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 -Yes, I can reach it!

```
z5516222@vx09:~/COMP9331$ ping www.google.co.uk
PING www.google.co.uk (142.250.204.3) 56(84) bytes of data.
64 bytes from syd09s25-in-f3.1e100.net (142.250.204.3): icmp_seq=1 ttl=116 time=1.73 ms
64 bytes from syd09s25-in-f3.1e100.net (142.250.204.3): icmp_seq=2 ttl=116 time=1.75 ms
64 bytes from syd09s25-in-f3.1e100.net (142.250.204.3): icmp_seq=3 ttl=116 time=1.50 ms
64 bytes from syd09s25-in-f3.1e100.net (142.250.204.3): icmp_seq=4 ttl=116 time=1.54 ms
^C
--- www.google.co.uk ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3005ms
rtt min/avg/max/mdev = 1.501/1.630/1.750/0.110 ms
```

- www.utoronto.ca -Yes, I can reach it!

```
z5516222@vx09:~/COMP9331$ 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=0.884 ms
64 bytes from 23.185.0.1 (23.185.0.1): icmp_seq=2 ttl=58 time=1.05 ms
64 bytes from 23.185.0.1 (23.185.0.1): icmp_seq=3 ttl=58 time=1.01 ms
^C
--- www.utoronto.ca ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2001ms
rtt min/avg/max/mdev = 0.884/0.982/1.051/0.071 ms
```

- www.cloudflare.com -No, I may be unable to ping cloudflare.com due to network connectivity issues, DNS resolution problems, or Cloudflare's security measures that block ICMP ping requests.

```
z5516222@vx09:~/COMP9331$ ping www.cloudflare.com
PING www.cloudflare.com (104.16.123.96) 56(84) bytes of data.
64 bytes from 104.16.123.96 (104.16.123.96): icmp_seq=1 ttl=56 time=1.42 ms
64 bytes from 104.16.123.96 (104.16.123.96): icmp_seq=2 ttl=56 time=1.63 ms
64 bytes from 104.16.123.96 (104.16.123.96): icmp_seq=3 ttl=56 time=1.61 ms
^C
--- www.cloudflare.com ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2001ms
rtt min/avg/max/mdev = 1.422/1.553/1.633/0.093 ms
```

- ec.ho -No, because this is not a valid address.

```
z5516222@vx09:~/COMP9331$ ping ec.ho
ping: ec.ho: Name or service not known
```

- west.cn -Yes, but with packet losses.

```
z5516222@vx09:~/COMP9331$ ping west.cn
PING west.cn (60.247.168.229) 56(84) bytes of data.
64 bytes from 60.247.168.229: icmp_seq=3 ttl=46 time=283 ms
64 bytes from 60.247.168.229: icmp_seq=4 ttl=46 time=282 ms
64 bytes from 60.247.168.229: icmp_seq=6 ttl=46 time=282 ms
^C
--- west.cn ping statistics ---
9 packets transmitted, 3 received, 66.6667% packet loss, time 43949ms
rtt min/avg/max/mdev = 281.591/282.189/283.112/0.662 ms
```

- defence.gov.au -No, because ICMP echo requests (used by the ping command) are blocked by their firewall settings.

```
z5516222@vx09:~/COMP9331$ ping defence.gov.au
PING defence.gov.au (54.206.239.18) 56(84) bytes of data.
^C
--- defence.gov.au ping statistics ---
219 packets transmitted, 0 received, 100% packet loss, time 222243ms
```

- yes.no -Yes, I can reach it!

```
z5516222@vx09:~/COMP9331$ 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=1.44 ms
64 bytes from 141.193.213.11 (141.193.213.11): icmp_seq=2 ttl=56 time=1.33 ms
64 bytes from 141.193.213.11 (141.193.213.11): icmp_seq=3 ttl=56 time=1.72 ms
64 bytes from 141.193.213.11 (141.193.213.11): icmp_seq=4 ttl=56 time=1.52 ms
^C
--- yes.no ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3001ms
rtt min/avg/max/mdev = 1.326/1.502/1.722/0.144 ms
```

- one.one.one.one -Yes, I can reach it!

```
z5516222@vx09:~/COMP9331$ 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=1.19 ms
64 bytes from one.one.one.one (1.1.1.1): icmp_seq=2 ttl=56 time=1.00 ms
64 bytes from one.one.one.one (1.1.1.1): icmp_seq=3 ttl=56 time=1.19 ms
64 bytes from one.one.one.one (1.1.1.1): icmp_seq=4 ttl=56 time=0.943 ms
^C
--- one.one.one.one ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3003ms
rtt min/avg/max/mdev = 0.943/1.082/1.192/0.111 ms
```

- theguardian.com -Yes, I can reach it!

```
z5516222@vx09:~/COMP9331$ ping theguardian.com
PING theguardian.com (151.101.129.111) 56(84) bytes of data.
64 bytes from 151.101.129.111 (151.101.129.111): icmp_seq=1 ttl=57 time=1.01 ms
64 bytes from 151.101.129.111 (151.101.129.111): icmp_seq=2 ttl=57 time=0.865 ms
64 bytes from 151.101.129.111 (151.101.129.111): icmp_seq=3 ttl=57 time=1.11 ms
^C
--- theguardian.com ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2002ms
rtt min/avg/max/mdev = 0.865/0.993/1.107/0.099 ms
```

- xn--i-7iq.ws -Yes, I can reach it!

```
z5516222@vx09:~/COMP9331$ 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=270 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=272 ms
^C
--- i❤.ws ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2001ms
rtt min/avg/max/mdev = 269.563/270.333/271.616/0.913 ms
```

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

Note: Include all traceroute outputs in your report.

