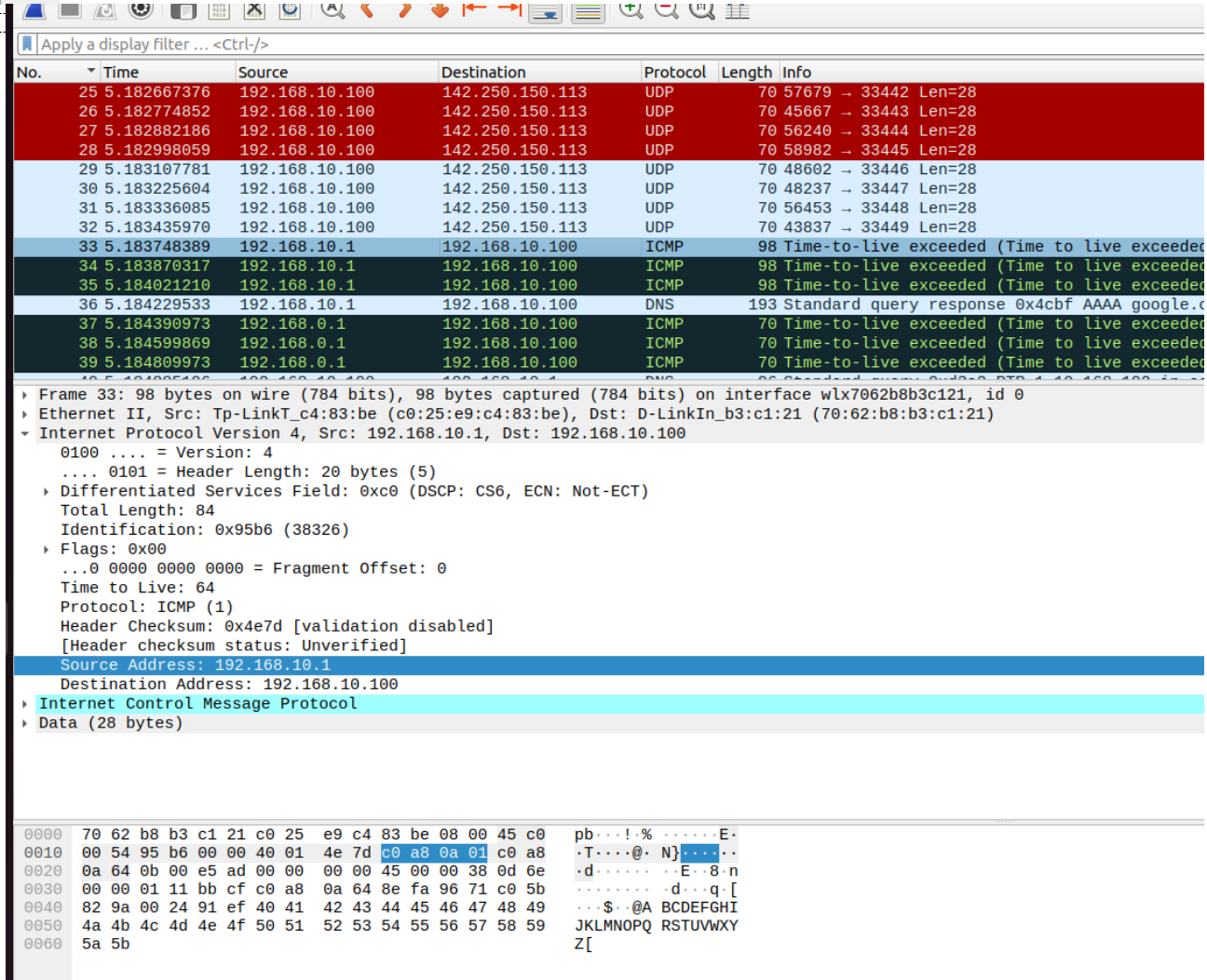
В заголовках IP-датаграм меняются поля Identification и TTL (ну и checksum, соответственно).

