Indian Institute of Technology Gandhinagar

CS331 - Computer Networks

ASSIGNMENT 1

REPORT

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Link to GitHub Repository

Table of Contents

Task 1 - DNS Resolver

Introduction & Setup

The purpose of this task is to understand and implement packet parsing and processing logic in a programming language, specifically a custom DNS resolution support, and also give an idea of load balancing and socket programming.

Procedure

After adding the last 3 digits of our roll numbers (279 + 059), we had to select the file **'8.pcap'.**
We used the `struct` Python module to read the packed binary data of each packet and process the DNS packets from the .pcap file in our client.

The client, after appending the custom header to the top, sends the DNS query packets to the server's PORT using the `socket` module.

The server listens on this PORT for the incoming packets. On receiving a packet, it parses the header, and resolves the IP using the given rules. It then returns the resolved IP to the client.
The client logs these requests and responses in a .txt file.

Result

Running the Client and Server at 4:14 AM (morning slot), we get the following:

Custom header value (HHMMSSID)	Domain name	Resolved IP address
04144000	github.com.	192.168.1.1
04144001	bing.com.	192.168.1.2
04144102	facebook.com.	192.168.1.3
04144103	amazon.com.	192.168.1.4
04144104	linkedin.com.	192.168.1.5
04144105	stackoverflow.com.	192.168.1.1

Running the Client and Server at 2:52 PM (afternoon slot), we get the following:

Custom header value (HHMMSSID)	Domain name	Resolved IP address
14525600	github.com.	192.168.1.6
14525601	bing.com.	192.168.1.7
14525702	facebook.com.	192.168.1.8
14525703	amazon.com.	192.168.1.9
14525804	linkedin.com.	192.168.1.10
14525905	stackoverflow.com.	192.168.1.6

Running the Client and Server at 11:22 PM (night slot), we get the following:

Custom header value (HHMMSSID)	Domain name	Resolved IP address
23222000	github.com.	192.168.1.11
23222001	bing.com.	192.168.1.12
23222102	facebook.com.	192.168.1.13
23222103	amazon.com.	192.168.1.14
23222104	linkedin.com.	192.168.1.15
23222105	stackoverflow.com.	192.168.1.11

Task 2 - Traceroute Protocol Behavior

Introduction & Setup

The purpose of this task is to understand how the traceroute utility works in different operating systems by capturing the network traffic during the executions using Wireshark.

We chose to work on Windows and Linux. And we decided to trace the route to www.dev.to.

