Question 1

```
[dxie32@compute ~]$ hostname
compute.gaul.csd.uwo.ca
[dxie32@compute ~]$ host compute.gaul.csd.uwo.ca
compute.gaul.csd.uwo.ca has address 129.100.21.48
[dxie32@compute ~]$
```

1)

Symbolic Name: **compute.gaul.csd.uwo.ca**

IP Address: **129.100.21.48** (Binary: **10**000001.01100100.00010101.00110000)

2)

Class B of IP Address since the first octet (129) starts with **10**.

3)

The prefix (network number) is **129.100** (Binary: 10000001.01100100)

Class B has subnet mask 255.255.0.0. The first two octets denote the network number which is 129.100

4)

Up to $2^{16} - 2$ = **65534** computers can belong to this network

32-16=16 bits for computer numbers. Subtract 2 because the value of all 1s and 0s are reserved for broadcast and network addresses.

Question 2

Generated **30** random IP addresses and issued a **ping** command for each one of these IP addresses:

```
129.100.96.100, 5 packets transmitted, 0 received, 100% packet loss, time 4114 ms
129.100.190.48, 5 packets transmitted, 5 received, 0% packet loss, time 4114 ms
129.100.124.176, 5 packets transmitted, 0 received, 100% packet loss, time 4083 ms
129.100.196.162, 5 packets transmitted, 0 received, 100% packet loss, time 4126 ms
129.100.63.159, 5 packets transmitted, 0 received, 100% packet loss, time 4130 ms
129.100.16.21, 5 packets transmitted, 0 received, 100% packet loss, time 4119 ms
129.100.112.185, 5 packets transmitted, 0 received, 100% packet loss, time 4132 ms
129.100.115.123, 5 packets transmitted, 0 received, 100% packet loss, time 4124 ms
129.100.140.156, 5 packets transmitted, 0 received, 100% packet loss, time 4132 ms
129.100.43.249, 5 packets transmitted, 0 received, 100% packet loss, time 4131 ms
129.100.101.49, 5 packets transmitted, 0 received, 100% packet loss, time 4131 ms
129.100.224.188, 5 packets transmitted, 5 received, 0% packet loss, time 4065 ms
129.100.215.253, 5 packets transmitted, 0 received, 100% packet loss, time 4085 ms
129.100.38.207, 5 packets transmitted, 0 received, 100% packet loss, time 4130 ms
129.100.148.157, 5 packets transmitted, 0 received, 100% packet loss, time 4132 ms
129.100.0.219, 5 packets transmitted, 0 received, 100% packet loss, time 4130 ms
129.100.237.227, 5 packets transmitted, 0 received, 100% packet loss, time 4129 ms
129.100.84.47, 5 packets transmitted, 0 received, 100% packet loss, time 4127 ms
129.100.73.130, 5 packets transmitted, 0 received, 100% packet loss, time 4126 ms
129.100.171.91, 5 packets transmitted, 0 received, 100% packet loss, time 4131 ms
129.100.251.195, 5 packets transmitted, 0 received, 100% packet loss, time 4065 ms
129.100.30.227, 5 packets transmitted, 0 received, 100% packet loss, time 4081 ms
129.100.127.8, 5 packets transmitted, 0 received, 100% packet loss, time 4132 ms
129.100.216.226, 5 packets transmitted, 0 received, 100% packet loss, time 4132 ms
129.100.105.28, 5 packets transmitted, 0 received, 100% packet loss, time 4122 ms
129.100.64.134, 5 packets transmitted, 0 received, 100% packet loss, time 4130 ms
129.100.190.61, 5 packets transmitted, 0 received, 100% packet loss, time 4132 ms
129.100.159.126, 5 packets transmitted, 0 received, 100% packet loss, time 4130 ms
129.100.27.73, 5 packets transmitted, 0 received, 100% packet loss, time 4130 ms
129.100.134.225, 5 packets transmitted, 0 received, 100% packet loss, time 4113 ms
```

