Lab Exercise 1: Tools of the Trade

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Exercise 1: nslookup

1. The IP address of the website www.koala.com.au:
   - 129.94.242.2#53
   - 172.67.219.46
   - 104.18.60.21
   - 104.18.61.21

   In my opinion, website may be replicated on multiple servers, with each server running on a different end system, and each having a different IP address. This allow for load balancing, and website replies to the requests with one of the listed Ips and the client thus can connect to the website. However, the IP address not always the same, so the load isn't concentrated always on the same server.

```
wagner % nslookup www.koala.com.au
Server:         129.94.242.2
Address:        129.94.242.2#53

Non-authoritative answer:
Name:   www.koala.com.au
Address: 172.67.219.46
Name:   www.koala.com.au
Address: 104.18.60.21
Name:   www.koala.com.au
Address: 104.18.61.21
```

2. The name of the IP address 127.0.0.1 is "the loopback address/localhost". The address is used to establish an IP connection to the same machine or computer being used by the end-user. The localhost refers to the internal interface used by the machine to send a packet to itself. TCP/IP send information locally but not on the network, it's always used for testing purpose.

```
wagner % nslookup 127.0.0.1
Server:         129.94.242.2
Address:        129.94.242.2#53

1.0.0.127.in-addr.arpa  name = localhost.
```

Exercise 2: Use ping to test host reachability

host	reachable by ping	Reachable from the Web
www.unsw.edu.au	Yes	Yes
www.getfittest.com.au	No	No
www.mit.edu	Yes	Yes
www.intel.com.au	Yes	Yes
www.tpg.com.au	Yes	Yes
www.hola.hp	No	No
www.amazon.com	Yes	Yes

www.tsinghua.edu.cn	Yes	Yes
www.kremlin.ru	No	Yes
8.8.8.8	Yes	No

```
wagner % ping www.unsw.edu.au
PING cdn.prod65.unsw.adobecqms.net (13.226.107.113) 56(84) bytes of data.
64 bytes from server-13-226-107-113.syd4.r.cloudfront.net (13.226.107.113): icmp_seq=1 ttl=244 time=1.24 ms
```

```
wagner % ping www.getfittest.com.au
ping: unknown host www.getfittest.com.au
```

```
wagner % ping www.mit.edu
PING e9566.dscb.akamaiedge.net (23.77.154.132) 56(84) bytes of data.
64 bytes from a23-77-154-132.deploy.static.akamaitechnologies.com (23.77.154.132): icmp_seq=1 ttl=56 time=1.41 ms
```

```
wagner % ping www.intel.com.au
PING e19235.dsca.akamaiedge.net (104.98.21.56) 56(84) bytes of data.
64 bytes from a104-98-21-56.deploy.static.akamaitechnologies.com (104.98.21.56): icmp_seq=1 ttl=56 time=1.20 ms
```

```
wagner % ping www.tpg.com.au
PING www.tpg.com.au (203.26.27.38) 56(84) bytes of data.
64 bytes from www.tpg.com.au (203.26.27.38): icmp_seq=1 ttl=119 time=1.66 ms
```

```
wagner % ping www.hola.hp
ping: unknown host www.hola.hp
```

```
wagner % ping www.amazon.com
PING d3ag4hukkh62yn.cloudfront.net (99.86.215.39) 56(84) bytes of data.
64 bytes from server-99-86-215-39.syd4.r.cloudfront.net (99.86.215.39): icmp_seq=1 ttl=244 time=1.21 ms
```

```
wagner % ping www.tsinghua.edu.cn
PING www.tsinghua.edu.cn (166.111.4.100) 56(84) bytes of data.
64 bytes from www.tsinghua.edu.cn (166.111.4.100): icmp_seq=1 ttl=42 time=242 ms
```

```
wagner % ping www.kremlin.ru
PING www.kremlin.ru (95.173.136.71) 56(84) bytes of data.
^C
--- www.kremlin.ru ping statistics ---
34 packets transmitted, 0 received, 100% packet loss, time 33768ms
```

```
wagner % ping 8.8.8.8
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data.
64 bytes from 8.8.8.8: icmp_seq=1 ttl=115 time=1.28 ms
```

www.getfittest.com.au and www.hola.hp are not reachable by ping and the Web browser, thus these websites does not exist.

www.kremlin.ru was not reachable by using ping, but it is reachable from the Web browser, this is because the organizations disable their network from replying to ICMP echo request packets which are used by ping. It's always used because of security measure.