Procedure

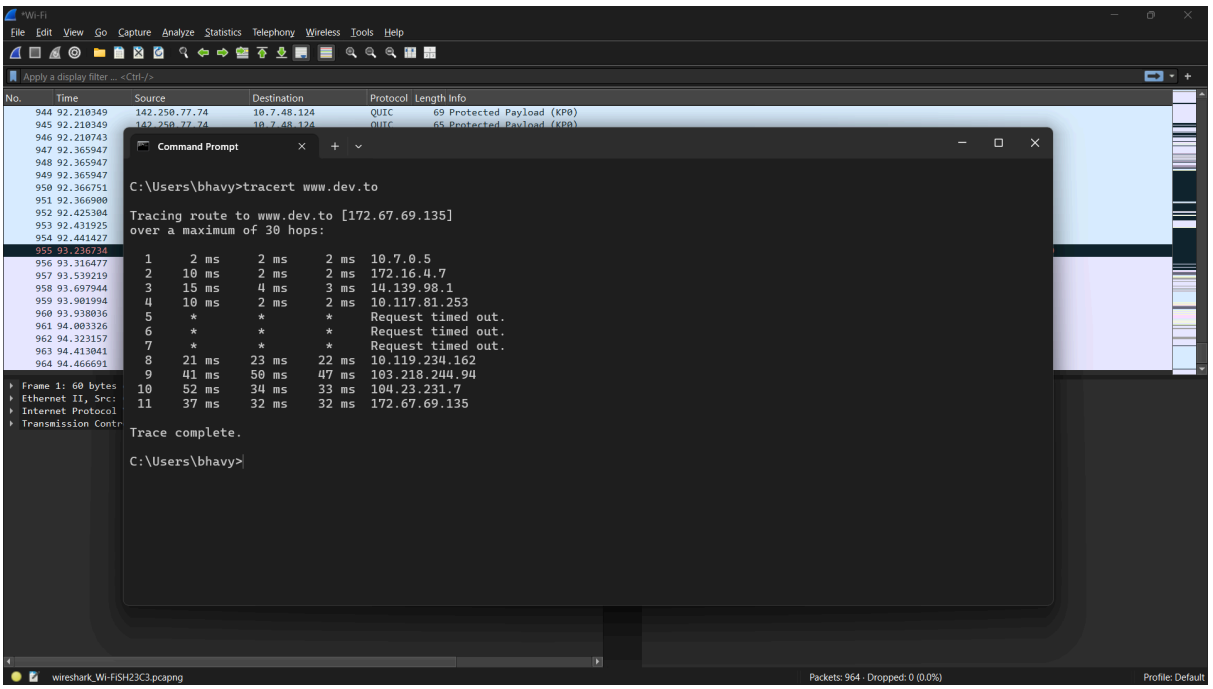
Windows

First, we opened up Wireshark and selected WiFi to capture, following which we ran the command:

```
tracert www.dev.to
```

This started to trace the route to the given destination over a maximum of 30 hops.

Upon completion, I stopped the packet capture in Wireshark and saved the file in .pcapng format.

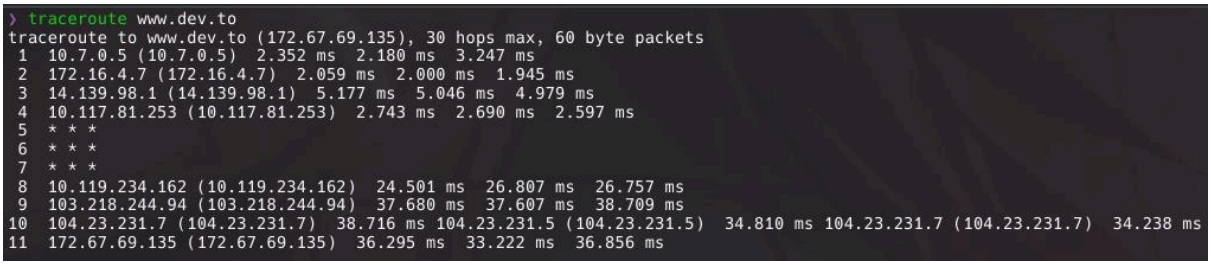


Linux

In Linux, the procedure was similar to that of Windows… We opened Wireshark and then selected wlan0 (which is the WiFi interface) to capture. Following which we ran the command:

```
traceroute www.dev.to
```

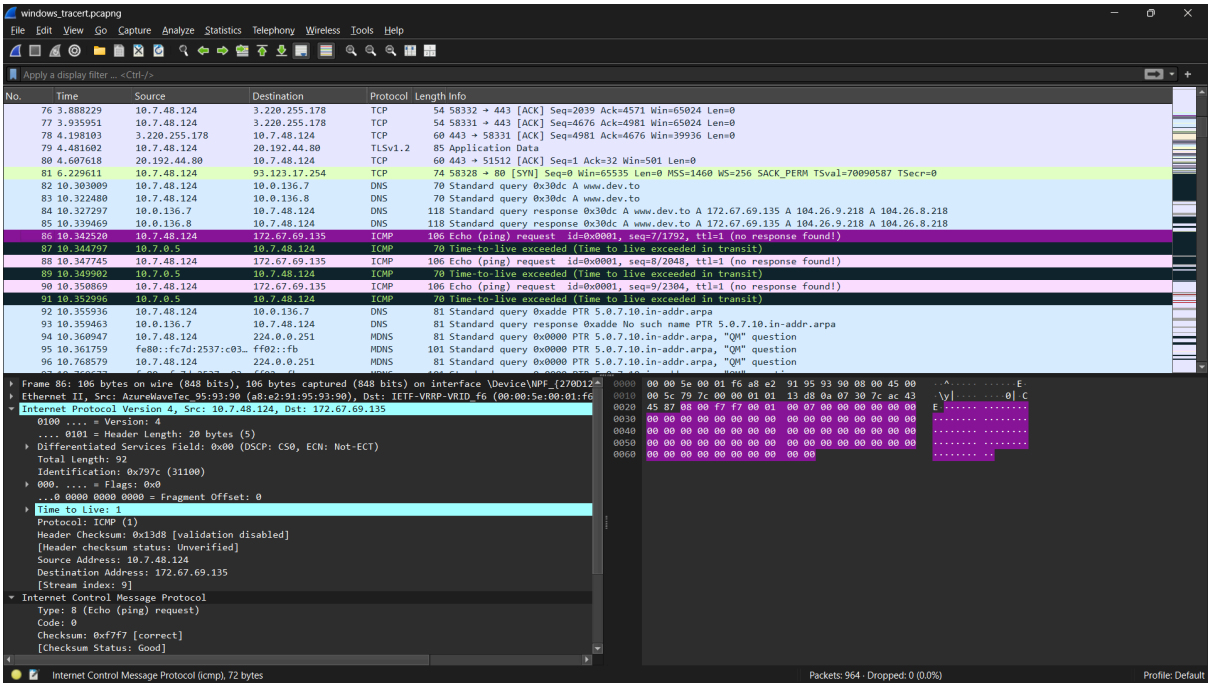
This started to trace the route to the given target over a maximum of 30 hops. And upon completion of this, I stopped the packet capture in Wireshark and saved the file in .pcapng format.



