COMP9331 - Lab1

Exercise 1: nslookup (Not Marked)

Use the nslookup command from the "Tools of the Trade" and answer the following questions:

1. Which is the IP address of the website www.telstra.com.au? In your opinion, what is the reason for having several IP addresses as an output? You can ignore any IPv6 addresses.

```
z5484442@vx22:~$ nslookup www.telstra.com.au
Server:         129.94.242.2
Address:        129.94.242.2#53

Non-authoritative answer:
www.telstra.com.au      canonical name = d2l3pjybjlbg0l.cloudfront.net.
Name:   d2l3pjybjlbg0l.cloudfront.net
Address: 108.158.32.71
Name:   d2l3pjybjlbg0l.cloudfront.net
Address: 108.158.32.129
Name:   d2l3pjybjlbg0l.cloudfront.net
Address: 108.158.32.35
Name:   d2l3pjybjlbg0l.cloudfront.net
Address: 108.158.32.85
Name:   d2l3pjybjlbg0l.cloudfront.net
Address: 2600:9000:277c:9800:17:876d:b540:93a1
Name:   d2l3pjybjlbg0l.cloudfront.net
Address: 2600:9000:277c:4600:17:876d:b540:93a1
Name:   d2l3pjybjlbg0l.cloudfront.net
Address: 2600:9000:277c:3000:17:876d:b540:93a1
Name:   d2l3pjybjlbg0l.cloudfront.net
Address: 2600:9000:277c:b000:17:876d:b540:93a1
Name:   d2l3pjybjlbg0l.cloudfront.net
Address: 2600:9000:277c:2a00:17:876d:b540:93a1
Name:   d2l3pjybjlbg0l.cloudfront.net
Address: 2600:9000:277c:ac00:17:876d:b540:93a1
Name:   d2l3pjybjlbg0l.cloudfront.net
Address: 2600:9000:277c:4000:17:876d:b540:93a1
Name:   d2l3pjybjlbg0l.cloudfront.net
Address: 2600:9000:277c:9400:17:876d:b540:93a1
```

   Answer: The IPv4 addresses listed are: 108.158.32.71; 108.158.32.129; 108.158.32.35; 108.158.32.85. Multiple IP addresses appear because the website is served through CDN which distributes content through various servers around the world. It helps with the performance, availability, and reliability of the website.

2. Find out the name of the IP address 127.0.0.1. What is special about this IP address?

```
z5484442@vx22:~$ nslookup 127.0.0.1
1.0.0.127.in-addr.arpa  name = localhost.
```

   Answer: The name of the IP address 127.0.0.1 is localhost. This address is special because it's primarily used for testing and troubleshooting network applications locally, ensuring that the TCP/IP stack is working correctly.

Exercise 2: Use ping to test host reachability (2 marks. 0.2 per each host)

Are the following hosts reachable from your machine by using ping:

If you observe that some hosts are unreachable, can you explain why? Check if the addresses unreachable by the ping command are reachable from the Web browser.

- www.google.co.uk

```
z5484442@vx22:~$ ping www.google.co.uk
PING www.google.co.uk (142.250.71.67) 56(84) bytes of data.
64 bytes from syd15s17-in-f3.1e100.net (142.250.71.67): icmp_seq=1 ttl=117 time=1.09 ms
64 bytes from syd15s17-in-f3.1e100.net (142.250.71.67): icmp_seq=2 ttl=117 time=1.34 ms
64 bytes from syd15s17-in-f3.1e100.net (142.250.71.67): icmp_seq=3 ttl=117 time=1.43 ms
64 bytes from syd15s17-in-f3.1e100.net (142.250.71.67): icmp_seq=4 ttl=117 time=1.45 ms
64 bytes from syd15s17-in-f3.1e100.net (142.250.71.67): icmp_seq=5 ttl=117 time=1.54 ms
64 bytes from syd15s17-in-f3.1e100.net (142.250.71.67): icmp_seq=6 ttl=117 time=1.46 ms
64 bytes from syd15s17-in-f3.1e100.net (142.250.71.67): icmp_seq=7 ttl=117 time=1.21 ms
64 bytes from syd15s17-in-f3.1e100.net (142.250.71.67): icmp_seq=8 ttl=117 time=1.48 ms
64 bytes from syd15s17-in-f3.1e100.net (142.250.71.67): icmp_seq=9 ttl=117 time=1.13 ms
64 bytes from syd15s17-in-f3.1e100.net (142.250.71.67): icmp_seq=10 ttl=117 time=1.36 ms
64 bytes from syd15s17-in-f3.1e100.net (142.250.71.67): icmp_seq=11 ttl=117 time=1.28 ms
^C
--- www.google.co.uk ping statistics ---
11 packets transmitted, 11 received, 0% packet loss, time 10011ms
rtt min/avg/max/mdev = 1.089/1.342/1.537/0.142 ms
```

- www.utoronto.ca

```
z5484442@vx22:~$ ping www.utoronto.ca
PING www.utoronto.ca (23.185.0.1) 56(84) bytes of data.
64 bytes from 23.185.0.1 (23.185.0.1): icmp_seq=1 ttl=58 time=1.25 ms
64 bytes from 23.185.0.1 (23.185.0.1): icmp_seq=2 ttl=58 time=0.876 ms
64 bytes from 23.185.0.1 (23.185.0.1): icmp_seq=3 ttl=58 time=1.04 ms
64 bytes from 23.185.0.1 (23.185.0.1): icmp_seq=4 ttl=58 time=1.02 ms
64 bytes from 23.185.0.1 (23.185.0.1): icmp_seq=5 ttl=58 time=1.01 ms
64 bytes from 23.185.0.1 (23.185.0.1): icmp_seq=6 ttl=58 time=0.998 ms
64 bytes from 23.185.0.1 (23.185.0.1): icmp_seq=7 ttl=58 time=0.947 ms
64 bytes from 23.185.0.1 (23.185.0.1): icmp_seq=8 ttl=58 time=1.25 ms
64 bytes from 23.185.0.1 (23.185.0.1): icmp_seq=9 ttl=58 time=1.05 ms
64 bytes from 23.185.0.1 (23.185.0.1): icmp_seq=10 ttl=58 time=0.908 ms
^C
--- www.utoronto.ca ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9049ms
rtt min/avg/max/mdev = 0.876/1.034/1.251/0.120 ms
```

- www.cloudflare.com

```
z5484442@vx22:~$ ping www.cloudflare.com
PING www.cloudflare.com (104.16.124.96) 56(84) bytes of data.
64 bytes from 104.16.124.96 (104.16.124.96): icmp_seq=1 ttl=56 time=1.06 ms
64 bytes from 104.16.124.96 (104.16.124.96): icmp_seq=2 ttl=56 time=1.50 ms
64 bytes from 104.16.124.96 (104.16.124.96): icmp_seq=3 ttl=56 time=1.06 ms
64 bytes from 104.16.124.96 (104.16.124.96): icmp_seq=4 ttl=56 time=1.14 ms
64 bytes from 104.16.124.96 (104.16.124.96): icmp_seq=5 ttl=56 time=1.23 ms
64 bytes from 104.16.124.96 (104.16.124.96): icmp_seq=6 ttl=56 time=1.19 ms
64 bytes from 104.16.124.96 (104.16.124.96): icmp_seq=7 ttl=56 time=1.10 ms
64 bytes from 104.16.124.96 (104.16.124.96): icmp_seq=8 ttl=56 time=1.21 ms
64 bytes from 104.16.124.96 (104.16.124.96): icmp_seq=9 ttl=56 time=1.10 ms
64 bytes from 104.16.124.96 (104.16.124.96): icmp_seq=10 ttl=56 time=1.15 ms
^C
--- www.cloudflare.com ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9008ms
rtt min/avg/max/mdev = 1.059/1.173/1.497/0.121 ms
```