(1) First 20 IP Addresses

1. 129.100.96.100, 5 packets transmitted, 0 received, 100% packet loss, time 4114 ms
2. **129.100.190.48, 5 packets transmitted, 5 received, 0% packet loss, time 4114 ms**
3. 129.100.124.176, 5 packets transmitted, 0 received, 100% packet loss, time 4083 ms
4. 129.100.196.162, 5 packets transmitted, 0 received, 100% packet loss, time 4126 ms
5. 129.100.63.159, 5 packets transmitted, 0 received, 100% packet loss, time 4130 ms
6. 129.100.16.21, 5 packets transmitted, 0 received, 100% packet loss, time 4119 ms
7. 129.100.112.185, 5 packets transmitted, 0 received, 100% packet loss, time 4132 ms
8. 129.100.115.123, 5 packets transmitted, 0 received, 100% packet loss, time 4124 ms
9. 129.100.140.156, 5 packets transmitted, 0 received, 100% packet loss, time 4132 ms
10. 129.100.43.249, 5 packets transmitted, 0 received, 100% packet loss, time 4131 ms
11. 129.100.101.49, 5 packets transmitted, 0 received, 100% packet loss, time 4131 ms
12. **129.100.224.188, 5 packets transmitted, 5 received, 0% packet loss, time 4065 ms**
13. 129.100.215.253, 5 packets transmitted, 0 received, 100% packet loss, time 4085 ms
14. 129.100.38.207, 5 packets transmitted, 0 received, 100% packet loss, time 4130 ms
15. 129.100.148.157, 5 packets transmitted, 0 received, 100% packet loss, time 4132 ms
16. 129.100.0.219, 5 packets transmitted, 0 received, 100% packet loss, time 4130 ms
17. 129.100.237.227, 5 packets transmitted, 0 received, 100% packet loss, time 4129 ms
18. 129.100.84.47, 5 packets transmitted, 0 received, 100% packet loss, time 4127 ms
19. 129.100.73.130, 5 packets transmitted, 0 received, 100% packet loss, time 4126 ms
20. 129.100.171.91, 5 packets transmitted, 0 received, 100% packet loss, time 4131 ms

(2) Fraction of addresses that correspond to actual machines: $\mathbf{\frac{2}{30}}$

(3) Estimated Size: $(2^{16} - 2)$ x $\frac{2}{30} \approx$ **4368**

Question 3

```
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1442 qdisc fq_codel state UP group default qlen 1000
    link/ether fa:16:3e:6e:75:82 brd ff:ff:ff:ff:ff:ff
    altname enp3s0
    inet 172.31.100.108/23 brd 172.31.101.255 scope global dynamic noprefixroute eth0
       valid_lft 31821sec preferred_lft 31821sec
    inet6 fe80::1791:f54f:6b0d:ac66/64 scope link noprefixroute
       valid_lft forever preferred_lft forever
```

1)

IP Address in CIDR Notation: **172.31.100.108/23**

2)

IP Address in binary: **10101100.00011111.01100100.01101100**

Network number in binary: **10101100.00011111.0110010**

Computer number in binary: **0.01101100**

3)

$2^9 - 2$ = **510**

Up to **510** computers can belong to the subnetwork

4)

MAC Address (Physical Address): **fa:16:3e:6e:75:82**

Question 4

Web site picked: www.youtube.com

```
[dxie32@compute internetalgo]$ traceroute youtube.com
traceroute to youtube.com (142.251.33.174), 30 hops max, 60 byte packets
 1  _gateway (172.31.100.1)  1.534 ms  1.505 ms  1.491 ms
 2  vlan20-pub1.edge-serv.netmgmt.uwo.pri (129.100.20.1)  16.460 ms  16.449 ms  16.449 ms
 3  172.29.102.169 (172.29.102.169)  2.018 ms  1.997 ms  2.001 ms
 4  uwo-core-ssb.netmgmt.uwo.pri (172.29.102.18)  2.122 ms  2.134 ms  2.110 ms
 5  199.71.2.113 (199.71.2.113)  2.445 ms  2.426 ms  2.386 ms
 6  66.97.23.73 (66.97.23.73)  2.908 ms  1.502 ms  1.495 ms
 7  66.97.16.17 (66.97.16.17)  7.963 ms  7.821 ms  7.820 ms
 8  74.125.48.230 (74.125.48.230)  6.186 ms  6.085 ms  18.410 ms
 9  108.170.250.225 (108.170.250.225)  5.794 ms  5.541 ms 108.170.250.241 (108.170.250.241)  6.480 ms
10  172.253.69.115 (172.253.69.115)  5.706 ms 172.253.69.113 (172.253.69.113)  5.432 ms 172.253.69.115 (172.253.69.115)  5.408 ms
11  yyz10s17-in-f14.1e100.net (142.251.33.174)  5.535 ms  5.280 ms  5.301 ms
```