Questions

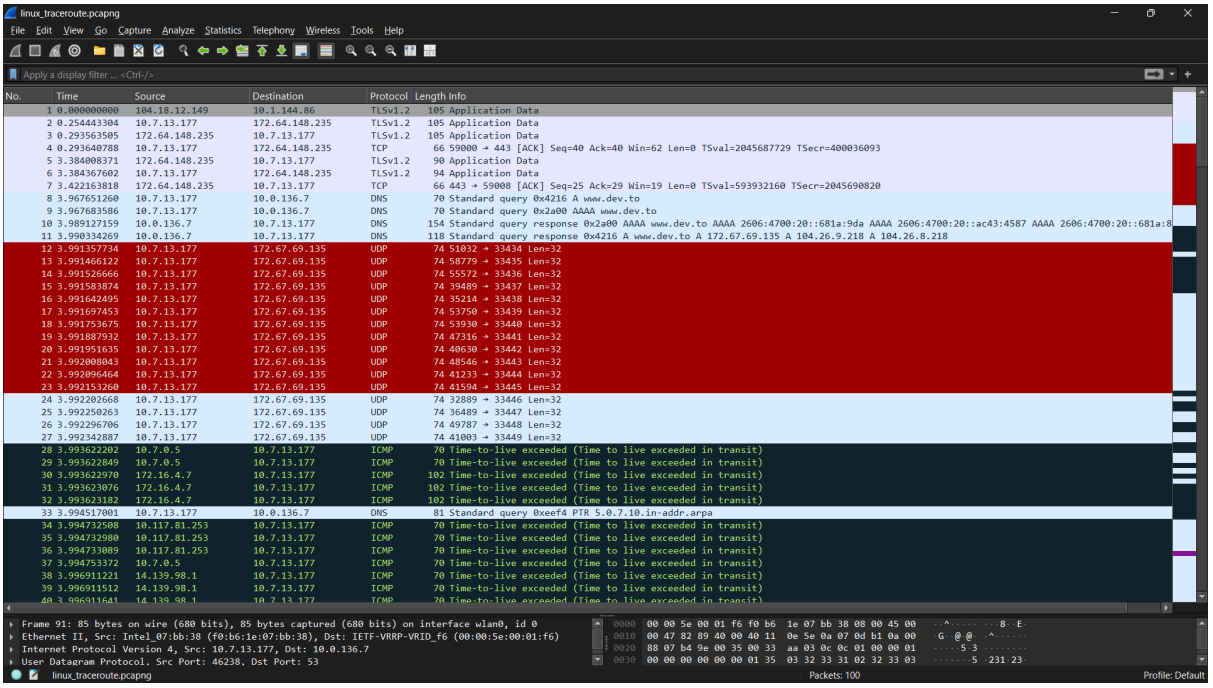
1. What protocol does Windows tracert use by default, and what protocol does Linux traceroute use by default?

Ans. Windows tracert uses the ICMP (Internet Control Message Protocol) by default, and sends echo request packets to the destination IP, probe-wise (3 messages in one probe), with the TTL (Time To Live) increasing at each probe. The intermediate routers respond with ICMP “Time Exceeded” messages.



The selected 86th packet is the first packet sent by the tracert operation via the ICMP protocol in the above image.

Whereas Linux traceroute uses UDP (User Datagram Protocol) by default, whilst also sending packets probe-wise (3 messages in one probe) to high-numbered ports (starting at 33434). Intermediate routers reply with ICMP "Time-to-live exceeded," and the destination replies with ICMP "Port Unreachable" (since no service listens on those high ports). The image showing the pcap file for Linux for the same is below:



2. Some hops in your traceroute output may show *. Provide at least two reasons why a router might not reply.**

Ans. In my tracert to www.dev.to, hops 5, 6, and 7 displayed ***, indicating that no response was received from those routers. This does not mean the route was broken, since subsequent hops (8 onwards) continued to respond, and the tracert was still able to reach the destination successfully. So, mostly the reasons could be the following:

- ➔ The ICMP responses for diagnostics using tracert may be considered of lower priority than the actual traffic data on that router, and hence may be dropped.
- ➔ A router may forward the packet on, but the ICMP response it generates may take a different return path that doesn't make it back to us.
- ➔ Some routers may be configured to ignore TTL-expired packets entirely to avoid exposing their internal topology.