- ec.ho

```
z5484442@vx22:~$ ping ec.ho
ping: ec.ho: Name or service not known
```

- west.cn

```
z5484442@vx22:~$ ping west.cn
PING west.cn (60.247.168.229) 56(84) bytes of data.
64 bytes from 60.247.168.229 (60.247.168.229): icmp_seq=1 ttl=41 time=270 ms
64 bytes from 60.247.168.229 (60.247.168.229): icmp_seq=2 ttl=41 time=270 ms
64 bytes from 60.247.168.229 (60.247.168.229): icmp_seq=4 ttl=41 time=273 ms
64 bytes from 60.247.168.229 (60.247.168.229): icmp_seq=6 ttl=41 time=270 ms
64 bytes from 60.247.168.229 (60.247.168.229): icmp_seq=8 ttl=41 time=269 ms
64 bytes from 60.247.168.229 (60.247.168.229): icmp_seq=9 ttl=41 time=270 ms
64 bytes from 60.247.168.229 (60.247.168.229): icmp_seq=12 ttl=41 time=273 ms
64 bytes from 60.247.168.229 (60.247.168.229): icmp_seq=13 ttl=41 time=269 ms
64 bytes from 60.247.168.229 (60.247.168.229): icmp_seq=14 ttl=41 time=270 ms
64 bytes from 60.247.168.229 (60.247.168.229): icmp_seq=16 ttl=41 time=273 ms
^C
--- west.cn ping statistics ---
16 packets transmitted, 10 received, 37.5% packet loss, time 17056ms
rtt min/avg/max/mdev = 269.219/270.596/272.940/1.457 ms
```

- defence.gov.au

```
z5484442@vx22:~$ ping defence.gov.au
PING defence.gov.au (13.236.242.190) 56(84) bytes of data.
^C
--- defence.gov.au ping statistics ---
41 packets transmitted, 0 received, 100% packet loss, time 40533ms
```

- yes.no

```
z5484442@vx22:~$ ping yes.no
PING yes.no (141.193.213.11) 56(84) bytes of data.
64 bytes from 141.193.213.11 (141.193.213.11): icmp_seq=1 ttl=56 time=1.36 ms
64 bytes from 141.193.213.11 (141.193.213.11): icmp_seq=2 ttl=56 time=1.87 ms
64 bytes from 141.193.213.11 (141.193.213.11): icmp_seq=3 ttl=56 time=1.46 ms
64 bytes from 141.193.213.11 (141.193.213.11): icmp_seq=4 ttl=56 time=1.42 ms
64 bytes from 141.193.213.11 (141.193.213.11): icmp_seq=5 ttl=56 time=1.49 ms
64 bytes from 141.193.213.11 (141.193.213.11): icmp_seq=6 ttl=56 time=1.71 ms
64 bytes from 141.193.213.11 (141.193.213.11): icmp_seq=7 ttl=56 time=1.44 ms
64 bytes from 141.193.213.11 (141.193.213.11): icmp_seq=8 ttl=56 time=1.48 ms
64 bytes from 141.193.213.11 (141.193.213.11): icmp_seq=9 ttl=56 time=1.67 ms
64 bytes from 141.193.213.11 (141.193.213.11): icmp_seq=10 ttl=56 time=1.50 ms
^C
--- yes.no ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9008ms
rtt min/avg/max/mdev = 1.363/1.540/1.867/0.149 ms
```

- one.one.one.one

```
z5484442@vx22:~$ ping one.one.one.one
PING one.one.one.one (1.1.1.1) 56(84) bytes of data.
64 bytes from one.one.one.one (1.1.1.1): icmp_seq=1 ttl=56 time=1.43 ms
64 bytes from one.one.one.one (1.1.1.1): icmp_seq=2 ttl=56 time=1.63 ms
64 bytes from one.one.one.one (1.1.1.1): icmp_seq=3 ttl=56 time=1.92 ms
64 bytes from one.one.one.one (1.1.1.1): icmp_seq=4 ttl=56 time=1.63 ms
64 bytes from one.one.one.one (1.1.1.1): icmp_seq=5 ttl=56 time=1.46 ms
64 bytes from one.one.one.one (1.1.1.1): icmp_seq=6 ttl=56 time=1.72 ms
64 bytes from one.one.one.one (1.1.1.1): icmp_seq=7 ttl=56 time=1.58 ms
64 bytes from one.one.one.one (1.1.1.1): icmp_seq=8 ttl=56 time=1.61 ms
64 bytes from one.one.one.one (1.1.1.1): icmp_seq=9 ttl=56 time=1.63 ms
64 bytes from one.one.one.one (1.1.1.1): icmp_seq=10 ttl=56 time=1.63 ms
^C
--- one.one.one.one ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9004ms
rtt min/avg/max/mdev = 1.428/1.622/1.920/0.127 ms
```

- theguardian.com

```
z5484442@vx22:~$ ping theguardian.com
PING theguardian.com (151.101.65.111) 56(84) bytes of data.
64 bytes from 151.101.65.111 (151.101.65.111): icmp_seq=1 ttl=57 time=1.10 ms
64 bytes from 151.101.65.111 (151.101.65.111): icmp_seq=2 ttl=57 time=1.16 ms
64 bytes from 151.101.65.111 (151.101.65.111): icmp_seq=3 ttl=57 time=1.19 ms
64 bytes from 151.101.65.111 (151.101.65.111): icmp_seq=4 ttl=57 time=1.10 ms
64 bytes from 151.101.65.111 (151.101.65.111): icmp_seq=5 ttl=57 time=0.940 ms
64 bytes from 151.101.65.111 (151.101.65.111): icmp_seq=6 ttl=57 time=1.14 ms
64 bytes from 151.101.65.111 (151.101.65.111): icmp_seq=7 ttl=57 time=1.04 ms
64 bytes from 151.101.65.111 (151.101.65.111): icmp_seq=8 ttl=57 time=1.32 ms
64 bytes from 151.101.65.111 (151.101.65.111): icmp_seq=9 ttl=57 time=1.20 ms
64 bytes from 151.101.65.111 (151.101.65.111): icmp_seq=10 ttl=57 time=0.928 ms
^C
--- theguardian.com ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9006ms
rtt min/avg/max/mdev = 0.928/1.111/1.321/0.113 ms
```

- xn--i-7iq.ws

```
z5484442@vx22:~$ ping xn--i-7iq.ws
PING i❤.ws (132.148.137.119) 56(84) bytes of data.
64 bytes from 119.137.148.132.host.secureserver.net (132.148.137.119): icmp_seq=1 ttl=48 time=269 ms
64 bytes from 119.137.148.132.host.secureserver.net (132.148.137.119): icmp_seq=2 ttl=48 time=270 ms
64 bytes from 119.137.148.132.host.secureserver.net (132.148.137.119): icmp_seq=3 ttl=48 time=270 ms
64 bytes from 119.137.148.132.host.secureserver.net (132.148.137.119): icmp_seq=4 ttl=48 time=270 ms
64 bytes from 119.137.148.132.host.secureserver.net (132.148.137.119): icmp_seq=5 ttl=48 time=270 ms
64 bytes from 119.137.148.132.host.secureserver.net (132.148.137.119): icmp_seq=6 ttl=48 time=270 ms
64 bytes from 119.137.148.132.host.secureserver.net (132.148.137.119): icmp_seq=7 ttl=48 time=270 ms
64 bytes from 119.137.148.132.host.secureserver.net (132.148.137.119): icmp_seq=8 ttl=48 time=270 ms
64 bytes from 119.137.148.132.host.secureserver.net (132.148.137.119): icmp_seq=9 ttl=48 time=270 ms
64 bytes from 119.137.148.132.host.secureserver.net (132.148.137.119): icmp_seq=10 ttl=48 time=270 ms
^C
--- i❤.ws ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9008ms
rtt min/avg/max/mdev = 269.466/269.653/269.828/0.110 ms
```

Answer: In conclusion, *www.google.co.uk*; *www.utoronto.ca*; *www.cloudflare.com*; *west.cn; yes.no; one.one.one.one; theguardian.com; xn--i-7iq.ws* are reachable. *ec.ho; defence.gov.au* are unreachable by ping.