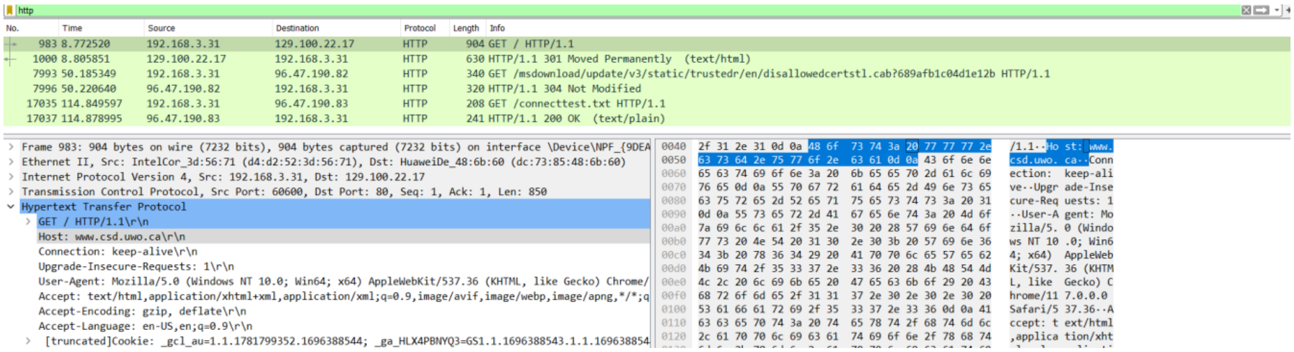
Number of hops between my computer and remote destinations: **11**

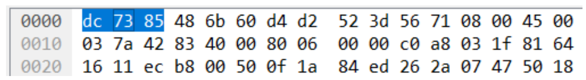
Max number of hops between two computers: **30**

IP Address	**Geographical Location**
172.31.100.1	London, Ontario, Canada
129.100.20.1	London, Ontario, Canada
172.29.102.169	London, Ontario, Canada
172.29.102.18	London, Ontario, Canada
199.71.2.113	London, Ontario, Canada
66.97.23.73	Toronto, Ontario, Canada
66.97.16.17	Toronto, Ontario, Canada
74.125.48.230	Mountain View, California, United States
108.170.250.225	Mountain View, California, United States
172.253.69.115	Mountain View, California, United States
142.251.33.174	Toronto, Ontario, Canada

Question 5

URL: https://www.csd.uwo.ca/





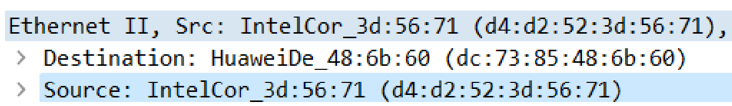
1)

The first 34 bytes of the package in hexadecimal notation:

dc 73 85 48 6b 60 d4 d2 52 3d 56 71 08 00 45 00
03 7a 42 83 40 00 80 06 00 00 c0 a8 03 1f 81 64
16 11

2)

The MAC source address and the MAC destination address contained in the header of the network packet in hexadecimal notation:

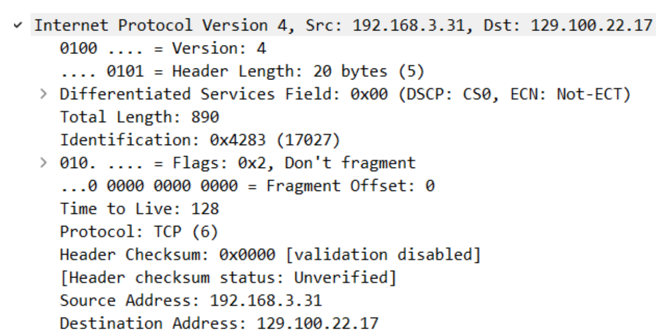


MAC Source Address: **d4:d2:52:3d:56:71**
MAC Destination Address: **dc:73:85:48:6b:60**

3)

Datagram:

(a) Protocol version number: **4**
(b) Header length: **20 bytes**
(c) Total length of datagram: **890**
(d) Time to live: **128**
(e) Source IP address: **192.168.3.31**
Destination IP address: **129.100.22.17**



Question 6

(a) This solution does not guarantee that the messages from A and C will be correctly delivered.

