

1. Wireshark. IP

1)

```
vitalpraxis@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.altnet.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 *
```

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

No.	Time	Source	Destination	Protocol	Length	Info
10	4.352023068	192.168.10.100	138.199.27.251	TCP	66	60548 → 443 [ACK] Seq=1 Ac
11	5.171075442	138.199.27.251	192.168.10.100	TCP	66	[TCP ACKed unseen segment]
12	5.171121867	192.168.10.100	138.199.27.251	TCP	66	[TCP ACKed unseen segment]
13	5.179216074	8.8.8.8	192.168.10.100	DNS	177	Standard query response 0x
14	5.180240498	64.233.165.132	192.168.10.100	TCP	54	443 → 60252 [RST] Seq=1 Wi
15	5.180606020	173.194.222.138	192.168.10.100	TCP	54	443 → 53436 [RST] Seq=1 Wi
16	5.181462309	192.168.10.1	192.168.10.100	DNS	177	Standard query response 0x
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

Frame 17: 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: 0x0d6e (3438)

Flags: 0x00

...0 0000 0000 0000 = Fragment Offset: 0

Time to Live: 1

Protocol: UDP (17)

Header Checksum: 0xbbcf [validation disabled]

[Header checksum status: Unverified]

Source Address: 192.168.10.100

Destination Address: 142.250.150.113

User Datagram Protocol, Src Port: 49243, Dst Port: 33434

Data (28 bytes)

0000 c0 25 e9 c4 83 be 70 62 b8 b3 c1 21 08 00 45 00 .%. . . . pb . . . ! . . E .

0010 00 38 0d 6e 00 00 01 11 bb cf c0 a8 0a 64 8e fa .8 . n d . .

0020 96 71 c0 5b 82 9a 00 24 91 ef 40 41 42 43 44 45 .q . [. . . \$. . @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 VWXYZ[

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 заголовков UDP)

4)

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

No.	Time	Source	Destination	Protocol	Length	Info
7	4.011751449	192.168.10.100	192.168.10.1	DNS	81	Standard query 0x4cbf AAAA google.com OPT
8	4.096011447	192.168.10.100	64.233.165.132	TCP	66	60252 → 443 [ACK] Seq=1 Ack=1 Win=501 Len=0
9	4.096036191	192.168.10.100	173.194.222.138	TCP	66	53436 → 443 [ACK] Seq=1 Ack=1 Win=501 Len=0
10	4.352023068	192.168.10.100	138.199.27.251	TCP	66	60548 → 443 [ACK] Seq=1 Ack=1 Win=501 Len=0
12	5.171121867	192.168.10.100	138.199.27.251	TCP	66	[TCP ACKed unseen segment] [TCP Previous seq
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	5.182882426	192.168.10.100	142.250.150.113	UDP	70	55040 → 33444 Len=28

Frame 17: 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: 0x0d6e (3438)

Flags: 0x00

...0 0000 0000 0000 = Fragment Offset: 0

Time to Live: 1

Protocol: UDP (17)

Header Checksum: 0xbbcf [validation disabled]

[Header checksum status: Unverified]

Source Address: 192.168.10.100

Destination Address: 142.250.150.113

User Datagram Protocol, Src Port: 49243, Dst Port: 33434

Data (28 bytes)

```
0000  c0 25 e9 c4 83 be 70 62 b8 b3 c1 21 08 00 45 00  .%. . . . pb . . . ! . . E .
0010  00 38 0d 6e 00 00 01 11 bb cf c0 a8 0a 64 8e fa  .8 . n . . . . . . . . . . d . .
0020  96 71 c0 5b 82 9a 00 24 91 ef 40 41 42 43 44 45  .q [ . . . $ . . . @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                                VWXYZ[
```

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 оставаться неизменными, исходя из логики ICMP. Поле TTL должно меняться, также исходя из логики ICMP.