Potential reasons for unreachability, for *ec.ho*, “Name or service not known” shows that the DNS lookup failed. This likely means that *ec.ho* is not a registered domain or is not correctly configured. For *defence.gov.au*, some government sites block ICMP (ping) traffic as a security measure to reduce the risk of attacks on the network. Although the

ping method fails, the website possibly be accessible via HTTP/HTTPS from a web browser, *defence.gov.au* can be accessed through web browser.

Exercise 3: Use traceroute to understand the network topology (4 marks)

1. Run traceroute (s) on your machine to uzh.ch **(NOT www.uzh.ch).** You might have slightly different outputs, and your tutor will explain why.

```
z5484442@vx22:~$ traceroute uzh.ch
traceroute to uzh.ch (130.60.184.132), 30 hops max, 60 byte packets
 1  cserouter1-server.orchestra.cse.unsw.EDU.AU (129.94.242.251)  0.069 ms  0.046 ms  0.091 ms
 2  unsw-gateway.orchestra.cse.unsw.EDU.AU (129.94.39.17)  0.690 ms  0.701 ms  0.760 ms
 3  172.17.47.2 (172.17.47.2)  8.889 ms  6.775 ms  6.817 ms
 4  172.17.17.45 (172.17.17.45)  0.901 ms 172.17.17.9 (172.17.17.9)  1.104 ms 172.17.17.45 (172.17.17.45)  0.896 ms
 5  172.17.17.33 (172.17.17.33)  1.045 ms 138.44.18.70 (138.44.18.70)  1.300 ms  1.297 ms
 6  138.44.18.70 (138.44.18.70)  1.246 ms  1.201 ms  0.967 ms
 7  138.44.226.17 (138.44.226.17)  360.096 ms  360.025 ms  359.992 ms
 8  lag-1-0.rt0.lon.uk.geant.net (62.40.98.60)  360.311 ms  360.154 ms  360.145 ms
 9  lag-1-0.rt0.lon.uk.geant.net (62.40.98.60)  360.062 ms lag-2-0.rt0.lon2.uk.geant.net (62.40.98.65)  361.130 ms  360.888 ms
10  lag-2-0.rt0.lon2.uk.geant.net (62.40.98.65)  360.902 ms lag-8-0.rt0.par.fr.geant.net (62.40.98.107)  362.763 ms lag-2-0.rt0.lon2.uk.geant.net (62.40.98.65)  360.984 ms
11  lag-8-0.rt0.par.fr.geant.net (62.40.98.107)  362.781 ms  362.594 ms  362.820 ms
12  lag-7-0.rt0.gen.ch.geant.net (62.40.98.238)  370.963 ms  370.953 ms ae3-0.mx1.gen.ch.geant.net (62.40.98.76)  370.713 ms
13  ae3-0.mx1.gen.ch.geant.net (62.40.98.76)  370.948 ms  371.012 ms swice1-100ge-0-3-0-1.switch.ch (62.40.124.22)  373.509 ms
14  swice1-100ge-0-3-0-1.switch.ch (62.40.124.22)  373.495 ms  373.454 ms swiCE1-400GE-0-0-0-0.switch.ch (130.59.37.34)  372.399 ms
15  swiEZ2-400GE-0-0-0-0.switch.ch (130.59.38.81)  377.088 ms swiCE1-400GE-0-0-0-0.switch.ch (130.59.37.34)  372.491 ms swiEZ2-400GE-0-0-0-0.switch.ch (130.59.38.81)  376.824 ms
16  swiEZ2-400GE-0-0-0-0.switch.ch (130.59.38.81)  375.485 ms  375.327 ms swiZH2-400GE-0-0-0-14.switch.ch (130.59.36.190)  376.649 ms
17  swiZH3-B2.switch.ch (130.59.37.170)  375.312 ms  374.975 ms  375.274 ms
18  swiZH3-B2.switch.ch (130.59.37.170)  375.372 ms  375.411 ms  375.149 ms
19  uzhix1-eth5-1.uzh.ch (192.41.136.2)  375.410 ms * *
20  * * *
21  * * *
22  * * *
23  * * *
24  * * *
25  * * *
26  * * *
27  * * *
28  * * *
29  * * *
30  * * *
```

1. How many routers are there between your workstation and uzh.ch? How many routers along the path are part of the UNSW network?

```
z5484442@vx22:~$ traceroute 138.44.226.17
traceroute to 138.44.226.17 (138.44.226.17), 30 hops max, 60 byte packets
 1  cserouter1-server.orchestra.cse.unsw.EDU.AU (129.94.242.251)  0.052 ms  0.049 ms  0.035 ms
 2  unsw-gateway.orchestra.cse.unsw.EDU.AU (129.94.39.17)  0.740 ms  0.440 ms  0.681 ms
 3  172.17.47.2 (172.17.47.2)  1.525 ms  1.533 ms  1.607 ms
 4  172.17.17.9 (172.17.17.9)  0.923 ms  1.174 ms 172.17.17.45 (172.17.17.45)  1.141 ms
 5  138.44.18.70 (138.44.18.70)  1.192 ms 172.17.17.33 (172.17.17.33)  0.852 ms 138.44.18.70 (138.44.18.70)  1.145 ms
 6  * 138.44.18.70 (138.44.18.70)  1.127 ms *
 7  et-2-0-5.bdr1.sing.sin.aarnet.net.au (113.197.15.233)  92.616 ms  92.543 ms  92.345 ms
```

Answer: The traceroute output shows 19 hops in total, where hop 19 (uzhix1-eth5-1.uzh.ch) is the destination. This means there are 18 intermediate routers between the workstation and uzh.ch. While sometimes additional hops (with no responses) might be shown after the destination. Hops 1 through 6 are part of the UNSW network (with UNSW domain names or internal IP used within UNSW. And the traffic leaves the UNSW network at hop 7. Thus, 6 routers along the path are part of the UNSW network.