Не меняется размер пакета, флаги, поле протокола и адреса отправки/назначения. Собственно, все они и должны оставать неизменными, исходя из логики ICMP. Поле TTL должно меняться, также исходя из логики ICMP.

Поле ID, как написано в соответсвующем RFC, должно быть уникально для каждого триплета (source-ip, dest-ip, proto).
5)


Apply a display filter ... <Ctrl-/>
No. Time Source Destination Protocol Length Info
13 5.179216074 8.8.8.8 192.168.10.100 DNS 177 Standard query response 0x08c3 A google.com
14 5.180240498 64.233.165.132 192.168.10.100 TCP 54 443 → 60252 [RST] Seq=1 Win=0 Len=0
15 5.180606020 173.194.222.138 192.168.10.100 TCP 54 443 → 53436 [RST] Seq=1 Win=0 Len=0
16 5.181462309 192.168.10.1 192.168.10.100 DNS 177 Standard query response 0x4f74 A google.com
17 5.181763237 192.168.10.100 142.250.150.113 UDP 70 49243 → 33434 Len=28
18 5.181892970 192.168.10.100 142.250.150.113 UDP 70 59461 → 33435 Len=28
19 5.182013128 192.168.10.100 142.250.150.113 UDP 70 42085 → 33436 Len=28
20 5.182127312 192.168.10.100 142.250.150.113 UDP 70 34825 → 33437 Len=28
21 5.182236839 192.168.10.100 142.250.150.113 UDP 70 47967 → 33438 Len=28
22 5.182344802 192.168.10.100 142.250.150.113 UDP 70 42111 → 33439 Len=28
23 5.182449970 192.168.10.100 142.250.150.113 UDP 70 54717 → 33440 Len=28
24 5.182557672 192.168.10.100 142.250.150.113 UDP 70 57140 → 33441 Len=28
25 5.182667376 192.168.10.100 142.250.150.113 UDP 70 57679 → 33442 Len=28
26 5.182774852 192.168.10.100 142.250.150.113 UDP 70 45667 → 33443 Len=28
27 5.182882186 192.168.10.100 142.250.150.113 UDP 70 56240 → 33444 Len=28
Frame 19: 70 bytes on wire (560 bits), 70 bytes captured (560 bits) on interface wlx7062b8b3c121, id 0
Ethernet II, Src: D-LinkIn_b3:c1:21 (70:62:b8:b3:c1:21), Dst: Tp-LinkT_c4:83:be (c0:25:e9:c4:83:be)
Internet Protocol Version 4, Src: 192.168.10.100, Dst: 142.250.150.113
0100 .... = Version: 4
.... 0101 = Header Length: 20 bytes (5)
Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
Total Length: 56
Identification: 0xc2a7 (49831)
Flags: 0x00
...0 0000 0000 0000 = Fragment Offset: 0
Time to Live: 1
Protocol: UDP (17)
Header Checksum: 0x0696 [validation disabled]
[Header checksum status: Unverified]
Source Address: 192.168.10.100
Destination Address: 142.250.150.113
User Datagram Protocol, Src Port: 42085, Dst Port: 33436
Data (28 bytes)
0000 c0 25 e9 c4 83 be 70 62 b8 b3 c1 21 08 00 45 00
0010 00 38 c2 a7 00 00 01 11 06 96 c0 a8 0a 64 8e fa
0020 96 71 a4 65 82 9c 00 24 ad e3 40 41 42 43 44 45
0030 46 47 48 49 4a 4b 4c 4d 4e 4f 50 51 52 53 54 55
0040 56 57 58 59 5a 5b