Exercise 3: Use traceroute to understand network topology

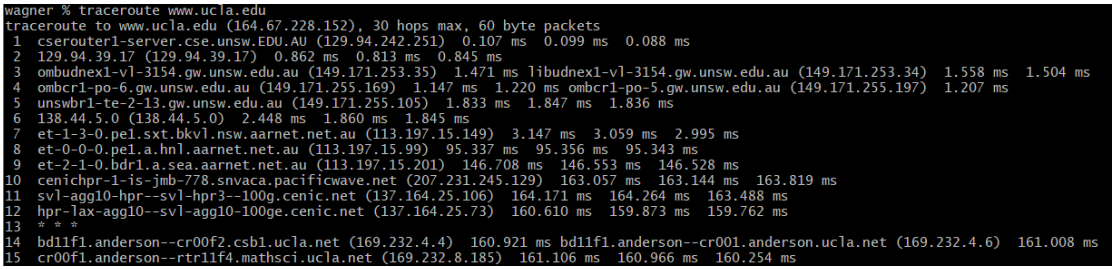
1. There are 21 routers between my workstation and www.columbia.edu (22 hops, which the last hop we have reached the webserver), there are 4 routers along the path are part of the UNSW network. Between et-1-3-

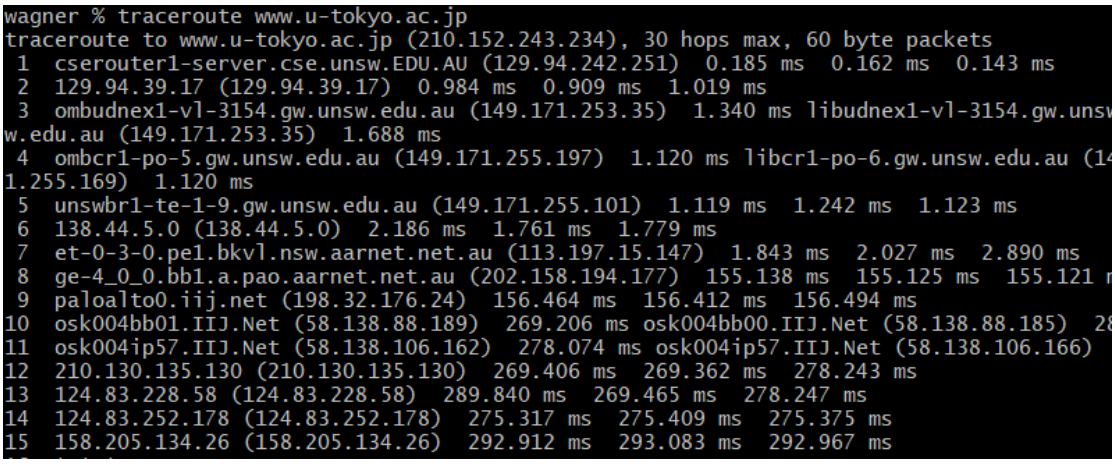
```
wagner % traceroute www.columbia.edu
traceroute to www.columbia.edu (128.59.105.24), 30 hops max, 60 byte packets
 1  cserouter1-server.cse.unsw.EDU.AU (129.94.242.251)  0.188 ms  0.164 ms  0.144 ms
 2  129.94.39.17 (129.94.39.17)  0.954 ms  0.953 ms  0.951 ms
 3  libudnex1-vl-3154.gw.unsw.edu.au (149.171.253.34)  1.854 ms  1.851 ms ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  1.574 ms
 4  libcr1-po-6.gw.unsw.edu.au (149.171.255.201)  1.242 ms libcr1-po-5.gw.unsw.edu.au (149.171.255.165)  1.147 ms libcr1-po-6.gw.unsw.edu.au (149.171.255.201)  1.219 ms
 5  unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.226 ms  1.223 ms  1.221 ms
 6  138.44.5.0 (138.44.5.0)  1.466 ms  1.339 ms  1.365 ms
 7  et-1-3-0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.15.149)  2.482 ms  2.278 ms  2.267 ms
 8  et-0-0-0.pe1.a.hnl.aarnet.net.au (113.197.15.99)  95.253 ms  95.140 ms  95.154 ms
 9  et-2-1-0.bdr1.a.sea.aarnet.net.au (113.197.15.201)  146.725 ms  146.728 ms  146.685 ms
10  abilene-1-lo-jmb-706.sttlwa.pacificwave.net (207.231.240.8)  146.889 ms  146.690 ms  146.676 ms
11  ae-1.4079.rtsw.minn.net.internet2.edu (162.252.70.173)  179.387 ms  179.429 ms  179.298 ms
12  ae-1.4079.rtsw.eqch.net.internet2.edu (162.252.70.106)  187.258 ms  187.236 ms  187.226 ms
13  ae-0.4079.rtsw3.eqch.net.internet2.edu (162.252.70.163)  191.819 ms  187.531 ms  187.347 ms