2. Which router is the first router outside of Australia?

```
z5484442@vx22:~$ nslookup 113.197.15.233
233.15.197.113.in-addr.arpa     name = et-2-0-5.bdr1.sing.sin.aarnet.net.au.
```

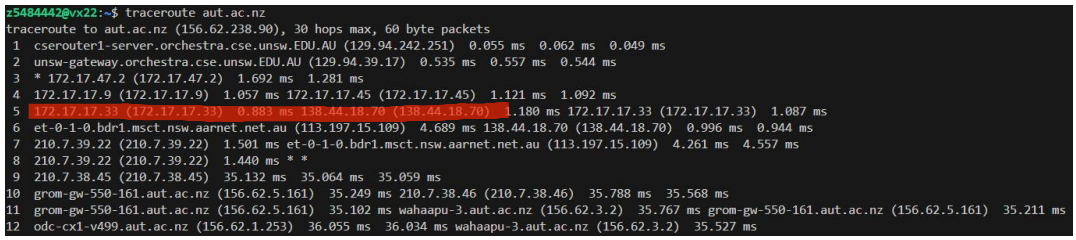
Answer: It shows that the IP 113.197.15.233 is associated with the hostname et-2-0-5.bdr1.sing.sin.aarnet.net.au. The hostname shows that this router is in Singapore. Therefore, the first router outside of Australia along the path is 113.197.15.233 (et-2-0-5.bdr1.sing.sin.aarnet.net.au).

3. Which router is the first router to be found in UK?

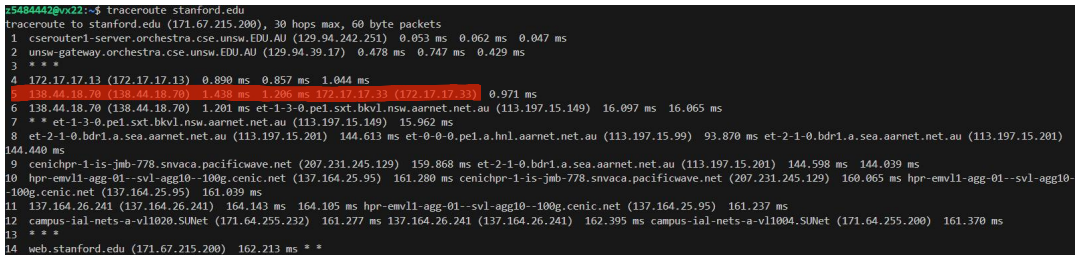
Answer: The first router that appears to be in the UK is lag-1-0.rt0.lon.uk.geant.net (62.40.98.60). The hostname includes "lon.uk," which indicates it is in London, United Kingdom. The round-trip times jump from around 1ms in the UNSW network to approximately 360ms at hop 8, indicates an international link.

2. Run a traceroute from your machine to the following destinations:

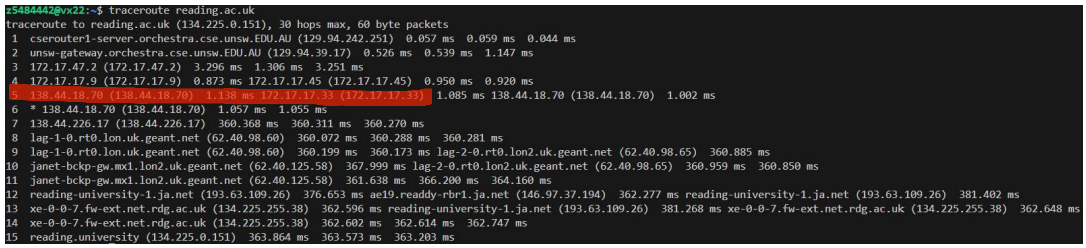
(i) aut.ac.nz



(ii) stanford.edu



(iii) reading.ac.uk



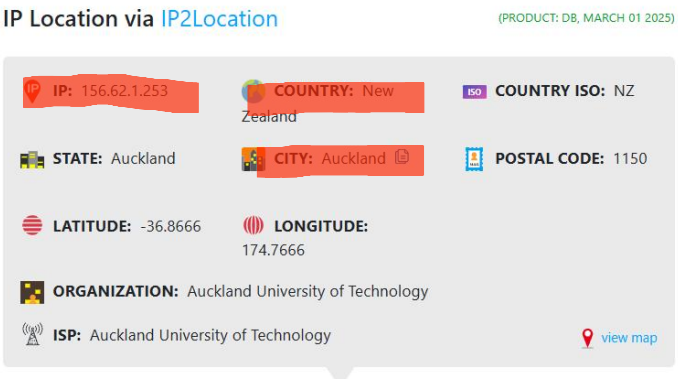
1. At which router do the paths from your machine to these three destinations diverge (i.e. which is the last router they have in common)? Find out further details about this router.

```
z5484442@vx22:~$ whois 138.44.18.70

#
# ARIN WHOIS data and services are subject to the Terms of Use
# available at: https://www.arin.net/resources/registry/whois/tou/
#
# If you see inaccuracies in the results, please report at
# https://www.arin.net/resources/registry/whois/inaccuracy_reporting/
#
# Copyright 1997-2025, American Registry for Internet Numbers, Ltd.
#


NetRange:       138.44.0.0 - 138.44.255.255
CIDR:           138.44.0.0/16
NetName:        APNIC-ERX-138-44-0-0
NetHandle:      NET-138-44-0-0-1
Parent:         NET138 (NET-138-0-0-0-0)
NetType:        Early Registrations, Transferred to APNIC
OriginAS:
Organization:   Asia Pacific Network Information Centre (APNIC)
RegDate:        2003-12-11
Updated:        2009-10-08
Comment:        This IP address range is not registered in the ARIN database.
Comment:        This range was transferred to the APNIC Whois Database as
Comment:        part of the ERX (Early Registration Transfer) project.
Comment:        For details, refer to the APNIC Whois Database via
Comment:        WHOIS.APNIC.NET or http://wq.apnic.net/apnic-bin/whois.pl
Comment:
Comment:        ** IMPORTANT NOTE: APNIC is the Regional Internet Registry
Comment:        for the Asia Pacific region.  APNIC does not operate networks
Comment:        using this IP address range and is not able to investigate
Comment:        spam or abuse reports relating to these addresses.  For more
Comment:        help, refer to http://www.apnic.net/apnic-info/whois_search2/abuse-and-spamming
Ref:            https://rdap.arin.net/registry/ip/138.44.0.0

ResourceLink:  https://apps.db.ripe.net/db-web-ui/query
ResourceLink:  whois.apnic.net
```

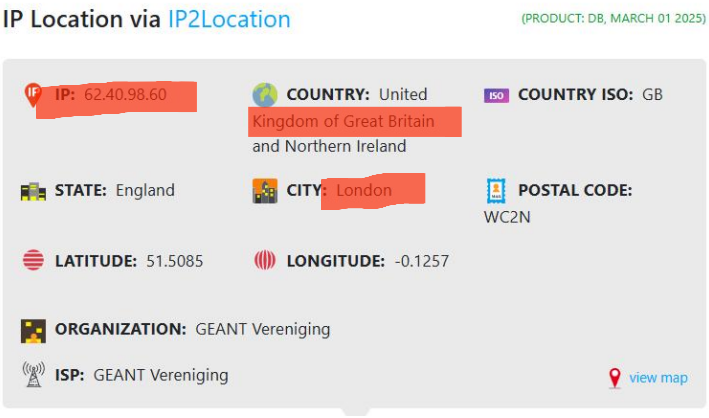
Answer: All three traceroutes show the same internal router at hop 5 which displays both 138.44.18.70, before the paths begin to diverge. Thus, 138.44.18.70 is the last router that is common to the paths to *aut.ac.nz, stanford.edu, and reading.ac.uk.* Further details as follows, 138.44.18.70 falls within the 138.44.0.0/16 block, which is allocated to the Australian Academic and Research Network (AARNET). Physical address listed as “Building 9, Banks Street” in Australia.