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.

```
z5516222@vx09:~/COMP9331$ 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)  0.178 ms  0.156 ms  0.140 ms
 2  unsw-gateway.orchestra.cse.unsw.EDU.AU (129.94.39.17)  0.559 ms  0.574 ms  0.559 ms
 3  172.17.47.2 (172.17.47.2)  2.501 ms  2.515 ms  2.498 ms
 4  172.17.17.45 (172.17.17.45)  0.822 ms 172.17.17.9 (172.17.17.9)  1.108 ms 172.17.17.45 (172.17.17.45)  0.812 ms
 5  172.17.17.33 (172.17.17.33)  1.122 ms  0.938 ms  1.109 ms
 6  138.44.18.70 (138.44.18.70)  1.104 ms * *
 7  * et-2-0-5.bdr1.sing.sin.aarnet.net.au (113.197.15.233)  92.295 ms *
 8  lag-1-0.rt0.lon.uk.geant.net (62.40.98.60)  359.995 ms 138.44.226.17 (138.44.226.17)  360.115 ms  360.068 ms
 9  lag-2-0.rt0.lon2.uk.geant.net (62.40.98.65)  360.766 ms lag-1-0.rt0.lon.uk.geant.net (62.40.98.60)  359.824 ms lag-2-0.rt0.lon2.uk.geant.net (62.40.98.65)
 360.624 ms
10  lag-8-0.rt0.par.fr.geant.net (62.40.98.107)  362.810 ms  363.649 ms lag-2-0.rt0.lon2.uk.geant.net (62.40.98.65)  360.675 ms
11  lag-8-0.rt0.par.fr.geant.net (62.40.98.107)  362.894 ms lag-7-0.rt0.gen.ch.geant.net (62.40.98.238)  370.845 ms  370.793 ms
12  lag-7-0.rt0.gen.ch.geant.net (62.40.98.238)  370.793 ms ae3-0.mx1.gen.ch.geant.net (62.40.98.76)  370.862 ms lag-7-0.rt0.gen.ch.geant.net (62.40.98.238)
370.495 ms
13  ae3-0.mx1.gen.ch.geant.net (62.40.98.76)  374.160 ms swice1-100ge-0-3-0-1.switch.ch (62.40.124.22)  373.057 ms  375.216 ms
14  swice1-100ge-0-3-0-1.switch.ch (62.40.124.22)  372.346 ms  375.165 ms swiCE1-400GE-0-0-0-0.switch.ch (130.59.37.34)  373.625 ms
15  swiEZ2-400GE-0-0-0-0.switch.ch (130.59.38.81)  378.807 ms  376.984 ms swiCE1-400GE-0-0-0-0.switch.ch (130.59.37.34)  374.234 ms
16  swiZH2-400GE-0-0-0-14.switch.ch (130.59.36.190)  378.587 ms  377.002 ms  377.444 ms
17  swiZH2-400GE-0-0-0-14.switch.ch (130.59.36.190)  377.249 ms  377.147 ms swiZH3-B2.switch.ch (130.59.37.170)  375.223 ms
18  uzhix1-eth5-1.uzh.ch (192.41.136.2)  375.365 ms  375.392 ms swiZH3-B2.switch.ch (130.59.37.170)  375.358 ms
19  uzhix1-eth5-1.uzh.ch (192.41.136.2)  375.620 ms  375.423 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?

- 18 routers. In the traceroute result, each line represents a router, except for the last hop which may be the destination host itself. And the "* * *", indicating no response. So from hop 1 to hop 18, they are all valid, with a total of 18 routers.

- 2 routers. The 1st and 2nd router are part of the UNSW network, since UNSW inside network addresses are with the string "unsw".

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

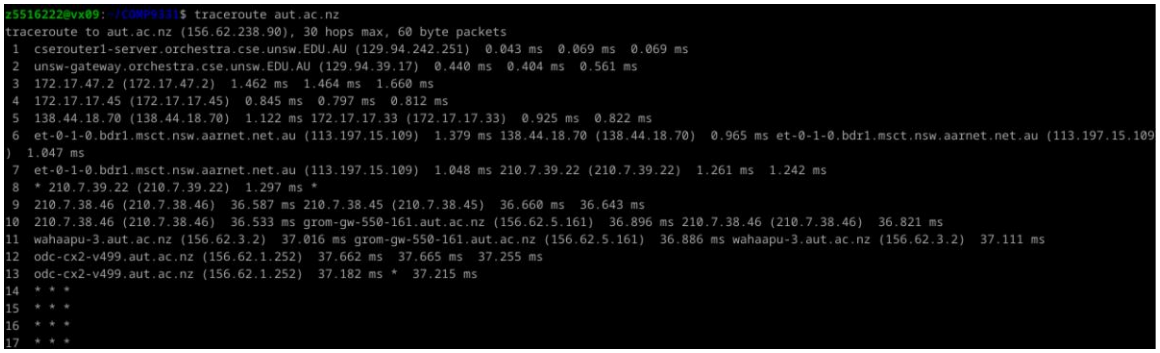
   - Hop 7 "et - 2 - 0 - 5.bdr1.sing.sin.aarnet.net.au (113.197.15.233)" is the first router outside Australia since the string "sing", which indicates the first router outside of Australia is Singapore.

3. Which router is the first router to be found in UK? HINT: compare the round trip times from your machine to the routers. You might also find some router names informative and/or looking at network maps (e.g. for AARNET/ www.submarinecablemap.com).

   - Hop 11 "lag - 8 - 0.rt0.par.fr.geant.net (62.40.98.107)" is the first router found in the UK. The judgment is based on comparing the round - trip times and the geographical location information in the router names. From hop 10 to hop 11, the round - trip time changes, and the router name contains "par.fr" (Paris, France). According to the network topology, France is a European country. It is reasonable that France is passed before reaching the UK, so we judge that hop 11 is the first router found in the UK.

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

   (i) aut.ac.nz



   (ii) stanford.edu