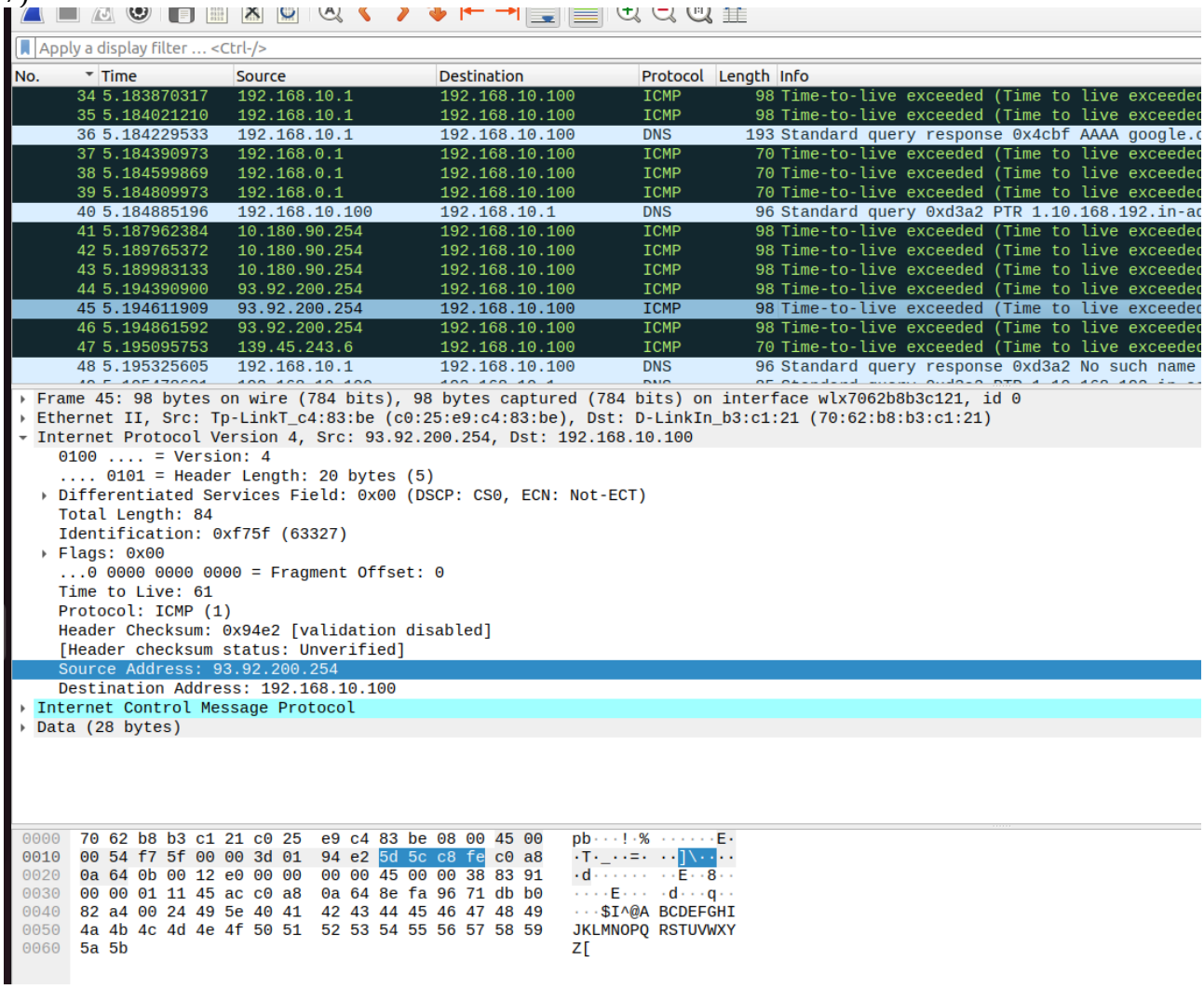
I


Apply a display filter ... <Ctrl-/>
No. Time Source Destination Protocol Length Info
25 5.182667376 192.168.10.100 142.250.150.113 UDP 70 57679 → 33442 Len=28
26 5.182774852 192.168.10.100 142.250.150.113 UDP 70 45667 → 33443 Len=28
27 5.182882186 192.168.10.100 142.250.150.113 UDP 70 56240 → 33444 Len=28
28 5.182998059 192.168.10.100 142.250.150.113 UDP 70 58982 → 33445 Len=28
29 5.183107781 192.168.10.100 142.250.150.113 UDP 70 48602 → 33446 Len=28
30 5.183225604 192.168.10.100 142.250.150.113 UDP 70 48237 → 33447 Len=28
31 5.183336085 192.168.10.100 142.250.150.113 UDP 70 56453 → 33448 Len=28
32 5.183435970 192.168.10.100 142.250.150.113 UDP 70 43837 → 33449 Len=28
33 5.183748389 192.168.10.1 192.168.10.100 ICMP 98 Time-to-live exceeded (Time to live exceeded
34 5.183870317 192.168.10.1 192.168.10.100 ICMP 98 Time-to-live exceeded (Time to live exceeded
35 5.184021210 192.168.10.1 192.168.10.100 ICMP 98 Time-to-live exceeded (Time to live exceeded
36 5.184229533 192.168.10.1 192.168.10.100 DNS 193 Standard query response 0x4cbf AAAA google.c
37 5.184390973 192.168.0.1 192.168.10.100 ICMP 70 Time-to-live exceeded (Time to live exceeded