2. Is the number of hops on each path proportional to the physical distance?

Hop 12 (156.62.1.253) for aut.ac.nz at Auckland, NZ



Hop 8 (62.40.98.60) for reading.ac.uk at London, UK



Answer: No, the number of hops isn't directly proportional to the physical distance between endpoints. Each hop can represent a link that covers a very different physical distance. While more hops can sometimes indicate a more complex route, they do not provide a reliable measure of how far in terms of physical distance the data has traveled.

3. Several servers are distributed worldwide to provide a web interface from which you can perform a traceroute to any other host on the Internet. Here are two examples: (i) http://lg.nexlinx.net.pk/ and (ii) www.as13030.net/traceroute.php .

    1. Run a traceroute from both these servers towards your machine and in the reverse direction (from your machine to these servers) What are the IP addresses of the two servers that you have chosen?

    lg.nexlinx.net.pk

```
z5484442@vx22:~$ traceroute lg.nexlinx.net.pk
traceroute to lg.nexlinx.net.pk (202.59.80.52), 30 hops max, 60 byte packets
 1  cserouter1-server.orchestra.cse.unsw.EDU.AU (129.94.242.251)  0.069 ms  0.058 ms  0.048 ms
 2  unsw-gateway.orchestra.cse.unsw.EDU.AU (129.94.39.17)  0.519 ms  0.515 ms  0.501 ms
 3  172.17.47.2 (172.17.47.2)  1.297 ms  1.294 ms  1.807 ms
 4  172.17.17.45 (172.17.17.45)  1.054 ms  1.064 ms  1.025 ms
 5  138.44.18.70 (138.44.18.70)  1.232 ms 172.17.17.33 (172.17.17.33)  0.736 ms 138.44.18.70 (138.44.18.70)  1.171 ms
 6  113.197.15.101 (113.197.15.101)  0.969 ms 138.44.18.70 (138.44.18.70)  1.035 ms 113.197.15.101 (113.197.15.101)  1.160 ms
 7  113.197.15.101 (113.197.15.101)  1.389 ms  1.180 ms  1.148 ms
 8  po1.syd-eqxsy5-bb13.globalsecurelayer.com (206.148.24.194)  1.320 ms  1.227 ms  1.065 ms
 9  po1.syd-eqxsy5-bb13.globalsecurelayer.com (206.148.24.194)  1.137 ms *  1.279 ms
10  po1.per-ndcp2-bb7.globalsecurelayer.com (206.148.24.221)  46.992 ms  46.630 ms po4.per-eqxpe2-bb5.globalsecurelayer.com (206.148.24.11)  46.796 ms
11  po4.per-eqxpe2-bb5.globalsecurelayer.com (206.148.24.11)  46.859 ms  47.041 ms po1.per-eqxpe2-cr6.globalsecurelayer.com (206.148.24.217)  46.814 ms
12  po1.per-eqxpe2-cr6.globalsecurelayer.com (206.148.24.217)  46.933 ms  46.935 ms po8.mct-eqxmc1-bb1.globalsecurelayer.com (206.148.27.4)  143.293 ms
13  po8.mct-eqxmc1-bb1.globalsecurelayer.com (206.148.27.4)  143.554 ms po3.mct-eqxmc1-cr2.globalsecurelayer.com (206.148.27.1)  143.104 ms  143.131 ms
14  po3.mct-eqxmc1-cr2.globalsecurelayer.com (206.148.27.1)  143.102 ms * 213.202.6.197 (213.202.6.197)  271.044 ms
15  * 213.202.6.214 (213.202.6.214)  267.975 ms *
16  213.202.6.214 (213.202.6.214)  267.657 ms 134.0.219.213 (134.0.219.213)  279.476 ms 213.202.6.214 (213.202.6.214)  267.581 ms
17  134.0.219.213 (134.0.219.213)  278.784 ms * *
18  * * *
19  * * *
20  * * FE-3-0-100M-CORE.nexlinx.net.pk (202.59.80.2)  298.558 ms
21  FE-3-0-100M-CORE.nexlinx.net.pk (202.59.80.2)  297.833 ms nasa.nexlinx.net.pk (202.59.80.52)  289.974 ms FE-3-0-100M-CORE.nexlinx.net.pk (202.59.80.2)  297.970 ms
```

```
Target: 129.94.242.251, IP: 129.94.242.251, FQDN: cserouter1-server.cse.unsw.EDU.AU

traceroute to 129.94.242.251 (129.94.242.251), 30 hops max, 60 byte packets
 1  FE-3-0-100M-CORE.nexlinx.net.pk (202.59.80.2)  0.311 ms  0.377 ms  0.445 ms
 2  10.10.80.11 (10.10.80.11)  0.381 ms  0.467 ms  0.582 ms
 3  110.93.202.169 (110.93.202.169)  0.711 ms  0.576 ms  0.693 ms
 4  110.93.255.26 (110.93.255.26)  16.864 ms 110.93.253.226 (110.93.253.226)  17.734 ms 110.93.255.104 (110.93.255.104)  21.148 ms
 5  110.93.255.138 (110.93.255.138)  18.219 ms  18.215 ms 110.93.252.146 (110.93.252.146)  16.787 ms
 6  134.0.219.214 (134.0.219.214)  29.383 ms  28.416 ms  29.419 ms
 7  * 213.202.6.213 (213.202.6.213)  131.714 ms  151.963 ms
 8  213.202.6.198 (213.202.6.198)  135.357 ms 82.178.32.238 (82.178.32.238)  122.741 ms 213.202.6.194 (213.202.6.194)  139.113 ms
 9  213.202.6.194 (213.202.6.194)  139.112 ms * *
10  213.202.6.202 (213.202.6.202)  129.558 ms 134.0.220.2 (134.0.220.2)  128.389 ms *
11  134.0.220.6 (134.0.220.6)  127.167 ms ae18.cr1.cdg12.fr.zip.zayo.com (64.125.26.68)  267.575 ms  271.553 ms
12  ae18.cr1.cdg12.fr.zip.zayo.com (64.125.26.68)  278.161 ms 64.124.200.234.IPYX-076771-003-ZYO.above.net (64.124.200.234)  294.676 ms  294.979 ms
13  et-8-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.152)  286.578 ms et-3-0-2.pe1.alxd.nsw.aarnet.net.au (113.197.15.136)  300.442 ms 64.124.200.234.IPYX-076771-003-ZYO.above.net (64.124.200.234)  296.565 ms
14  et-3-0-2.pe1.alxd.nsw.aarnet.net.au (113.197.15.136)  298.759 ms 138.44.18.71 (138.44.18.71)  294.034 ms  284.947 ms
15  138.44.18.71 (138.44.18.71)  284.915 ms et-3-0-2.pe1.alxd.nsw.aarnet.net.au (113.197.15.136)  300.636 ms et-8-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.152)  291.352 ms
16  * 138.44.18.71 (138.44.18.71)  287.910 ms  294.433 ms
```