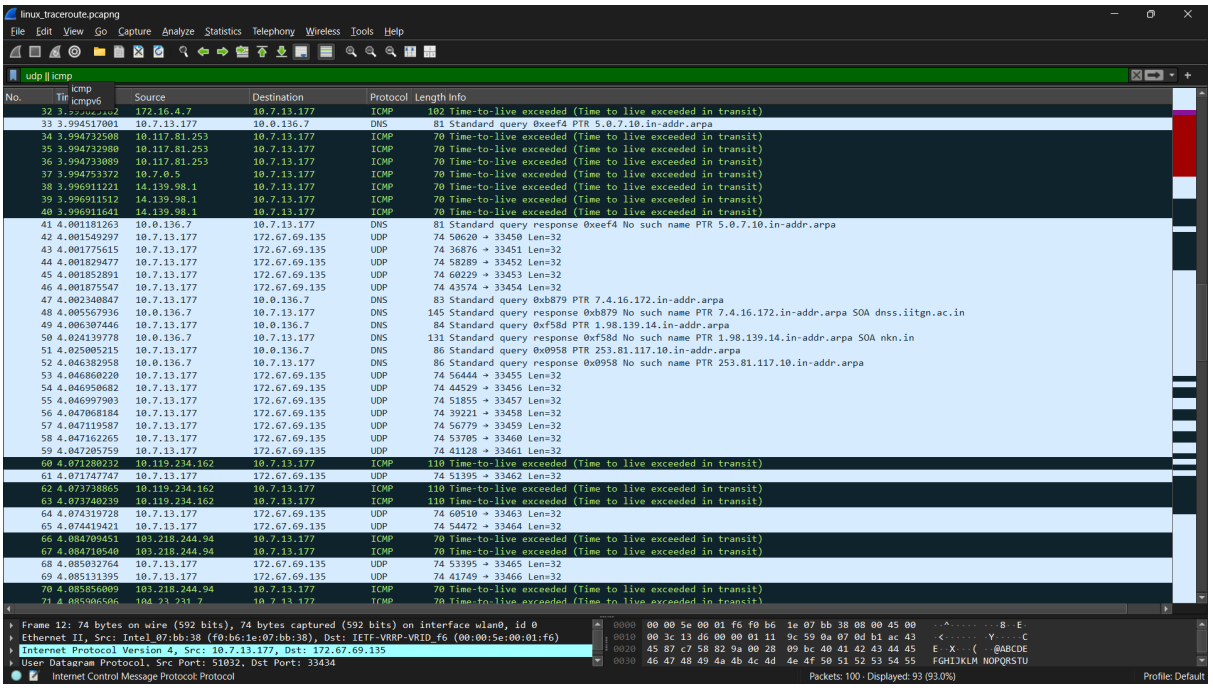
tracert and captured packets in Wireshark for Windows:

```
Tracing route to www.dev.to [172.67.69.135]
over a maximum of 30 hops:

  1     2 ms     2 ms     2 ms  10.7.0.5
  2    10 ms     2 ms     2 ms  172.16.4.7
  3    15 ms     4 ms     3 ms  14.139.98.1
  4    10 ms     2 ms     2 ms  10.117.81.253
  5     *        *        *     Request timed out.
  6     *        *        *     Request timed out.
  7     *        *        *     Request timed out.
  8    21 ms    23 ms    22 ms  10.119.234.162
  9    41 ms    50 ms    47 ms  103.218.244.94
 10    52 ms    34 ms    33 ms  104.23.231.7
 11    37 ms    32 ms    32 ms  172.67.69.135

Trace complete.
```