38 5.184599869 192.168.0.1 192.168.10.100 ICMP 70 Time-to-live exceeded (Time to live exceeded
39 5.184809973 192.168.0.1 192.168.10.100 ICMP 70 Time-to-live exceeded (Time to live exceeded
Frame 33: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface wlx7062b8b3c121, id 0
Ethernet II, Src: Tp-LinkT_c4:83:be (c0:25:e9:c4:83:be), Dst: D-LinkIn_b3:c1:21 (70:62:b8:b3:c1:21)
Internet Protocol Version 4, Src: 192.168.10.1, Dst: 192.168.10.100
0100 .... = Version: 4
.... 0101 = Header Length: 20 bytes (5)
Differentiated Services Field: 0xc0 (DSCP: CS6, ECN: Not-ECT)
Total Length: 84
Identification: 0x95b6 (38326)
Flags: 0x00
...0 0000 0000 0000 = Fragment Offset: 0
Time to Live: 64
Protocol: ICMP (1)
Header Checksum: 0x4e7d [validation disabled]
[Header checksum status: Unverified]
Source Address: 192.168.10.1
Destination Address: 192.168.10.100
Internet Control Message Protocol
Data (28 bytes)
0000 70 62 b8 b3 c1 21 c0 25 e9 c4 83 be 08 00 45 c0
0010 00 54 95 b6 00 00 40 01 4e 7d c0 a8 0a 01 c0 a8
0020 0a 64 0b 00 e5 ad 00 00 00 00 45 00 00 38 0d 6e
0030 00 00 01 11 bb cf c0 a8 0a 64 8e fa 96 71 c0 5b
0040 82 9a 00 24 91 ef 40 41 42 43 44 45 46 47 48 49
0050 4a 4b 4c 4d 4e 4f 50 51 52 53 54 55 56 57 58 59
0060 5a 5b

6)