The collision occurred at 4.0 µs, C detected the collision at 4.5 µs. C didn't send a message to A indicating that a collision has taken place. That means A will continues sending incorrect message to D after collision. Therefore, it does not guarantee correct delivery for both messages.

(b) This solution will guarantee that the messages from A and C will be correctly delivered.

In this solution, C stops transmission when it detects a collision, and A stops transmission when it receives a notification message. Both A and C then execute the binary exponential backoff algorithm after a collision occurs. There are two possible cases based on the delay time they select from the set {1 µs, 2 µs, . . ., 9 µs, 10 µs}

Case 1: A's delay time ≥ C's delay time

This case will guarantee correct delivery for both message because A will resend message and it needs at least 8 µs to reach C after the collision:

4 µs get notice after collision + 4 µs message reach C = 8 µs

C has a message of length 8 µs for E. Therefore, before A's message reach C, C already delivered its message to E

Case 2: A's delay time < C's delay time

This case will not cause more collisions only if C waits until A has the full message to pass to D, which means C's delay time minus A's delay time is greater than or equal to 10 µs: *4 µs collision notice + A has a message of length 6 µs for D = 10 µs*

Since the valid delay time range is between 1 µs and the 10 µs, a collision will occur during the first execution of binary exponential backoff algorithm. However, after that, the delay time will be double with each subsequent attempt (*2d*) based on the binary exponential backoff algorithm, therefore, eventually resulting in successful delivery of both messages.

(c) This solution will guarantee that the messages from A and C will be correctly delivered.

In this scenario, C stops transmission when it detects a collision, and A stops transmission when it receives a notification message. Only A executes the binary exponential backoff algorithm after a collision occurs, while C immediately sends a message after detecting the collision.
We can observe that this solution is a special case of solution (b) in which C's delay time is always 0.
As we discussed in the solution (b), and also considering that C always stops transmission once it detects a collision and sends a notification message to A, these factors guarantee that the messages from A and C will be correctly delivered.

Question 7

Received Data:

Red number shows where calculated parity bits disagree, indicating the row and column of the error. The cell highlighted in red is the bit to be changed during transmission.

1	1	0	0
0	**1**	1	1
1	0	1	0
0	1	0	1

Expected:

Since even parity is used, the expected row and column encoding with data bits arranged in a 3 x 3 array and an even parity bit added for each row and each column:

1	1	0	0
0	**0**	1	1
1	0	1	0
0	1	0	1

m = 110001101

Question 8

Destination	Next Hop
129.1.0.0	Deliver direct
194.8.11.0	Deliver direct
192.10.4.0	192.10.4.16
132.32.0.0	132.32.21.22
164.80.0.0	132.32.21.22
196.3.7.0	132.32.21.22

Question 9

<u>Network 1 packet:</u>

MAC A, MAC R1	Data

Data:

IP A, IP B	120 bytes

Total Length: 120 + 20 + 20 = 160 bytes

<u>Network 2 packets:</u>

Packet 1:

MAC R1, MAC R2	Data

Data:

IP A, IP B	60 bytes

Total Length: 60 + 20 + 20 = 100 bytes

Packet 2:

MAC R1, MAC R2	Data

Data:

IP A, IP B	60 bytes

Total Length: 60 + 20 + 20 = 100 bytes

<u>Network 3 packets:</u>

Packet 1:

MAC R2, MAC B	Data

Data:

IP A, IP B	60 bytes

Total Length: 60 + 20 + 20 = 100 bytes

Packet 2:

MAC R2, MAC B	Data

Data:

IP R2, IP B	60 bytes

Total Length: 60 + 20 + 20 = 100 bytes