as13030.net

```
z5484447@vx227:~$ traceroute as13030.net
traceroute to as13030.net (213.144.137.198), 30 hops max, 60 byte packets
 1  cserouter1-server.orchestra.cse.unsw.EDU.AU (129.94.242.251)  0.043 ms  0.056 ms  0.058 ms
 2  unsw-gateway.orchestra.cse.unsw.EDU.AU (129.94.39.17)  0.628 ms  0.614 ms  0.573 ms
 3  172.17.47.11 (172.17.47.11)  6.032 ms  6.020 ms  5.979 ms
 4  172.17.17.13 (172.17.17.13)  0.950 ms  0.964 ms  0.952 ms
 5  172.17.17.33 (172.17.17.33)  0.734 ms  0.924 ms 138.44.18.70 (138.44.18.70)  0.973 ms
 6  138.44.18.70 (138.44.18.70)  0.980 ms  0.855 ms *
 7  ae1.170.bdr1.b.sea.aarnet.net.au (113.197.15.63)  137.824 ms  137.768 ms  137.900 ms
 8  ae27.cs1.sea1.us.eth.zayo.com (64.125.29.0)  271.580 ms  271.442 ms xe-4-1-1.mpr1.sea1.us.above.net (64.125.193.129)  137.734 ms
 9  ae8.cr1.sea1.us.zip.zayo.com (64.125.28.193)  265.130 ms ae27.cs1.sea1.us.eth.zayo.com (64.125.29.0)  271.392 ms ae8.cr1.sea1.us.zip.zayo.com (64.125.28.193)  264.952 ms
10  ae8.cr1.sea1.us.zip.zayo.com (64.125.28.193)  264.967 ms  264.964 ms ae12.mpr1.yyz1.ca.zip.zayo.com (64.125.19.5)  265.932 ms
11  ae12.mpr1.yyz1.ca.zip.zayo.com (64.125.19.5)  265.744 ms  265.459 ms *
12  * * *
13  * * *
14  ae5.cr1.lhr11.uk.eth.zayo.com (64.125.29.127)  268.378 ms * *
15  * ae4.mpr1.lhr15.uk.zip.zayo.com (64.125.28.195)  266.070 ms  265.610 ms
16  r1lon2.init7.net (5.180.135.189)  285.711 ms  288.233 ms ae4.mpr1.lhr15.uk.zip.zayo.com (64.125.28.195)  265.392 ms
17  r2lon2.core.init7.net (5.180.135.248)  272.614 ms  271.834 ms  272.084 ms
18  r2fra3.core.init7.net (5.180.135.129)  278.181 ms  278.109 ms  278.208 ms
19  r2fra3.core.init7.net (5.180.135.129)  315.806 ms 5-180-134-168.init7.net (5.180.134.168)  279.610 ms  279.501 ms
20  5-180-134-168.init7.net (5.180.134.168)  279.535 ms r1fra2.core.init7.net (5.180.135.130)  291.197 ms  285.443 ms
21  r1fra2.core.init7.net (5.180.135.130)  282.810 ms 5-180-134-46.init7.net (5.180.134.46)  283.930 ms r1fra2.core.init7.net (5.180.135.130)  278.625 ms
22  r1zrh3.core.init7.net (5.180.134.38)  283.637 ms 5-180-134-46.init7.net (5.180.134.46)  283.522 ms r1zrh3.core.init7.net (5.180.134.38)  283.491 ms
23  r1zrh3.core.init7.net (5.180.134.38)  283.762 ms 5-180-134-172.init7.net (5.180.134.172)  284.249 ms r1zrh3.core.init7.net (5.180.134.38)  283.307 ms
24  s1zrh17.edge.init7.net (5.180.134.183)  282.987 ms  283.217 ms  282.923 ms
25  vwebd03.sys.init7.net (213.144.137.198)  283.069 ms  283.184 ms s1zrh17.edge.init7.net (5.180.134.183)  282.952 ms
```

Traceroute Ausgabe

```
Start: 2025-03-03T13:08:32+0000
HOST: b7e0e1b778bf                                                  Loss%   Snt   Last   Avg  Best  Wrst StDev
  2. AS13030  s1zrh17.edge.init7.net (213.144.137.193)               0.0%     1    0.8   0.8   0.8   0.8   0.0
  3. AS13030  r2zrh17.core.init7.net (5.180.134.182)                0.0%     1    1.5   1.5   1.5   1.5   0.0
  4. AS13030  5-180-134-173.init7.net (5.180.134.173)               0.0%     1    1.9   1.9   1.9   1.9   0.0
  5. AS13030  r1zrh5.core.init7.net (5.180.134.39)                  0.0%     1    1.8   1.8   1.8   1.8   0.0
  6. AS13030  5-180-134-47.init7.net (5.180.134.47)                 0.0%     1    6.6   6.6   6.6   6.6   0.0
  7. AS13030  r1fra3.core.init7.net (5.180.135.131)                 0.0%     1   21.6  21.6  21.6  21.6   0.0
  8. AS13030  r2par1.core.init7.net (5.180.135.66)                  0.0%     1   15.4  15.4  15.4  15.4   0.0
  9. AS???    equinix-paris.mpr1.cdg12.fr.above.net (195.42.144.13)  0.0%     1   15.9  15.9  15.9  15.9   0.0
 10. AS6461   ae1.cs1.cdg12.fr.eth.zayo.com (64.125.29.86)           0.0%     1  151.0 151.0 151.0 151.0   0.0
 11. AS6461   64.124.200.234.ipyx-076771-003-zyo.above.net (64.124.200.234)  0.0%  1  151.4 151.4 151.4 151.4   0.0
 12. AS7575   et-3-0-2.pe1.alxd.nsw.aarnet.net.au (113.197.15.136)  0.0%     1  284.5 284.5 284.5 284.5   0.0
 13. AS7575   et-8-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.152)  0.0%     1  283.7 283.7 283.7 283.7   0.0
 14. AS7575   138.44.18.71                                          0.0%     1  283.9 283.9 283.9 283.9   0.0
 15. AS???    ???                                                  100.0     1    0.0   0.0   0.0   0.0   0.0
 16. AS???    ???                                                  100.0     1    0.0   0.0   0.0   0.0   0.0
 17. AS23859  cserouter1-server.cse.unsw.edu.au (129.94.242.251)    0.0%     1  283.3 283.3 283.3 283.3   0.0
```

Answer: Target IP: 129.94.242.251, cserouter1server.cse.unsw.EDU.AU, 100% packet loss after 138.44.18.71. (target IP might also be 138.44.18.71)

2. Does the reverse path go through the same routers as the forward path?

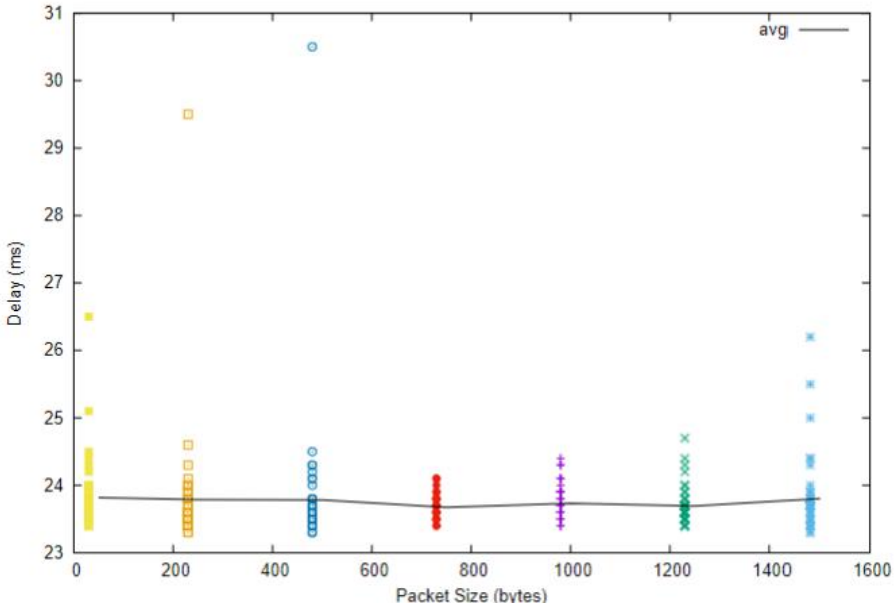
Answer: No, the reverse path is not guaranteed to follow the same routers as the forward path. In computer networks, routing is asymmetrical. Due to factors such as: Routers independently determine the best path based on their routing tables. Traffic may be distributed over multiple paths to optimize network performance. Networks may apply different routes for incoming versus outgoing traffic.