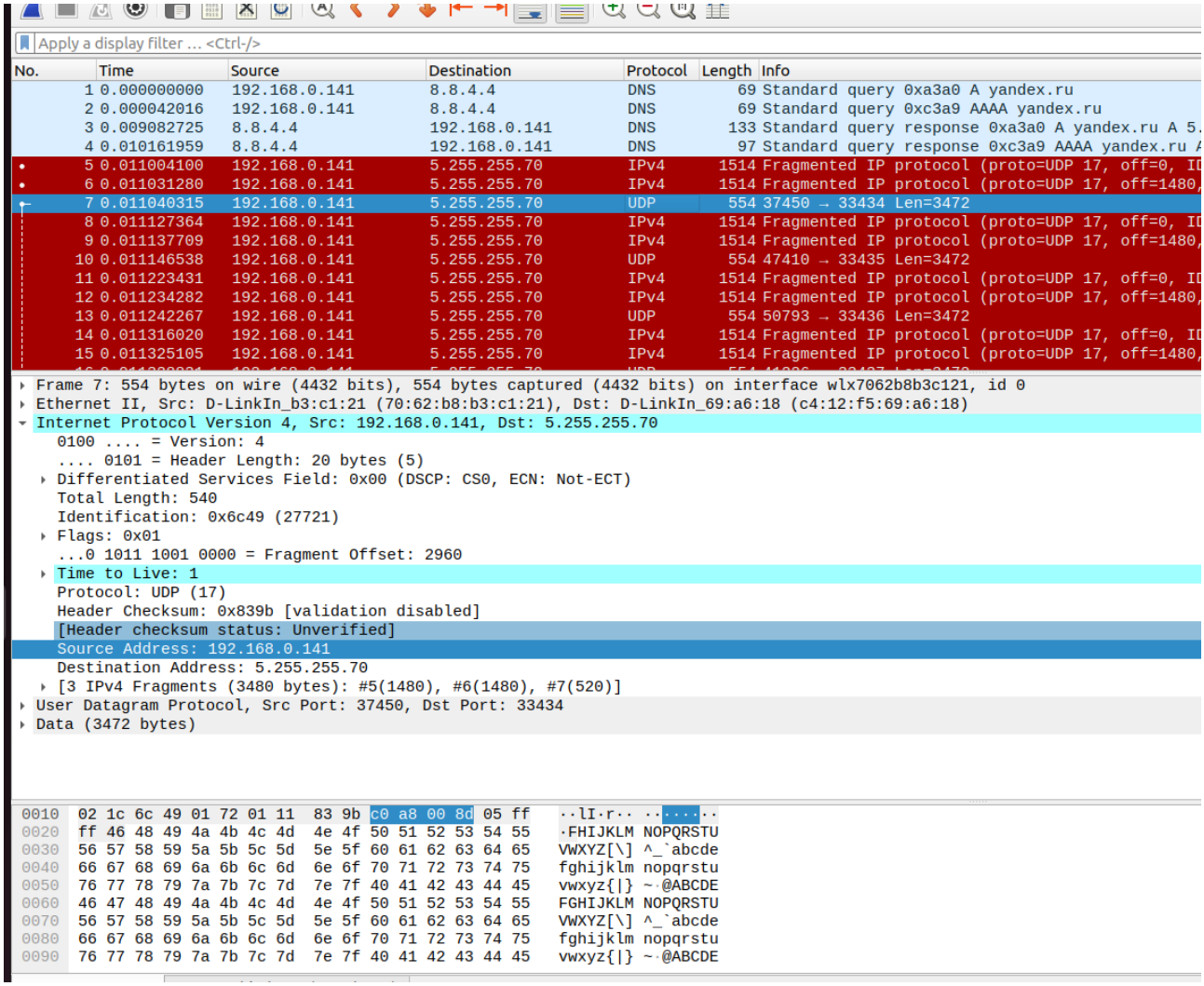
поле identification меняется (причем с шагом 1), поле TTL не меняется (64)

7)



поле identification – 63327, TTL – 61 (этот ICMP-пакет прошел до меня через несколько машртуризаторов, которые уменьшили TTL, изначально видимо было 64).

8)



сообщение было разбито на 3 IP-датаграммы.

Меняется поле длины (в первых датаграммах – MTU 1500, в последнем то что осталось от 3500 байт). Меняются флаги (в последнем фрагменте нет флага more fragments). Меняется checsum.