366	33.017140	10.7.48.124	172.67.69.135	ICMP	106 Echo (ping) request id=0x0001, seq=19/4864, ttl=5 (no response found!)
378	36.720374	10.7.48.124	172.67.69.135	ICMP	106 Echo (ping) request id=0x0001, seq=20/5120, ttl=5 (no response found!)
384	40.719946	10.7.48.124	172.67.69.135	ICMP	106 Echo (ping) request id=0x0001, seq=21/5376, ttl=5 (no response found!)
391	44.726594	10.7.48.124	172.67.69.135	ICMP	106 Echo (ping) request id=0x0001, seq=22/5632, ttl=6 (no response found!)
460	48.719964	10.7.48.124	172.67.69.135	ICMP	106 Echo (ping) request id=0x0001, seq=23/5888, ttl=6 (no response found!)
508	52.712599	10.7.48.124	172.67.69.135	ICMP	106 Echo (ping) request id=0x0001, seq=24/6144, ttl=6 (no response found!)
594	56.723420	10.7.48.124	172.67.69.135	ICMP	106 Echo (ping) request id=0x0001, seq=25/6400, ttl=7 (no response found!)
612	60.710026	10.7.48.124	172.67.69.135	ICMP	106 Echo (ping) request id=0x0001, seq=26/6656, ttl=7 (no response found!)
625	64.723878	10.7.48.124	172.67.69.135	ICMP	106 Echo (ping) request id=0x0001, seq=27/6912, ttl=7 (no response found!)
631	68.712645	10.7.48.124	172.67.69.135	ICMP	106 Echo (ping) request id=0x0001, seq=28/7168, ttl=8 (no response found!)
632	68.734196	10.119.234.162	10.7.48.124	ICMP	110 Time-to-live exceeded (Time to live exceeded in transit)

traceroute and captured packets in Wireshark for Linux:

```
❯ traceroute www.dev.to
traceroute to www.dev.to (172.67.69.135), 30 hops max, 60 byte packets
 1  10.7.0.5 (10.7.0.5)  2.352 ms  2.180 ms  3.247 ms
 2  172.16.4.7 (172.16.4.7)  2.059 ms  2.000 ms  1.945 ms
 3  14.139.98.1 (14.139.98.1)  5.177 ms  5.046 ms  4.979 ms
 4  10.117.81.253 (10.117.81.253)  2.743 ms  2.690 ms  2.597 ms
 5  * * *
 6  * * *
 7  * * *
 8  10.119.234.162 (10.119.234.162)  24.501 ms  26.807 ms  26.757 ms
 9  103.218.244.94 (103.218.244.94)  37.680 ms  37.607 ms  38.709 ms
10  104.23.231.7 (104.23.231.7)  38.716 ms 104.23.231.5 (104.23.231.5)  34.810 ms 104.23.231.7 (104.23.231.7)  34.238 ms
11  172.67.69.135 (172.67.69.135)  36.295 ms  33.222 ms  36.856 ms
```

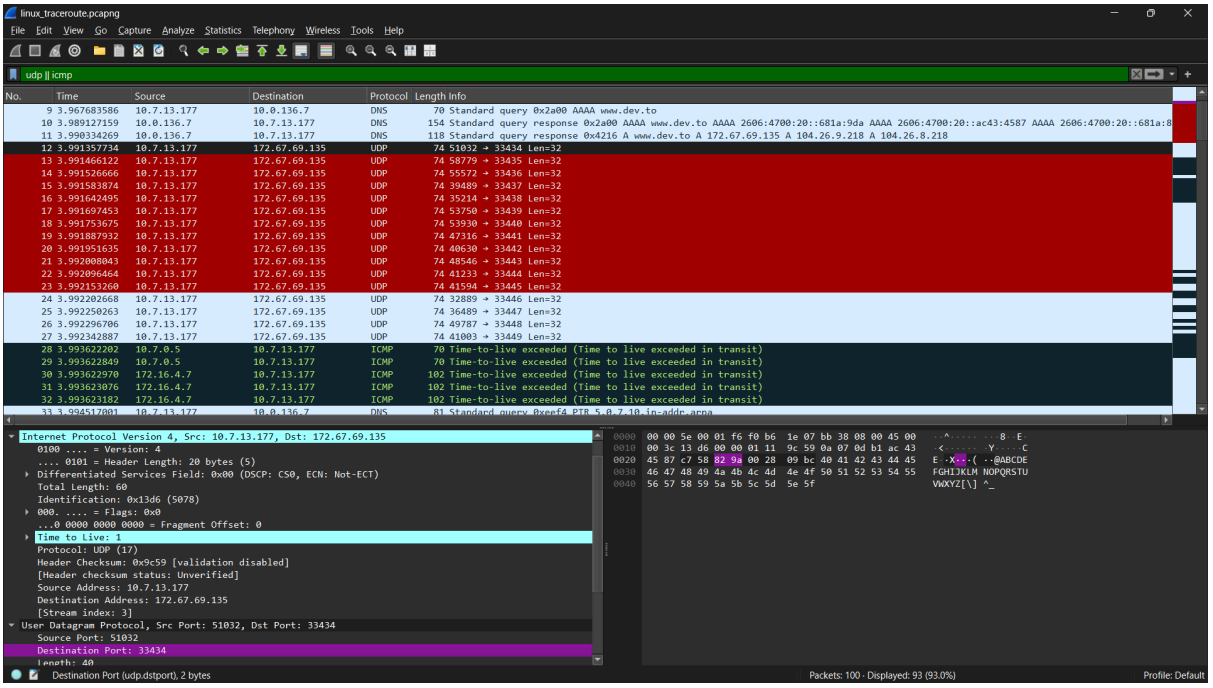


Here we can see that the packets 34, 35, 36 are received from IP 10.117.81.253, which is at hop 4, giving the ICMP TTL exceeded message, and then there is a large gap before it receives the same from the IP of hop 8.