14  ae-1.4079.rtsw.clev.net.internet2.edu (162.252.70.130)  193.196 ms  193.167 ms  193.203 ms
15  buf-9208-I2-CLEV.nysernet.net (199.109.11.33)  196.677 ms  196.543 ms  196.520 ms
16  syr-9208-buf-9208.nysernet.net (199.109.7.193)  199.746 ms  200.066 ms  199.955 ms
17  nyc111-9204-syr-9208.nysernet.net (199.109.7.94)  215.691 ms  208.869 ms  208.889 ms
18  nyc-9208-nyc111-9204.nysernet.net (199.109.7.165)  209.141 ms  209.080 ms  209.122 ms
19  columbia.nyc-9208.nysernet.net (199.109.4.14)  209.008 ms  208.868 ms  209.457 ms
20  cc-core-1-x-nyser32-gw-1.net.columbia.edu (128.59.255.5)  209.543 ms  209.139 ms  209.279 ms
21  cc-conc-1-x-cc-core-1.net.columbia.edu (128.59.255.21)  209.451 ms  209.437 ms  209.393 ms
22  www-ltm.cc.columbia.edu (128.59.105.24)  209.254 ms  209.152 ms  209.048 ms
wagner %
```

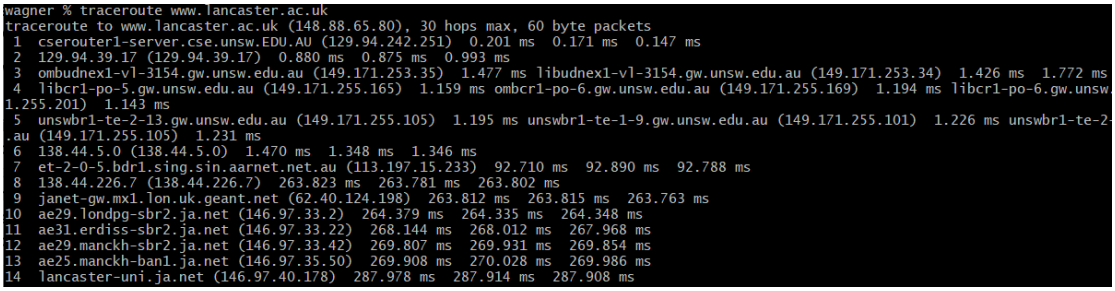
0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.15.149) and et-0-0-0.pe1.a.hnl.aarnet.net.au (113.197.15.99), the round-trip times from my machine to the routers change from 1.9ms to 95.1ms. which means it packets cross the Pacific Ocean. However, according to my research of the IP address, the router address change from Australia to America is between et-2-1-0.bdr1.a.sea.aarnet.net.au (113.197.15.201) and abilene-1-lo-jmb-706.sttlwa.pacificwave.net (207.231.240.8), because these are very likely part of AARNET PoP (Point of Presence) that are physically located in Honolulu and Seattle (hostnames have “hnl” and “sea”). Therefore, between et-1-3-0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.15.149) and et-0-0-0.pe1.a.hnl.aarnet.net.au (113.197.15.99) the address crosses the Pacific Ocean physically.