2. Программирование. ECHO-запросы через ICMP

Ruby MRI 3.0.0

Задания A, B, C: ruby task-2/icmp.rb <host>

Хост yandex.ru, евразия:

```
viralpraxis@primary:~/Documents/spbu/2023-spring/networks/spbu-masters-compnet/homeworks/10$ ruby task-2/icmp.rb yandex.ru
PING yandex.ru (5.255.255.77)
12 bytes from yandex.ru, time: 22, (min: 22, max: 22, avg: 22.0, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from yandex.ru, time: 19, (min: 19, max: 22, avg: 20.5, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from yandex.ru, time: 35, (min: 19, max: 35, avg: 25.33, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from yandex.ru, time: 20, (min: 19, max: 35, avg: 24.0, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from yandex.ru, time: 33, (min: 19, max: 35, avg: 25.8, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from yandex.ru, time: 36, (min: 19, max: 36, avg: 27.5, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from yandex.ru, time: 21, (min: 19, max: 36, avg: 26.57, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from yandex.ru, time: 49, (min: 19, max: 49, avg: 29.38, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from yandex.ru, time: 23, (min: 19, max: 49, avg: 28.67, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from yandex.ru, time: 22, (min: 19, max: 49, avg: 28.0, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from yandex.ru, time: 37, (min: 19, max: 49, avg: 28.82, lost: 0.0%), ICMP code: ECHO_REPLY
```

Хост akamai.com, северная америка:

```
viralpraxis@primary:~/Documents/spbu/2023-spring/networks/spbu-masters-compnet/homeworks/10$ ruby task-2/icmp.rb akamai.com
PING akamai.com (23.63.115.111)
12 bytes from akamai.com, time: 133, (min: 133, max: 133, avg: 133.0, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 67, (min: 67, max: 133, avg: 100.0, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 67, (min: 67, max: 133, avg: 89.0, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 72, (min: 67, max: 133, avg: 84.75, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 72, (min: 67, max: 133, avg: 82.2, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 69, (min: 67, max: 133, avg: 80.0, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 71, (min: 67, max: 133, avg: 78.71, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 68, (min: 67, max: 133, avg: 77.38, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 70, (min: 67, max: 133, avg: 76.56, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 75, (min: 67, max: 133, avg: 76.4, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 65, (min: 65, max: 133, avg: 75.36, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 75, (min: 65, max: 133, avg: 75.33, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 65, (min: 65, max: 133, avg: 74.54, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 63, (min: 63, max: 133, avg: 73.71, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 82, (min: 63, max: 133, avg: 74.27, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 62, (min: 62, max: 133, avg: 73.5, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 64, (min: 62, max: 133, avg: 72.94, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 63, (min: 62, max: 133, avg: 72.39, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 70, (min: 62, max: 133, avg: 72.26, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 95, (min: 62, max: 133, avg: 73.4, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 50, (min: 50, max: 133, avg: 72.29, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 52, (min: 50, max: 133, avg: 71.36, lost: 0.0%), ICMP code: ECHO_REPLY
12 bytes from akamai.com, time: 49, (min: 49, max: 133, avg: 70.39, lost: 0.0%), ICMP code: ECHO_REPLY
```

в среднем RTT на другой континент, очевидно, больше.

В программе реализовано отображение типа ICMP-ответа (поел ICMP code), min/max/avg RTT, подсчет процента кол-ва потерянных пакетов, настраиваемый таймаут.

2. Протокол GBN

Запуск:
клиент: ruby task-2/gbn/client.rb <path-to-file:string> <n:int=3>
сервер: ruby task-2/gbn/server.rb