Поле ID, как написано в соответствующем 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 .%. . . . pb . . . ! . . E.
0010 00 38 c2 a7 00 00 01 11 06 96 c0 a8 0a 64 8e fa .8. d . .
0020 96 71 a4 65 82 9c 00 24 ad e3 40 41 42 43 44 45 .q.e. . . \$. . @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 VWXYZ[

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 pb . . . ! . % E.
0010 00 54 95 b6 00 00 40 01 4e 7d c0 a8 0a 01 c0 a8 .T. . . . @. N}.
0020 0a 64 0b 00 e5 ad 00 00 00 00 45 00 00 38 0d 6e .d. E. . . n
0030 00 00 01 11 bb cf c0 a8 0a 64 8e fa 96 71 c0 5b d . . . q.[
0040 82 9a 00 24 91 ef 40 41 42 43 44 45 46 47 48 49 . . . \$. . @A BCDEFGHI
0050 4a 4b 4c 4d 4e 4f 50 51 52 53 54 55 56 57 58 59 JKLMNOPQ RSTUVWXY
0060 5a 5b Z[

6)

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

7)

The image shows a Wireshark packet capture interface. The top pane displays a list of captured packets. The bottom pane shows the detailed view of a selected packet (No. 45).

No.	Time	Source	Destination	Protocol	Length	Info
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)
40	5.184885196	192.168.10.100	192.168.10.1	DNS	96	Standard query 0xd3a2 PTR 1.10.168.192.in-ac
41	5.187962384	10.180.90.254	192.168.10.100	ICMP	98	Time-to-live exceeded (Time to live exceeded)
42	5.189765372	10.180.90.254	192.168.10.100	ICMP	98	Time-to-live exceeded (Time to live exceeded)
43	5.189983133	10.180.90.254	192.168.10.100	ICMP	98	Time-to-live exceeded (Time to live exceeded)
44	5.194390900	93.92.200.254	192.168.10.100	ICMP	98	Time-to-live exceeded (Time to live exceeded)
45	5.194611909	93.92.200.254	192.168.10.100	ICMP	98	Time-to-live exceeded (Time to live exceeded)
46	5.194861592	93.92.200.254	192.168.10.100	ICMP	98	Time-to-live exceeded (Time to live exceeded)
47	5.195095753	139.45.243.6	192.168.10.100	ICMP	70	Time-to-live exceeded (Time to live exceeded)
48	5.195325605	192.168.10.1	192.168.10.100	DNS	96	Standard query response 0xd3a2 No such name

Frame 45: 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: 93.92.200.254, Dst: 192.168.10.100

0100 = Version: 4
.... 0101 = Header Length: 20 bytes (5)

Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
Total Length: 84
Identification: 0xf75f (63327)
Flags: 0x00
...0 0000 0000 0000 = Fragment Offset: 0
Time to Live: 61
Protocol: ICMP (1)
Header Checksum: 0x94e2 [validation disabled]
[Header checksum status: Unverified]
Source Address: 93.92.200.254
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 00	pb...!.%E.
0010	00 54 f7 5f 00 00 3d 01 94 e2 5d 5c c8 fe c0 a8	.T...=-..j\... ..
0020	0a 64 0b 00 12 e0 00 00 00 00 45 00 00 38 83 91	.d.....E...8...
0030	00 00 01 11 45 ac c0 a8 0a 64 8e fa 96 71 db b0	...E...d...q...
0040	82 a4 00 24 49 5e 40 41 42 43 44 45 46 47 48 49	...\$I^@A BCDEFGHI
0050	4a 4b 4c 4d 4e 4f 50 51 52 53 54 55 56 57 58 59	JKLMNOPQ RSTUVWXY
0060	5a 5b	Z[

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

8)