```
z5516222@vx09:~/COMP9331$ traceroute stanford.edu
traceroute to stanford.edu (171.67.215.200), 30 hops max, 60 byte packets
 1  cserouter1-server.orchestra.cse.unsw.EDU.AU (129.94.242.251)  0.064 ms  0.034 ms  0.054 ms
 2  unsw-gateway.orchestra.cse.unsw.EDU.AU (129.94.39.17)  0.686 ms  0.428 ms  0.433 ms
 3  172.17.47.11 (172.17.47.11)  1.579 ms  1.588 ms  1.433 ms
 4  172.17.17.13 (172.17.17.13)  1.244 ms 172.17.17.49 (172.17.17.49)  1.195 ms 172.17.17.13 (172.17.17.13)  0.748 ms
 5  138.44.18.70 (138.44.18.70)  1.517 ms  1.064 ms  0.927 ms
 6  et-1-3-0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.15.149)  3.453 ms 138.44.18.70 (138.44.18.70)  0.991 ms et-1-3-0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.
15.149)  2.905 ms
 7  * * et-1-3-0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.15.149)  2.794 ms
 8  et-2-1-0.bdr1.a.sea.aarnet.net.au (113.197.15.201)  143.709 ms  143.682 ms et-0-0-0.pe1.a.hnl.aarnet.net.au (113.197.15.99)  94.070 ms
 9  et-2-1-0.bdr1.a.sea.aarnet.net.au (113.197.15.201)  143.575 ms  143.511 ms  143.487 ms
10  hpr-emvl1-agg-01--svl-agg10--100g.cenic.net (137.164.25.95)  160.969 ms cenichpr-1-is-jmb-778.snvaca.pacificwave.net (207.231.245.129)  160.010 ms hpr-emv
l1-agg-01--svl-agg10--100g.cenic.net (137.164.25.95)  161.453 ms
11  hpr-emvl1-agg-01--svl-agg10--100g.cenic.net (137.164.25.95)  160.971 ms  161.251 ms  161.002 ms
12  137.164.26.241 (137.164.26.241)  162.206 ms campus-east-rtr-vl1020.SUNet (171.64.255.232)  162.891 ms 137.164.26.241 (137.164.26.241)  164.336 ms
13  campus-east-rtr-vl1120.SUNet (171.66.255.232)  161.372 ms * *
14  web.stanford.edu (171.67.215.200)  162.526 ms * *
```

(iii) reading.ac.uk

```
z5516222@vx09:~/COMP9331$ traceroute reading.ac.uk
traceroute to reading.ac.uk (134.225.0.151), 30 hops max, 60 byte packets
 1  cserouter1-server.orchestra.cse.unsw.EDU.AU (129.94.242.251)  0.045 ms  0.049 ms  0.054 ms
 2  unsw-gateway.orchestra.cse.unsw.EDU.AU (129.94.39.17)  0.554 ms  0.565 ms  0.565 ms
 3  172.17.47.2 (172.17.47.2)  1.667 ms  1.976 ms  1.946 ms
 4  172.17.17.9 (172.17.17.9)  0.892 ms  0.893 ms 172.17.17.45 (172.17.17.45)  0.848 ms
 5  138.44.18.70 (138.44.18.70)  0.999 ms 172.17.17.33 (172.17.17.33)  0.784 ms 138.44.18.70 (138.44.18.70)  1.079 ms
 6  138.44.18.70 (138.44.18.70)  1.032 ms *  1.046 ms
 7  et-2-0-5.bdr1.sing.sin.aarnet.net.au (113.197.15.233)  92.466 ms  92.359 ms *
 8  lag-1-0.rt0.lon.uk.geant.net (62.40.98.60)  360.061 ms 138.44.226.17 (138.44.226.17)  360.138 ms  360.112 ms
 9  lag-1-0.rt0.lon.uk.geant.net (62.40.98.60)  360.474 ms  360.092 ms lag-2-0.rt0.lon2.uk.geant.net (62.40.98.65)  360.782 ms
10  janet-bckp-gw.mx1.lon2.uk.geant.net (62.40.125.58)  361.462 ms lag-2-0.rt0.lon2.uk.geant.net (62.40.98.65)  360.899 ms  360.522 ms
11  ae19.readdy-rbr1.ja.net (146.97.37.194)  361.977 ms  361.939 ms  362.096 ms
12  reading-university-1.ja.net (193.63.109.26)  373.637 ms  378.021 ms ae19.readdy-rbr1.ja.net (146.97.37.194)  362.179 ms
13  reading-university-1.ja.net (193.63.109.26)  367.958 ms xe-0-0-7.fw-ext.net.rdg.ac.uk (134.225.255.38)  362.386 ms  362.456 ms
14  xe-0-0-7.fw-ext.net.rdg.ac.uk (134.225.255.38)  362.321 ms wap-slb-vip.rdg.ac.uk (134.225.0.151)  363.586 ms xe-0-0-7.fw-ext.net.rdg.ac.uk (134.225.255.38
)  362.910 ms
```

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. HINT: You can learn more about a router by running the Whois command: whois router-IP-address.

   - The paths to these three diverge at hop 6. The last common router is 138.44.18.70. This router belongs to AARNet (Australia's Academic and Research Network). And below is result running command 'whois 138.44.18.70'.