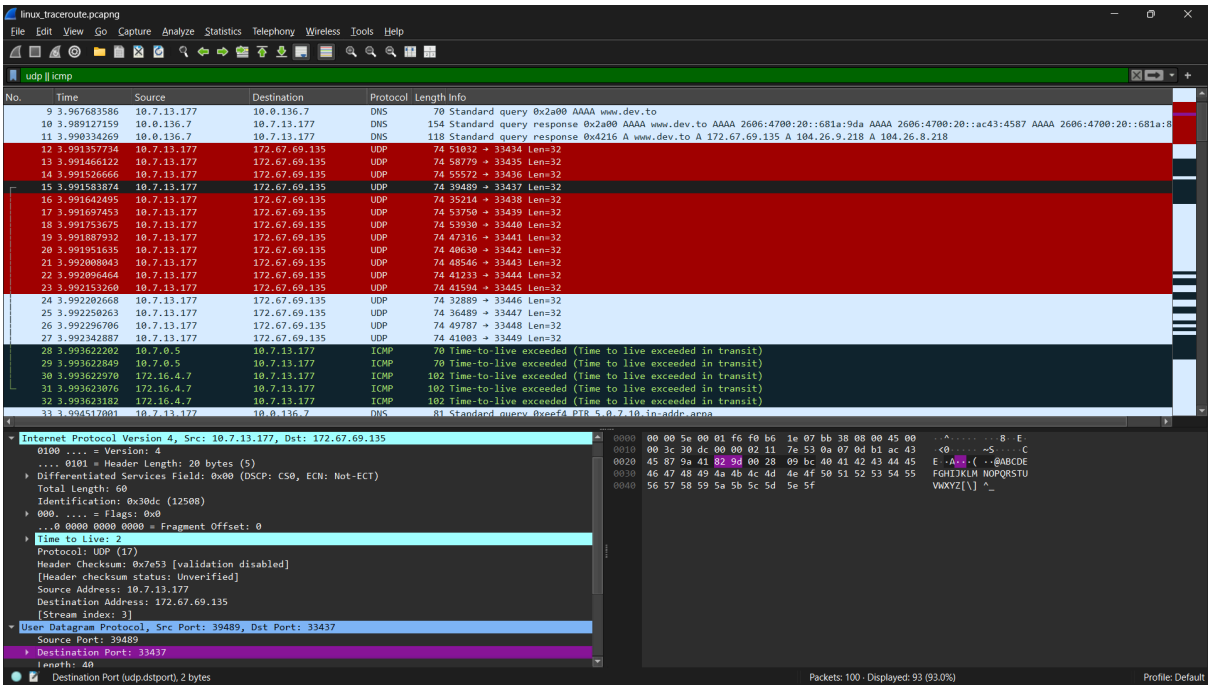
3. In Linux traceroute, which field in the probe packets changes between successive probes sent to the destination?

Ans. In Linux traceroute, two fields change:

- ➔ The TTL (Time-To-Live) field → increments for each hop (1, 2, 3, …).
- ➔ The UDP destination port number → changes for each probe, starting at 33434 and incrementing (33435, 33436, …).



In the above image, we can see that the TTL is 1 and the destination port is 33434 (this is for packet 12, which is the first UDP packet sent of hop 1). And in the below image, we can see that the TTL is 2 and the destination port is 33435 (which is for packet 15, corresponding to the first packet sent of hop 2).