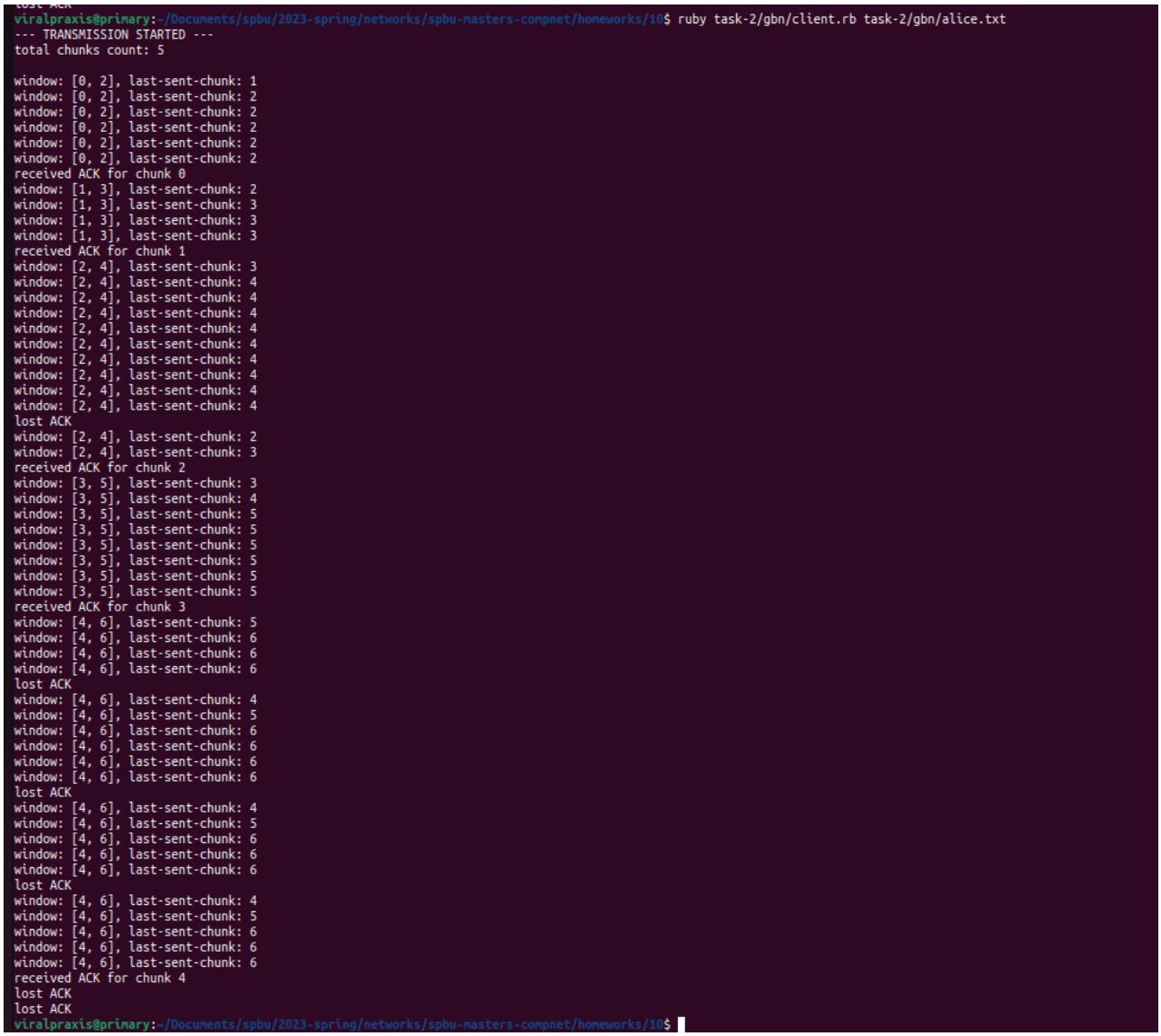
path-to-file – путь к файлу для передачи, n – размер окна (3 по умолчанию)

у сервера выставлена задержка обработки запроса, поэтому часть ACK считаются утерянными (по таймауту):