```
% Information related to '138.44.18.0/24AS7575'

route:          138.44.18.0/24
origin:         AS7575
descr:          Australian Academic and Research Network
                Building 9
                Banks Street
mnt-by:         MAINT-AARNET-AP
last-modified:  2019-04-03T03:55:59Z
source:         APNIC
```

2. Is the number of hops on each path proportional to the physical distance? HINT: You can use the following tool to find the geographical location of a server - https://iplocation.io/ .

   - The number of hops is not necessarily proportional to the physical distance. Here's the analysis:

aut.ac.nz (New Zealand): 12 hops, relatively short physical distance.

stanford.edu (USA): 14 hops, moderate physical distance.

reading.ac.uk (UK): 14 hops, longer physical distance.

While the hop counts are similar, the physical distances vary significantly. The number of hops depends more on the network topology and routing policies than on the physical distance.

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 - do not include the full URL while doing this, e.g. just " **lg.nexlinx.net.pk** ". You may also try other traceroute servers from the list at www.traceroute.org . What are the IP addresses of the two servers that you have chosen?

    - Use 'nslookup' command to get the ip of addresses given:

    They are 129.94.242.2:53 for lg.nexlinx.net.pk; and 129.94.242.2:53 for www.as13030.net.

```
z5516222@vx09:~/COMP9331$ nslookup lg.nexlinx.net.pk
Server:         129.94.242.2
Address:        129.94.242.2#53

Non-authoritative answer:
lg.nexlinx.net.PK       canonical name = nasa.nexlinx.net.PK.
Name:   nasa.nexlinx.net.PK
Address: 202.59.80.52

z5516222@vx09:~/COMP9331$ nslookup www.as13030.net
Server:         129.94.242.2
Address:        129.94.242.2#53

Non-authoritative answer:
www.as13030.net canonical name = as13030.net.
Name:   as13030.net
Address: 213.144.137.198
Name:   as13030.net
Address: 2001:1620:2777:1a::198
```

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

- My ip address is fetched by command ‘curl ifconfig.me’:

```
z5516222@vx09:~/COMP9331$ curl ifconfig.me
129.94.242.139z5516222@vx09:~/COMP9331$
```

Visit http://lg.nexlinx.net.pk/ and www.as13030.net/traceroute.php, enter the ip address, and run traceroute. Record the router information for the forward path.

Nexlinx（Internet Services）LG

Target：129.94.242.139，IP：129.94.242.139，FQDN：vx09.orchestra.cse.unsw.EDU.AU

```
traceroute to 129.94.242.139 (129.94.242.139), 30 hops max, 60 byte packets
 1  FE-3-0-100M-CORE.nexlinx.net.pk (202.59.80.2)  0.342 ms  0.378 ms  0.447 ms
 2  10.10.80.11 (10.10.80.11)  0.568 ms  0.680 ms  0.634 ms
 3  110.93.202.169 (110.93.202.169)  0.907 ms  0.907 ms  0.899 ms
 4  110.93.255.127 (110.93.255.127)  1.051 ms 110.93.253.202 (110.93.253.202)  21.294 ms 110.93.255.104 (110.93.255.104)  21.295 ms
 5  110.93.252.198 (110.93.252.198)  17.410 ms 110.93.255.138 (110.93.255.138)  18.366 ms 110.93.252.190 (110.93.252.190)  16.976 ms
 6  134.0.219.214 (134.0.219.214)  27.027 ms 110.93.255.138 (110.93.255.138)  18.295 ms 110.93.254.40 (110.93.254.40)  17.608 ms
 7  213.202.6.213 (213.202.6.213)  127.716 ms  127.708 ms *
 8  * 213.202.6.198 (213.202.6.198)  139.030 ms 82.178.32.238 (82.178.32.238)  122.757 ms
 9  134.0.219.217 (134.0.219.217)  123.666 ms 82.178.32.234 (82.178.32.234)  126.414 ms *
10  ae18.cr1.cdg12.fr.zip.zayo.com (64.125.26.68)  263.692 ms 134.0.220.214 (134.0.220.214)  134.302 ms 134.0.220.173 (134.0.220.173)  138.985 ms
11  * * *
12  et-3-0-2.pe1.alxd.nsw.aarnet.net.au (113.197.15.136)  298.869 ms  289.976 ms 64.124.200.234.IPYX-076771-003-ZYO.above.net (64.124.200.234)  293.052 ms
13  64.124.200.234.IPYX-076771-003-ZYO.above.net (64.124.200.234)  288.981 ms  294.978 ms et-3-0-2.pe1.alxd.nsw.aarnet.net.au (113.197.15.136)  290.531 ms
14  et-8-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.152)  295.562 ms  295.931 ms 64.124.200.234.IPYX-076771-003-ZYO.above.net (64.124.200.234)  294.015 ms
15  et-3-0-2.pe1.alxd.nsw.aarnet.net.au (113.197.15.136)  300.379 ms et-8-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.152)  298.955 ms *
16  138.44.18.71 (138.44.18.71)  294.974 ms  294.981 ms *
17  * 138.44.18.71 (138.44.18.71)  295.769 ms *
18  * 129.94.39.23 (129.94.39.23)  294.378 ms *
19  * * *
20  * * *
21  * * *
22  * * *
23  * * *
24  * * *
```

AS13030

Traceroute

Traceroute, Tracert, Trace oder Tracepath meint immer das selbe: nämlich die Anzeige des "Wegs" von Datenpaketen durch das Internet. Dabei "hangelt" sich das Traceroute-Programm von Router zu Router, bis es schliesslich das Ziel (Target) erreicht.

Testen Sie den "Pfad" der Datenpakete von www.init7.net zu Ihrem Computer. *Dies kann eine Weile dauern, haben Sie also bitte etwas Geduld.* Falls ab einem bestimmten Hop nur noch * * * Sterne angezeigt werden, verhindert mutmasslich eine Firewall die weitere Anzeige.

Traceroute Ausgabe

Start: 2025-02-27T05:32:31+0000
HOST: b7e0e1b778bf

			Loss%	Snt	Last	Avg	Best	Wrst	StDev
2.	AS13030	s1-zrh17.edge.init7.net (213.144.137.193)	0.0%	1	0.7	0.7	0.7	0.7	0.0
3.	AS13030	r2-zrh17.core.init7.net (5.180.134.182)	0.0%	1	1.4	1.4	1.4	1.4	0.0
4.	AS13030	5-180-134-173.init7.net (5.180.134.173)	0.0%	1	2.1	2.1	2.1	2.1	0.0
5.	AS13030	r1-zrh5.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	6.8	6.8	6.8	6.8	0.0
7.	AS13030	r1-fra3.core.init7.net (5.180.135.131)	0.0%	1	7.2	7.2	7.2	7.2	0.0
8.	AS13030	r2-par1.core.init7.net (5.180.135.66)	0.0%	1	27.9	27.9	27.9	27.9	0.0
9.	AS???	equinix-paris.mpr1.cdg12.fr.above.net (195.42.144.13)	0.0%	1	15.1	15.1	15.1	15.1	0.0
10.	AS6461	ae1.cs1.cdg12.fr.eth.zayo.com (64.125.29.86)	0.0%	1	154.7	154.7	154.7	154.7	0.0
11.	AS6461	64.124.200.234.ipyx-076771-003-zyo.above.net (64.124.200.234)	0.0%	1	150.3	150.3	150.3	150.3	0.0
12.	AS7575	et-3-0-2.pe1.alxd.nsw.aarnet.net.au (113.197.15.136)	0.0%	1	283.4	283.4	283.4	283.4	0.0
13.	AS7575	et-8-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.152)	0.0%	1	282.9	282.9	282.9	282.9	0.0
14.	AS7575	138.44.18.71	0.0%	1	283.0	283.0	283.0	283.0	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	129.94.39.23	0.0%	1	283.3	283.3	283.3	283.3	0.0

run the following commands:

traceroute lg.nexlinx.net.pk

traceroute www.as13030.net