Apply a display filter ... <Ctrl-/>							
No.	Time	Source	Destination	Protocol	Length	Info	
1	0.000000000	192.168.0.141	8.8.4.4	DNS	69	Standard query	0xa3a0 A yandex.ru
2	0.000042016	192.168.0.141	8.8.4.4	DNS	69	Standard query	0xc3a9 AAAA yandex.ru
3	0.009082725	8.8.4.4	192.168.0.141	DNS	133	Standard query response	0xa3a0 A yandex.ru A 5.
4	0.010161959	8.8.4.4	192.168.0.141	DNS	97	Standard query response	0xc3a9 AAAA yandex.ru /
5	0.011004100	192.168.0.141	5.255.255.70	IPv4	1514	Fragmented IP protocol	(proto=UDP 17, off=0, ID
6	0.011031280	192.168.0.141	5.255.255.70	IPv4	1514	Fragmented IP protocol	(proto=UDP 17, off=1480,
7	0.011040315	192.168.0.141	5.255.255.70	UDP	554	37450 → 33434	Len=3472
8	0.011127364	192.168.0.141	5.255.255.70	IPv4	1514	Fragmented IP protocol	(proto=UDP 17, off=0, ID
9	0.011137709	192.168.0.141	5.255.255.70	IPv4	1514	Fragmented IP protocol	(proto=UDP 17, off=1480,
10	0.011146538	192.168.0.141	5.255.255.70	UDP	554	47410 → 33435	Len=3472
11	0.011223431	192.168.0.141	5.255.255.70	IPv4	1514	Fragmented IP protocol	(proto=UDP 17, off=0, ID
12	0.011234282	192.168.0.141	5.255.255.70	IPv4	1514	Fragmented IP protocol	(proto=UDP 17, off=1480,
13	0.011242267	192.168.0.141	5.255.255.70	UDP	554	50793 → 33436	Len=3472
14	0.011316020	192.168.0.141	5.255.255.70	IPv4	1514	Fragmented IP protocol	(proto=UDP 17, off=0, ID
15	0.011325105	192.168.0.141	5.255.255.70	IPv4	1514	Fragmented IP protocol	(proto=UDP 17, off=1480,
16	0.011328001	192.168.0.141	5.255.255.70	UDP	554	44006 → 33437	Len=3472
▶ Frame 7: 554 bytes on wire (4432 bits), 554 bytes captured (4432 bits) on interface wlx7062b8b3c121, id 0 ▶ Ethernet II, Src: D-LinkIn_b3:c1:21 (70:62:b8:b3:c1:21), Dst: D-LinkIn_69:a6:18 (c4:12:f5:69:a6:18) ▶ Internet Protocol Version 4, Src: 192.168.0.141, Dst: 5.255.255.70 0100 = Version: 4 0101 = Header Length: 20 bytes (5) ▶ Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT) Total Length: 540 Identification: 0x6c49 (27721) ▶ Flags: 0x01 ...0 1011 1001 0000 = Fragment Offset: 2960 ▶ Time to Live: 1 Protocol: UDP (17) Header Checksum: 0x839b [validation disabled] [Header checksum status: Unverified] Source Address: 192.168.0.141 Destination Address: 5.255.255.70 ▶ [3 IPv4 Fragments (3480 bytes): #5(1480), #6(1480), #7(520)] ▶ User Datagram Protocol, Src Port: 37450, Dst Port: 33434 ▶ Data (3472 bytes)							
0010	02 1c 6c 49 01 72 01 11	83 9b c0 a8 00 8d	05 ff	..li.r..			
0020	ff 46 48 49 4a 4b 4c 4d	4e 4f 50 51 52 53 54 55	.FHIJKLM NOPQRSTU				
0030	56 57 58 59 5a 5b 5c 5d	5e 5f 60 61 62 63 64 65	vwxyz[\] ^_abcde				
0040	66 67 68 69 6a 6b 6c 6d	6e 6f 70 71 72 73 74 75	fghijklm nopqrstu				
0050	76 77 78 79 7a 7b 7c 7d	7e 7f 40 41 42 43 44 45	vwxyz{ } ~@ABCDE				
0060	46 47 48 49 4a 4b 4c 4d	4e 4f 50 51 52 53 54 55	FGHIJKLM NOPQRSTU				
0070	56 57 58 59 5a 5b 5c 5d	5e 5f 60 61 62 63 64 65	vwxyz[\] ^_abcde				
0080	66 67 68 69 6a 6b 6c 6d	6e 6f 70 71 72 73 74 75	fghijklm nopqrstu				
0090	76 77 78 79 7a 7b 7c 7d	7e 7f 40 41 42 43 44 45	vwxyz{ } ~@ABCDE				

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 checksum.

2. Программирование. ЕСНО-запросы через ICMP

Ruby MRI 3.0.0

Задания А, В, С: 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 (поле 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 conversations 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
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
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
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
received ACK for chunk 4
lost ACK
lost ACK
viralpraxis@primary: ~/Documents/spbu/2023-spring/networks/spbu-masters-compnet/homeworks/10$
```