4. At the final hop, how is the response different compared to the intermediate hop?

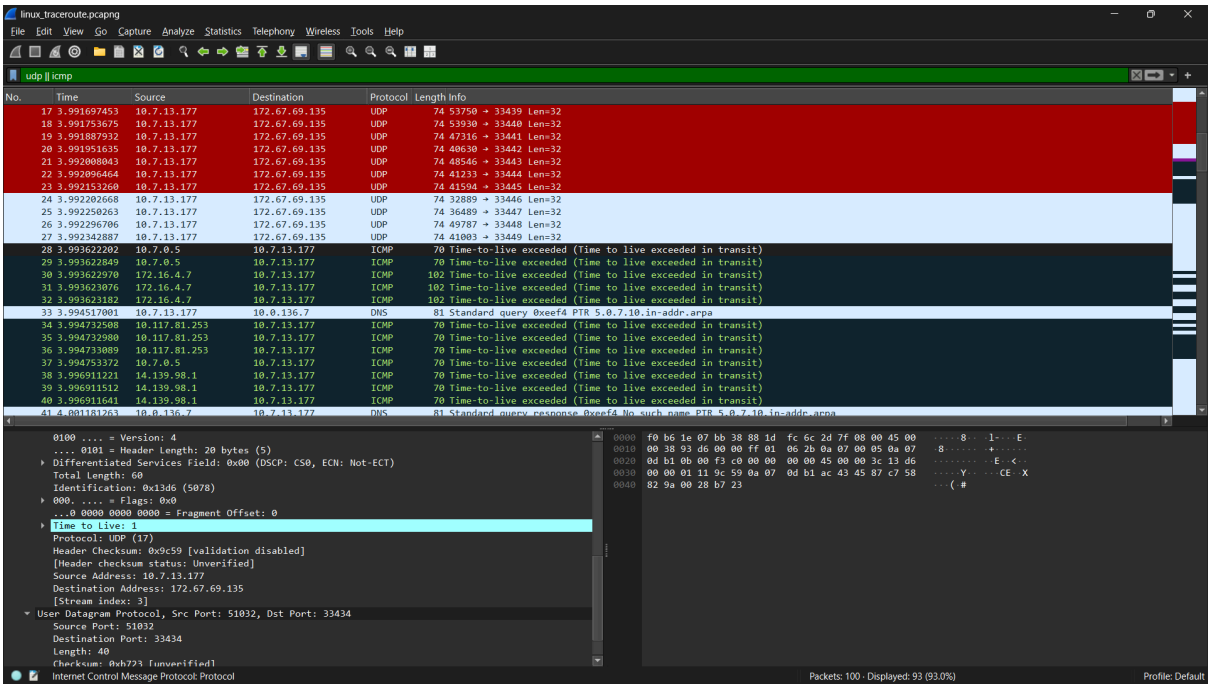
Ans. In Windows, at the final hop, each ICMP echo request of the final hop receives an echo reply from the destination IP.

```
  869 85.607921    10.7.48.124     172.67.69.135   ICMP     106 Echo (ping) request  id=0x0001, seq=37/9472, ttl=11 (reply in 870)
  870 85.645357    172.67.69.135   10.7.48.124     ICMP     106 Echo (ping) reply    id=0x0001, seq=37/9472, ttl=53 (request in 869)
  871 85.646247    10.7.48.124     172.67.69.135   ICMP     106 Echo (ping) request  id=0x0001, seq=38/9728, ttl=11 (reply in 872)
  872 85.678630    172.67.69.135   10.7.48.124     ICMP     106 Echo (ping) reply    id=0x0001, seq=38/9728, ttl=53 (request in 871)
  873 85.679834    10.7.48.124     172.67.69.135   ICMP     106 Echo (ping) request  id=0x0001, seq=39/9984, ttl=11 (reply in 874)
  874 85.711903    172.67.69.135   10.7.48.124     ICMP     106 Echo (ping) reply    id=0x0001, seq=39/9984, ttl=53 (request in 873)
```