```
z5516222@vx09:~/COMP9331$ 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)  0.043 ms  0.053 ms  0.056 ms
 2  unsw-gateway.orchestra.cse.unsw.EDU.AU (129.94.39.17)  0.538 ms  0.522 ms  0.479 ms
 3  172.17.47.2 (172.17.47.2)  1.364 ms  1.634 ms  1.635 ms
 4  172.17.17.9 (172.17.17.9)  1.374 ms  1.389 ms  1.373 ms
 5  172.17.17.33 (172.17.17.33)  1.073 ms  0.887 ms 138.44.18.70 (138.44.18.70)  1.137 ms
 6  113.197.15.101 (113.197.15.101)  1.198 ms 138.44.18.70 (138.44.18.70)  0.958 ms 113.197.15.101 (113.197.15.101)  1.319 ms
 7  as137409.syd.edgeix.net.au (202.77.88.23)  1.401 ms 113.197.15.101 (113.197.15.101)  1.274 ms  1.258 ms
 8  po1.syd-eqxsy5-bb13.globalsecurelayer.com (206.148.24.194)  1.747 ms as137409.syd.edgeix.net.au (202.77.88.23)  1.548 ms po1.syd-eqxsy5-bb13.globalsecurel
ayer.com (206.148.24.194)  3.816 ms
 9  * po1.syd-eqxsy5-bb13.globalsecurelayer.com (206.148.24.194)  1.469 ms *
10  po1.per-ndcp2-bb7.globalsecurelayer.com (206.148.24.221)  46.836 ms  46.810 ms  46.787 ms
11  po1.per-eqxpe2-cr6.globalsecurelayer.com (206.148.24.217)  46.814 ms po4.per-eqxpe2-bb5.globalsecurelayer.com (206.148.24.11)  47.686 ms po1.per-eqxpe2-cr
6.globalsecurelayer.com (206.148.24.217)  47.336 ms
12  po1.per-eqxpe2-cr6.globalsecurelayer.com (206.148.24.217)  46.746 ms  46.906 ms po8.mct-eqxmc1-bb1.globalsecurelayer.com (206.148.27.4)  143.107 ms
13  po8.mct-eqxmc1-bb1.globalsecurelayer.com (206.148.27.4)  144.271 ms po3.mct-eqxmc1-cr2.globalsecurelayer.com (206.148.27.1)  416.133 ms po8.mct-eqxmc1-bb1
.globalsecurelayer.com (206.148.27.4)  143.232 ms
14  * 160.202.164.163 (160.202.164.163)  268.909 ms po3.mct-eqxmc1-cr2.globalsecurelayer.com (206.148.27.1)  409.515 ms
15  * * *
16  213.202.6.214 (213.202.6.214)  264.661 ms  263.042 ms  262.841 ms
17  134.0.219.213 (134.0.219.213)  281.573 ms  277.985 ms  277.647 ms
18  * * *
19  * * *
20  * * *
21  * FE-3-0-100M-CORE.nexlinx.net.pk (202.59.80.2)  296.522 ms  296.582 ms
22  nasa.nexlinx.net.pk (202.59.80.52)  286.840 ms  286.755 ms  285.823 ms
```