3. If you observe common routers between the forward and the reverse path, do you also observe the same IP addresses? Why or why not?

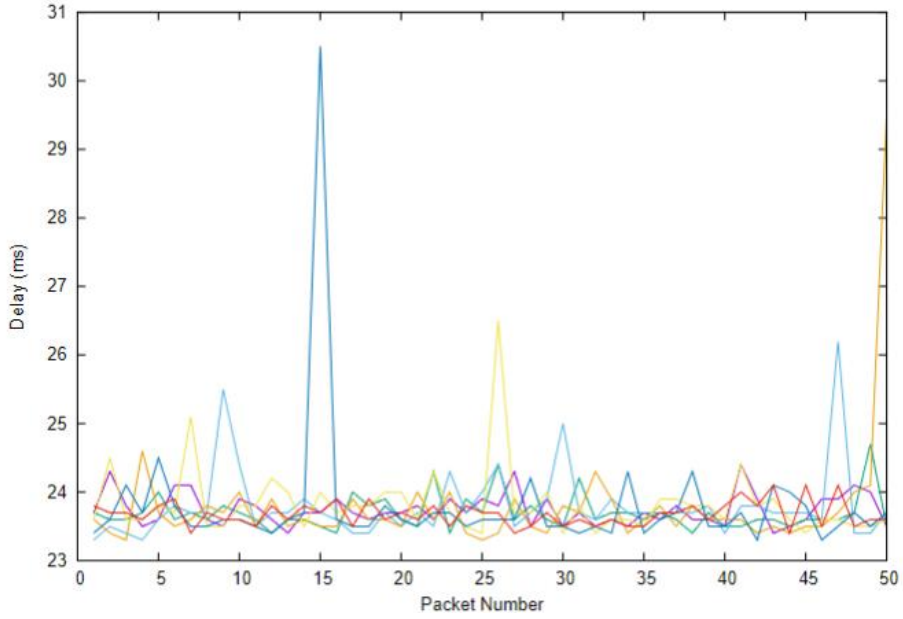
Answer: Even though there can be common routers between the forward and the reverse path, but the IP address may not be the same. Because routers typically have multiple interfaces, each with their own IP address. When a packet's TTL expires or when a router sends an ICMP response, different IP address of the interface may be used.

Exercise 4: Use ping to gain insights into network performance (4 marks)