сервер:

```
viralpraxis@primary:~/Documents/spbu/2023-spring/networks/spbu-masters-compnet/homeworks/10$ ruby task-2/gbn/server.rb
server: ready to receive
Received chunk 0, expected 0
Received chunk 1, expected 1
Received chunk 1, expected 2
Received chunk 2, expected 2
Received chunk 2, expected 3
Received chunk 3, expected 3
Received chunk 2, expected 4
Received chunk 3, expected 4
Received chunk 3, expected 4
Received chunk 4, expected 4
Received chunk 4, expected 5
data:
Alice was beginning to get very tired of sitting by her sister on the bank, and of having nothing to do: once or twice she had peeped into the book her sister was reading, but it had no pictures or conve
rsations in it, `and what is the use of a book,' thought Alice `without pictures or conversation?'
viralpraxis@primary:~/Documents/spbu/2023-spring/networks/spbu-masters-compnet/homeworks/10$
```

клиент:


lost ACK
viralpraxis@primary:~/Documents/spbu/2023-spring/networks/spbu-masters-compnet/homeworks/10$ ruby task-2/gbn/client.rb task-2/gbn/alice.txt
--- TRANSMISSION STARTED ---
total chunks count: 5
window: [0, 2], last-sent-chunk: 1
window: [0, 2], last-sent-chunk: 2
window: [0, 2], last-sent-chunk: 2
window: [0, 2], last-sent-chunk: 2
window: [0, 2], last-sent-chunk: 2
window: [0, 2], last-sent-chunk: 2
received ACK for chunk 0
window: [1, 3], last-sent-chunk: 2
window: [1, 3], last-sent-chunk: 3
window: [1, 3], last-sent-chunk: 3
window: [1, 3], last-sent-chunk: 3
received ACK for chunk 1
window: [2, 4], last-sent-chunk: 3
window: [2, 4], last-sent-chunk: 4
window: [2, 4], last-sent-chunk: 4
window: [2, 4], last-sent-chunk: 4
window: [2, 4], last-sent-chunk: 4
window: [2, 4], last-sent-chunk: 4
window: [2, 4], last-sent-chunk: 4
window: [2, 4], last-sent-chunk: 4
window: [2, 4], last-sent-chunk: 4
window: [2, 4], last-sent-chunk: 4
lost ACK
window: [2, 4], last-sent-chunk: 2
window: [2, 4], last-sent-chunk: 3
received ACK for chunk 2
window: [3, 5], last-sent-chunk: 3
window: [3, 5], last-sent-chunk: 4
window: [3, 5], last-sent-chunk: 5
window: [3, 5], last-sent-chunk: 5
window: [3, 5], last-sent-chunk: 5
window: [3, 5], last-sent-chunk: 5
window: [3, 5], last-sent-chunk: 5
window: [3, 5], last-sent-chunk: 5
received ACK for chunk 3
window: [4, 6], last-sent-chunk: 5
window: [4, 6], last-sent-chunk: 6
window: [4, 6], last-sent-chunk: 6
window: [4, 6], last-sent-chunk: 6
lost ACK
window: [4, 6], last-sent-chunk: 4
window: [4, 6], last-sent-chunk: 5
window: [4, 6], last-sent-chunk: 6
window: [4, 6], last-sent-chunk: 6
window: [4, 6], last-sent-chunk: 6
window: [4, 6], last-sent-chunk: 6
lost ACK
window: [4, 6], last-sent-chunk: 4
window: [4, 6], last-sent-chunk: 5
window: [4, 6], last-sent-chunk: 6
window: [4, 6], last-sent-chunk: 6
window: [4, 6], last-sent-chunk: 6
lost ACK
window: [4, 6], last-sent-chunk: 4
window: [4, 6], last-sent-chunk: 5
window: [4, 6], last-sent-chunk: 6
window: [4, 6], last-sent-chunk: 6
window: [4, 6], last-sent-chunk: 6
received ACK for chunk 4
lost ACK
lost ACK
viralpraxis@primary:~/Documents/spbu/2023-spring/networks/spbu-masters-compnet/homeworks/10$