```
z5516222@vx09:~/COMP9331$ traceroute www.as13030.net
traceroute to www.as13030.net (213.144.137.198), 30 hops max, 60 byte packets
 1  cserouter1-server.orchestra.cse.unsw.EDU.AU (129.94.242.251)  0.046 ms  0.047 ms  0.046 ms
 2  unsw-gateway.orchestra.cse.unsw.EDU.AU (129.94.39.17)  0.458 ms  0.618 ms  0.581 ms
 3  172.17.47.11 (172.17.47.11)  1.211 ms  1.177 ms  1.659 ms
 4  172.17.17.49 (172.17.17.49)  0.769 ms  1.016 ms 172.17.17.13 (172.17.17.13)  0.988 ms
 5  172.17.17.33 (172.17.17.33)  0.829 ms  0.839 ms 138.44.18.70 (138.44.18.70)  1.159 ms
 6  * 138.44.18.70 (138.44.18.70)  1.050 ms *
 7  ae1.170.bdr1.b.sea.aarnet.net.au (113.197.15.63)  137.700 ms xe-4-1-1.mpr1.sea1.us.above.net (64.125.193.129)  142.807 ms  142.791 ms
 8  xe-4-1-1.mpr1.sea1.us.above.net (64.125.193.129)  142.739 ms  142.667 ms ae27.cs1.sea1.us.eth.zayo.com (64.125.29.0)  267.434 ms
 9  ae8.cr1.sea1.us.zip.zayo.com (64.125.28.193)  262.124 ms  262.218 ms  268.568 ms
10  ae12.mpr1.yyz1.ca.zip.zayo.com (64.125.19.5)  263.153 ms  262.947 ms  263.140 ms
11  ae12.mpr1.yyz1.ca.zip.zayo.com (64.125.19.5)  263.145 ms  263.251 ms *
12  ae3.cs2.lga5.us.eth.zayo.com (64.125.29.212)  264.669 ms * *
13  ae3.cs2.lga5.us.eth.zayo.com (64.125.29.212)  268.455 ms *  268.442 ms
14  * * *
15  ae4.mpr1.lhr15.uk.zip.zayo.com (64.125.28.195)  263.032 ms  266.141 ms  266.133 ms
16  ae4.mpr1.lhr15.uk.zip.zayo.com (64.125.28.195)  266.096 ms  263.665 ms r1lon2.init7.net (5.180.135.189)  272.917 ms
17  r1lon2.init7.net (5.180.135.189)  273.668 ms  273.083 ms r2lon2.core.init7.net (5.180.135.248)  272.231 ms
18  r2lon2.core.init7.net (5.180.135.248)  271.979 ms  271.879 ms  272.347 ms
19  5-180-134-168.init7.net (5.180.134.168)  279.951 ms  279.618 ms r2fra3.core.init7.net (5.180.135.129)  279.759 ms
20  5-180-134-168.init7.net (5.180.134.168)  279.583 ms  279.805 ms  279.429 ms
21  5-180-134-46.init7.net (5.180.134.46)  283.234 ms r1fra2.core.init7.net (5.180.135.130)  278.328 ms  278.057 ms
22  r1zrh3.core.init7.net (5.180.134.38)  284.377 ms 5-180-134-46.init7.net (5.180.134.46)  287.500 ms  287.611 ms
23  r1zrh3.core.init7.net (5.180.134.38)  284.324 ms 5-180-134-172.init7.net (5.180.134.172)  286.100 ms r1zrh3.core.init7.net (5.180.134.38)  284.751 ms
24  5-180-134-172.init7.net (5.180.134.172)  283.923 ms s1zrh17.edge.init7.net (5.180.134.183)  284.182 ms  284.040 ms
25  s1zrh17.edge.init7.net (5.180.134.183)  283.993 ms  284.199 ms vwebd03.sys.init7.net (213.144.137.198)  283.218 ms
```

No. Forward and reverse paths may pass through different routers because Internet routing is asymmetric. The path of packets depends on network topology, routing policies, and load balancing.

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?

   - Not necessarily. Even if the same routers are used, the forward and reverse paths may use different interfaces, so the IP addresses may differ. Additionally, routers may be configured with multiple IP addresses for traffic in different directions.

IMPORTANT : (1) When running this test on your machine connected to UniWide, the reverse traceroute fails because of the 10.x.x.x IP address assigned to your machine is a private IP address (i.e. it is behind a NAT) and thus not publicly routable. So, make sure you

conduct the above experiment through VLAB. (2) Feel free to terminate the traceroute if you start receiving output with multiple " * * * " responses or if you can confirm that the traceroute messages have reached the destination network.

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

Note: Include all graphs in your report. You need to run the scripts (runping.sh and plot.sh) when you are physically using a lab machine or connected to a CSE server/lab machine using VLAB / VNC client. You need to ensure gnuplot and ps2pdf are available on your system if you plan to do this exercise on your machine.

We now use the ping utility to investigate network delay and its implications on network performance. In particular, we will analyze the dependency of packet size and delay.

There is a shell script runping.sh , provided that you can use it instead of running many pings with different packet sizes by hand. After downloading this script on your machine, make sure you can execute it. If not, you must execute the following command in the command line: *chmod u+x runping.sh* . To run the ping traces, you may use the runping.sh script as follows: ./runping.sh www.abc.net (or whatever other destination you want to ping). It will automatically run ping for different packet sizes, with 50 ping packets per size (-c 50). This script will take a few minutes to finish since ping is sent once per second (-i 1). Additional options are enabled to use IPv4 only (-4) and not lookup symbolic names for host addresses (-n). This script only executes the commands:

```
$ ping -4 -n -c 50 -i 1 -s 22 www.abc.net > www.abc.net -p50

...