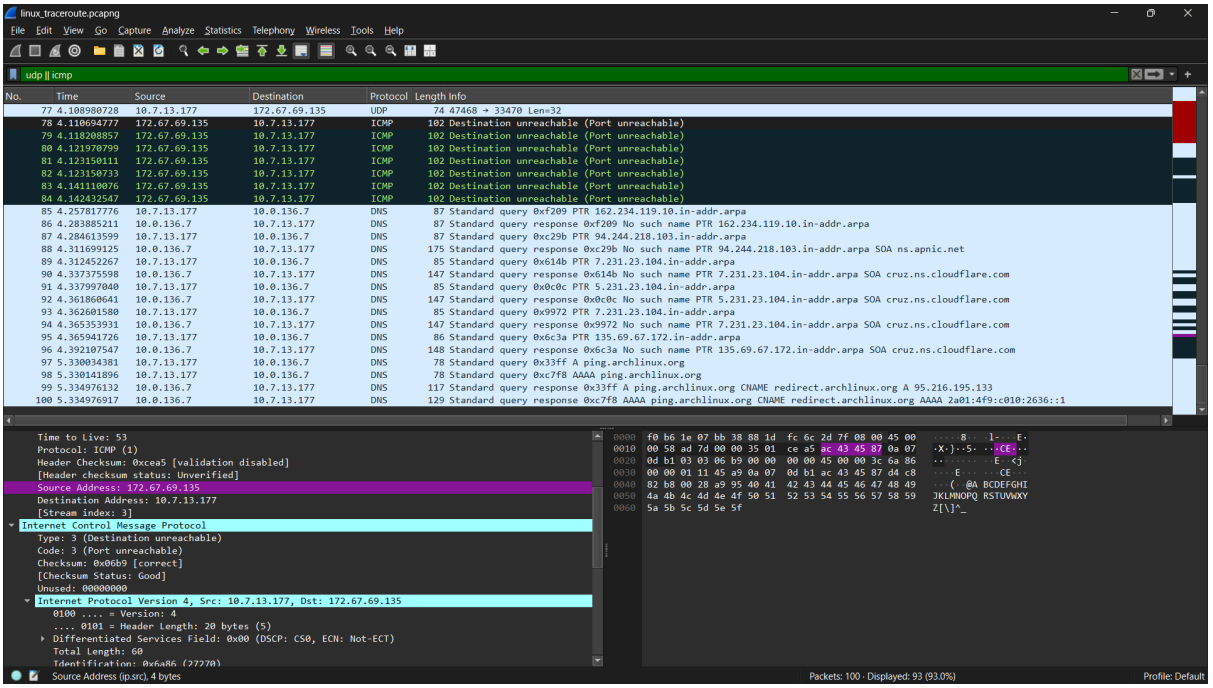
Whereas at the intermediate hops, each ICMP echo request was followed by an ICMP error message saying “Time-to-live exceeded”, as the packets didn’t reach the destination within the fixed TTL.

```
  126 16.303820    10.7.48.124     172.67.69.135   ICMP     106 Echo (ping) request  id=0x0001, seq=10/2560, ttl=2 (no response found!)
  127 16.314366    172.16.4.7      10.7.48.124     ICMP     134 Time-to-live exceeded (Time to live exceeded in transit)
  128 16.316690    10.7.48.124     172.67.69.135   ICMP     106 Echo (ping) request  id=0x0001, seq=11/2816, ttl=2 (no response found!)
  129 16.318724    172.16.4.7      10.7.48.124     ICMP     134 Time-to-live exceeded (Time to live exceeded in transit)
  130 16.319976    10.7.48.124     172.67.69.135   ICMP     106 Echo (ping) request  id=0x0001, seq=12/3072, ttl=2 (no response found!)
  131 16.321826    172.16.4.7      10.7.48.124     ICMP     134 Time-to-live exceeded (Time to live exceeded in transit)
  145 21.889113    10.7.48.124     172.67.69.135   ICMP     106 Echo (ping) request  id=0x0001, seq=13/3328, ttl=3 (no response found!)
  146 21.904199    14.139.98.1     10.7.48.124     ICMP      70 Time-to-live exceeded (Time to live exceeded in transit)
  147 21.906945    10.7.48.124     172.67.69.135   ICMP     106 Echo (ping) request  id=0x0001, seq=14/3584, ttl=3 (no response found!)
  148 21.911332    14.139.98.1     10.7.48.124     ICMP      70 Time-to-live exceeded (Time to live exceeded in transit)
  149 21.912971    10.7.48.124     172.67.69.135   ICMP     106 Echo (ping) request  id=0x0001, seq=15/3840, ttl=3 (no response found!)
  150 21.916788    14.139.98.1     10.7.48.124     ICMP      70 Time-to-live exceeded (Time to live exceeded in transit)
```

Whereas in Linux, at intermediate hops, routers send back ICMP TTL exceeded messages when the TTL reaches zero. We can see that in the image below that packet 28 is the ICMP TTL exceeded message received for our first UDP packet sent on hop 1, which had a TTL of 1 and destination port 33434.



And at the final hop (destination), since the UDP probe reaches the host but no service is listening on the high port, the host replies with an ICMP Port Unreachable error message (Type 3, Code 3). We can see that in the image below, the packet 74 comes straight from our target IP.



5. Suppose a firewall blocks UDP traffic but allows ICMP — how would this affect the results of Linux traceroute vs. Windows tracert?

Ans.

- ➔ Linux traceroute (UDP-based): The probes would never reach the destination. No ICMP Port Unreachable responses would come back, so traceroute would fail or hang.

- ➔ Windows tracert (ICMP-based): It would still work correctly, since ICMP Echo Requests and Replies are allowed through the firewall.

Thus, Windows tracert is more resilient in this scenario.