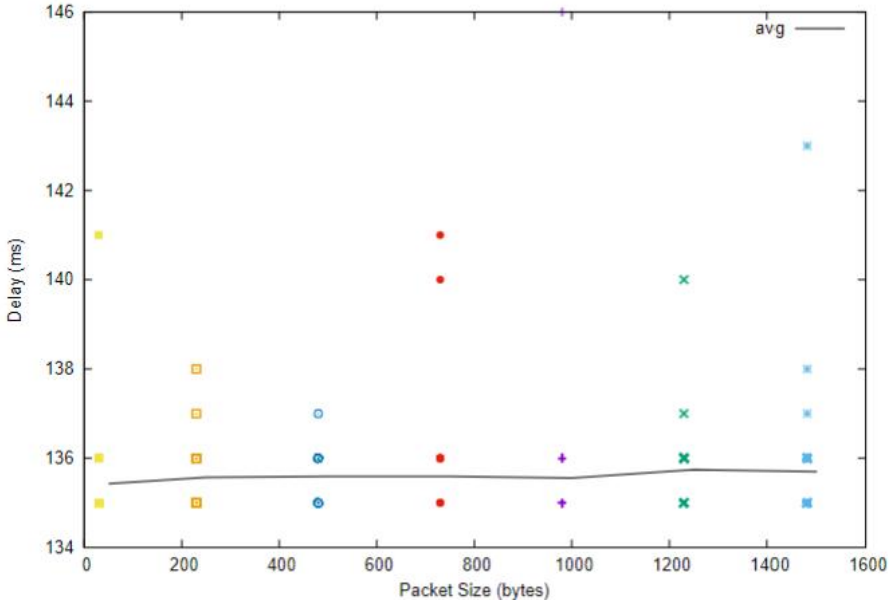
- *flinders.edu.au_scatter*



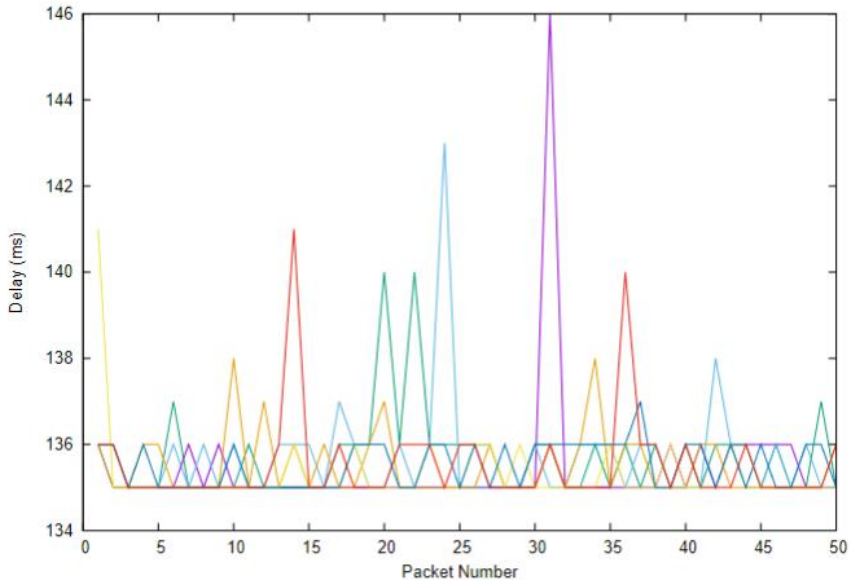
- *flinders.edu.au_delay*



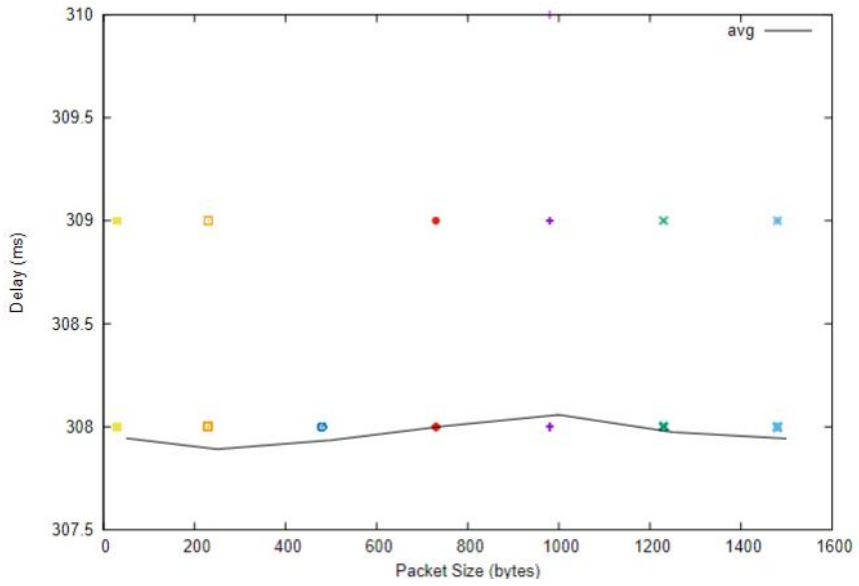
- *upd.edu.ph_scatter*



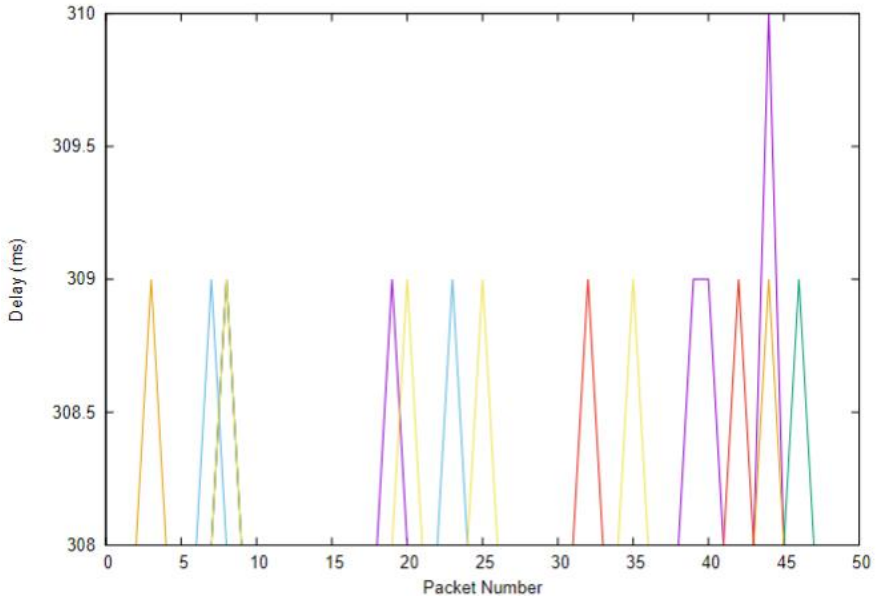
- *upd.edu.ph_delay*



- *uio.no_scatter*



- *uio.no_delay*

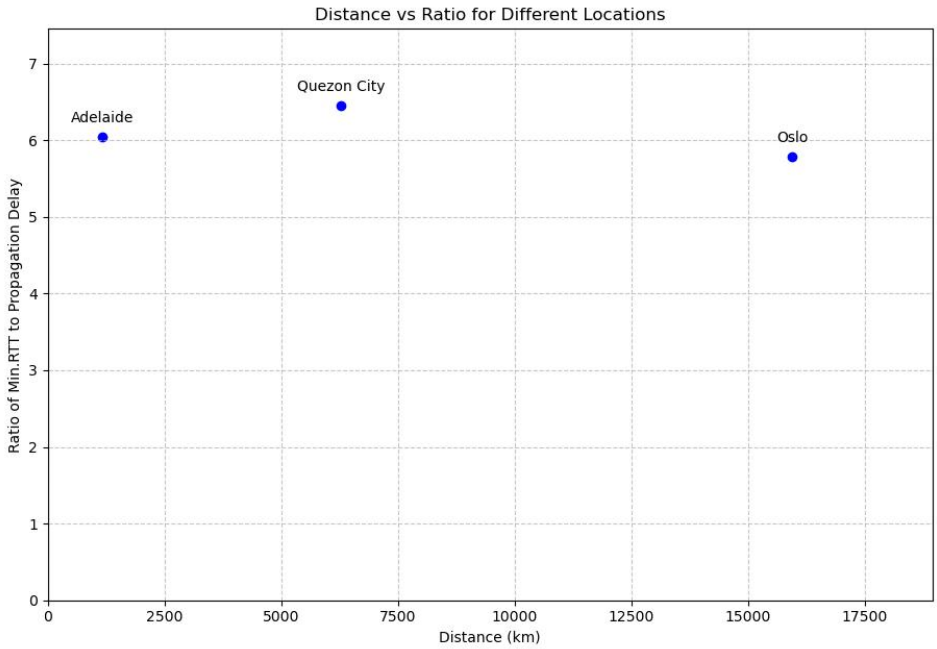


1. For each location, find the (approximate) physical distance from UNSW. Then, compute the shortest possible time T for a packet from UNSW to reach that location. You should assume that the packet moves (i.e. propagates) at the speed of light, 3 x 10^8 m/s. Note that the shortest possible time will be the distance divided by the propagation speed.

   Answer: (approximate) physical distance; UNSW to Flinders University: 1161.71 km; UNSW to University of the Philippines Diliman: 6272.09 km; UNSW to University of Oslo: 15950.20 km. Shortest possible time; UNSW to Flinders University: T = 1,161,710 m / 3×10^8 m/s ≈ 0.00387s (3.87ms); UNSW to University of the Philippines Diliman: T = 6,272,090 m / 3×10^8 m/s ≈ 0.02091s (20.91ms); UNSW to University of Oslo: : T = 15,950,200 m / 3×10^8 m/s ≈ 0.05317s (53.17ms).

2. Plot a graph where the x-axis represents the distance to each city (i.e. **Adelaide, Australia, Quezon City, Philippines** and **Oslo, Norway)**. The y-axis represents the ratio between the minimum delay (i.e. RTT) measured by the ping program (select the values for 50-byte packets) and the shortest possible time T to reach that city from UNSW. (Note that the y-values are no smaller than 2 since it takes at least 2*T time for any packet to reach the destination from UNSW and return).

   Answer:



3. Can you think of at least two reasons why the y-axis values you plot are greater than 2?

   Answer:

   Several factors make the ratios greater than 2:

   - The real network paths are not straight lines between UNSW and the destination. They follow existing infrastructure (e.g., undersea cables, terrestrial routes), often take a longer route than the direct distance.
   - Each router along the path takes time to process, forward, and sometimes queue packets before sending them on. Even if each delay is small, they add up over multiple hops.
   - Even for small packets, there is a serialization delay when bits are put onto the link, plus additional overhead from protocol processing and link-layer encapsulation. Besides, real-world signals travel in fiber optics (typically about 2/3 the speed of light).

4. Is the delay to the destinations constant, or does it vary over time? Explain why.

Answer: The delay to the destinations is not constant; it varies over time. Because real-time traffic loads fluctuate over time, causing variable queuing delays in routers and switches. Routers and other network devices have variable processing times depending on their current load and operational conditions. Link performance may differ due to real-time conditions.

5. The measured delay (i.e., the delay you can see in the graphs) comprises propagation, transmission, processing, and queuing delays. Which of these delays depend on the packet size and which do not?

   Answer:

   - Transmission delay depends on packet size, since it's calculated as the packet size divided by the transmission rate.
   - Propagation delay does not depend on packet size; it depends only on physical distance between nodes and the speed of signal propagation.
   - Processing delay does not depend on packet size, mainly the time taken by routers to examine packet headers and make forwarding decisions.
   - Queuing Delay is independent of packet size, determined by network congestion and the time packets spend waiting in router queues.