$ ping -4 -n -c 50 -i 1 -s 1472 www.abc.net > www.abc.net -p1500
```

and writes the output of the pings to the corresponding files.

- Download and test the script:

```
z5516222@vx09:~/COMP9331$ wget https://webcms3.cse.unsw.edu.au/COMP3331/25T1/resources/107382
--2025-02-27 16:47:51--  https://webcms3.cse.unsw.edu.au/COMP3331/25T1/resources/107382
Resolving webcms3.cse.unsw.edu.au (webcms3.cse.unsw.edu.au)... 129.94.242.67
Connecting to webcms3.cse.unsw.edu.au (webcms3.cse.unsw.edu.au)|129.94.242.67|:443... connected.
HTTP request sent, awaiting response... 403 FORBIDDEN
2025-02-27 16:47:51 ERROR 403: FORBIDDEN.

z5516222@vx09:~/COMP9331$ wget https://webcms3.cse.unsw.edu.au/files/b669a219bc84e1148d83633077d07f5271ebf5b1e39706a6e7ee68575d597f2a/attachment
--2025-02-27 16:48:37--  https://webcms3.cse.unsw.edu.au/files/b669a219bc84e1148d83633077d07f5271ebf5b1e39706a6e7ee68575d597f2a/attachment
Resolving webcms3.cse.unsw.edu.au (webcms3.cse.unsw.edu.au)... 129.94.242.67
Connecting to webcms3.cse.unsw.edu.au (webcms3.cse.unsw.edu.au)|129.94.242.67|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 381 [application/x-sh]
Saving to: 'attachment'

attachment                          100%[=========================================================================>]     381  --.-KB/s    in 0s

2025-02-27 16:48:37 (12.7 MB/s) - 'attachment' saved [381/381]

z5516222@vx09:~/COMP9331$ ls
attachment  www.abc.net
z5516222@vx09:~/COMP9331$ mv attachment runping.sh
z5516222@vx09:~/COMP9331$ chmod u+x runping.sh
z5516222@vx09:~/COMP9331$ ./runping.sh www.abc.net

ping -s 22 -c 50 -i 1 www.abc.net > www.abc.net-p50
ping -s 222 -c 50 -i 1 www.abc.net > www.abc.net-p250
ping -s 472 -c 50 -i 1 www.abc.net > www.abc.net-p500
ping -s 722 -c 50 -i 1 www.abc.net > www.abc.net-p750
ping -s 972 -c 50 -i 1 www.abc.net > www.abc.net-p1000
```

Use this script for the following destinations:

1. flinders.edu.au (Flinders University - Adelaide, Australia)
2. upd.edu.ph (University of the Philippines Diliman - Quezon City, Philippines)

3. uio.no (University of Oslo - Oslo, Norway)

Alternatively, use **kcl.ac.uk (King's College, London, UK) / columbia.edu (Columbia University, New York, USA)** if any of the above destinations are down.

In other words, execute the following commands:

```
$ ./runping.sh flinders.edu.au
$ ./runping.sh upd.edu.ph
$ ./runping.sh uio.no
```

- Run the script:

```
z5516222@vx09:~/COMP9331$ ./runping.sh flinders.edu.au
./runping.sh upd.edu.ph
./runping.sh uio.no

ping -s 22 -c 50 -i 1 flinders.edu.au > flinders.edu.au-p50
ping -s 222 -c 50 -i 1 flinders.edu.au > flinders.edu.au-p250
ping -s 472 -c 50 -i 1 flinders.edu.au > flinders.edu.au-p500
ping -s 722 -c 50 -i 1 flinders.edu.au > flinders.edu.au-p750
ping -s 972 -c 50 -i 1 flinders.edu.au > flinders.edu.au-p1000
ping -s 1222 -c 50 -i 1 flinders.edu.au > flinders.edu.au-p1250
ping -s 1472 -c 50 -i 1 flinders.edu.au > flinders.edu.au-p1500



ping -s 22 -c 50 -i 1 upd.edu.ph > upd.edu.ph-p50
ping -s 222 -c 50 -i 1 upd.edu.ph > upd.edu.ph-p250
ping -s 472 -c 50 -i 1 upd.edu.ph > upd.edu.ph-p500
ping -s 722 -c 50 -i 1 upd.edu.ph > upd.edu.ph-p750
ping -s 972 -c 50 -i 1 upd.edu.ph > upd.edu.ph-p1000
ping -s 1222 -c 50 -i 1 upd.edu.ph > upd.edu.ph-p1250
ping -s 1472 -c 50 -i 1 upd.edu.ph > upd.edu.ph-p1500



ping -s 22 -c 50 -i 1 uio.no > uio.no-p50
ping -s 222 -c 50 -i 1 uio.no > uio.no-p250
ping -s 472 -c 50 -i 1 uio.no > uio.no-p500
ping -s 722 -c 50 -i 1 uio.no > uio.no-p750
ping -s 972 -c 50 -i 1 uio.no > uio.no-p1000
ping -s 1222 -c 50 -i 1 uio.no > uio.no-p1250
ping -s 1472 -c 50 -i 1 uio.no > uio.no-p1500
```

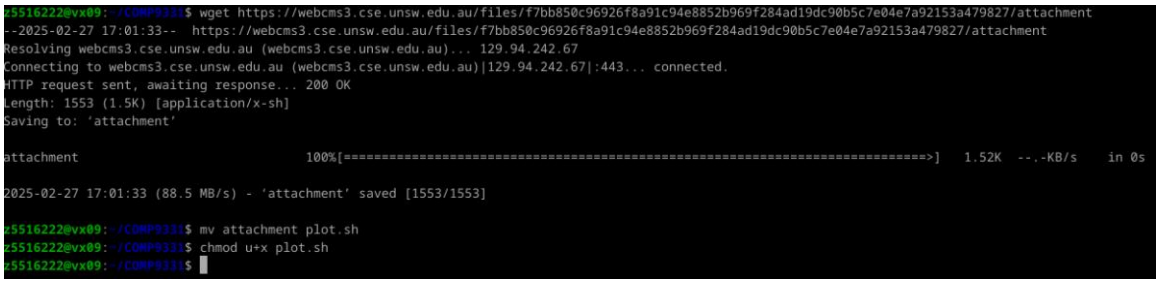
Note that all delay values reported are in milliseconds (ms) and reflect the round trip time (RTT) between your host and the destinations.

If you cannot execute runping.sh, then fix the permissions by running the following command in the command line:

```
$ chmod u+x runping.sh
```

When the runping.sh script is finished for all destinations, you can plot the results using another provided script, plot.sh , as follows:

- Download and test the script:

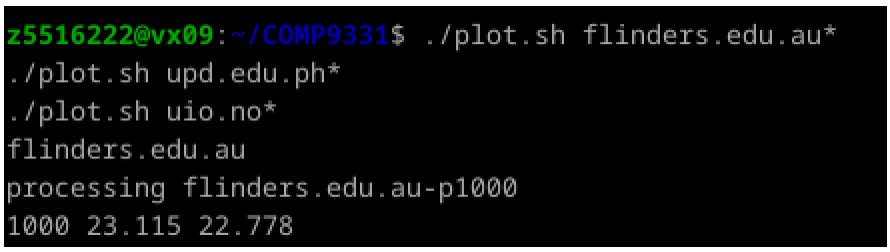



```
$ ./plot.sh flinders.edu.au*

$ ./plot.sh upd.edu.ph*

$ ./plot.sh uio.no*
```

If you cannot execute plot.sh, then fix the permissions by running the following command in the command line:

```
$ chmod u+x plot.sh
```

- Run the script:



The script plot.sh will produce the following files: *destination_delay.pdf* , *destination_scatter.pdf,* and *destination_avg.txt* for each destination (e.g., for cdu.edu.au we have *cdu.edu.au_delay.pdf* and *cdu.edu.au_scatter.pdf* and *cdu.edu.au_avg.txt*).

The graph *destination_delay.pdf* shows how delay varies over time (different colours correspond to different packet sizes), and *destination_scatter.pdf* shows delay vs. packet size as a scatter plot. *destination_avg.txt* contains the average (2nd column) and minimum (3rd column) delay values corresponding to each packet size (1st column).

1. For each location, find the (approximate) physical distance from UNSW . You can use a site like Distance Calculator , Google Maps , or whatever you prefer to take this measurement. 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.

   -Distance to Adelaide, Quezon City, Oslo: 1161.71, 6272.09, 15950.20

   Such that, in the code, distances = [1164, 6110, 16210]

   Shortest possible time: 0.00388s, 0.02037s, 0.05403s

   T= Distance/Speed of Light (Speed of Light=3×10^8m/s)

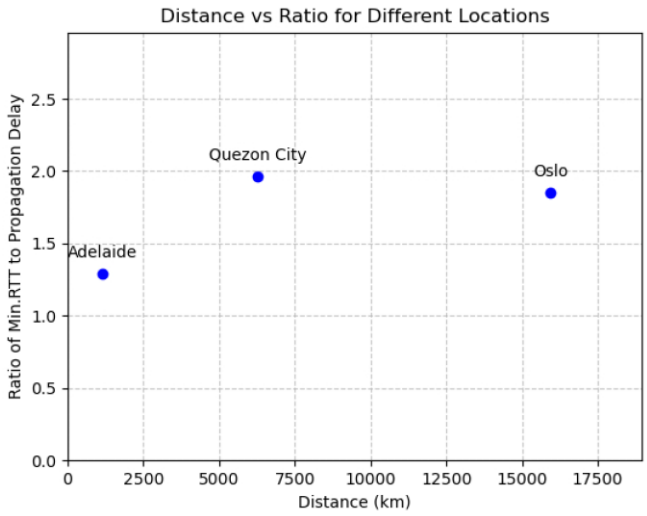
2. Plot a graph where the x-axis represents the distance to each city (i.e. **Adelaide, Australia** , **Quezon City, Philippines** and **Oslo, Norway**). The y-axis represents the ratio between the minimum delay (i.e. RTT) measured by the ping program (select the values for 50-byte packets) and the shortest 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).

   - Ratio= Min.RTT/(2×T)

   So the ratio in the code is: ratios = [1.29, 1.96, 1.85]

You can also use the provided generate_plot.py to generate the plot. Download (to Vlab or personal machines with Python 3 installed). Open the generate_plot.py and uncomment the designated lists, and replace them with the actual values.

-The plot is shown as below:



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

- Reason 1: Packets pass through multiple routers, and each router introduces processing and queuing delays.
Reason 2: Network congestion or poor link quality may cause packet retransmission or increased delay.

4. Is the delay to the destinations constant, or does it vary over time? Explain why.
- The delay varies over time. Factors such as network traffic, router load, and link quality can cause fluctuations in delay.
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?
- Depends on packet size: Transmission delay (proportional to packet size).
Does not depend on packet size: Propagation delay, processing delay, and queuing delay.