2. There are 5 hops are identical on all 3 paths, at the sixth router IP address 138.44.5.0 the paths from my machine to these three destinations diverge. The sixth router belongs to the AARNET network.

   No, the number of hops on each path is not proportional to the physical distance. From Sydney to Tokyo is closer to from Sydney to LA, but from Sydney to Tokyo takes about 15 hops while from Sydney to LA also takes 15 hops.







3.

i. The IP address of my machine is 129.94.242.251, the IP address of www.speedtest.com.sg is 202.150.221.170

Traceroute from my machine to www.speedtest.com.sg:

```
wagner % traceroute www.speedtest.com.sg
traceroute to www.speedtest.com.sg (202.150.221.170), 30 hops max, 60 byte packets
 1  cserouter1-server.cse.unsw.EDU.AU (129.94.242.251)  0.162 ms  0.139 ms  0.108 ms
 2  129.94.39.17 (129.94.39.17)  0.880 ms  0.857 ms  0.909 ms
 3  ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  1.313 ms libudnex1-vl-3154.gw.unsw.edu.au (149.171.253.34)  1.842 ms  1.812 ms
 4  libcr1-po-5.gw.unsw.edu.au (149.171.255.165)  1.131 ms libcr1-po-6.gw.unsw.edu.au (149.171.255.201)  1.201 ms ombcr1-po-5.gw.unsw.edu.a
 5  unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  1.161 ms unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.131 ms unswbr1-te-1-9.gw.
 6  138.44.5.0 (138.44.5.0)  3.278 ms  2.779 ms  2.752 ms
 7  et-0-3-0.pe1.alxd.nsw.aarnet.net.au (113.197.15.153)  1.995 ms  1.848 ms  1.708 ms
 8  xe-0-2-7.bdr1.a.lax.aarnet.net.au (202.158.194.173)  148.005 ms  147.967 ms  147.898 ms
 9  singtel.as7473.any2ix.coresite.com (206.72.210.63)  147.713 ms  147.656 ms  147.745 ms
10  203.208.171.117 (203.208.171.117)  148.933 ms  148.105 ms  148.386 ms
11  203.208.172.145 (203.208.172.145)  246.684 ms 203.208.177.110 (203.208.177.110)  328.298 ms 203.208.172.145 (203.208.172.145)  246.168
12  203.208.158.17 (203.208.158.17)  322.250 ms *  322.308 ms
13  202-150-221-170.rev.ne.com.sg (202.150.221.170)  210.634 ms  213.776 ms 203.208.177.110 (203.208.177.110)  321.541 ms
```

Traceroute from www.speedtest.com.sg to my machine:

```
traceroute to 129.94.242.251 (129.94.242.251), 30 hops max, 60 byte packets
 1  ge2-8.r01.sin01.ne.com.sg (202.150.221.169)  0.129 ms  0.148 ms  0.161 ms
 2  10.11.34.146 (10.11.34.146)  0.392 ms  0.502 ms  0.545 ms
 3  aarnet.sgix.sg (103.16.102.67)  209.116 ms  209.130 ms  209.175 ms
 4  et-7-3-0.pe1.nsw.brwy.aarnet.net.au (113.197.15.232)  204.294 ms  204.329 ms  204.310 ms
 5  138.44.5.1 (138.44.5.1)  206.833 ms  206.806 ms  206.850 ms
 6  ombcr1-te-1-5.gw.unsw.edu.au (149.171.255.106)  209.252 ms  209.247 ms  209.218 ms
 7  libudnex1-po-2.gw.unsw.edu.au (149.171.255.198)  200.398 ms  200.323 ms  200.642 ms
 8  ufw1-ae-1-3154.gw.unsw.edu.au (149.171.253.36)  209.917 ms  209.924 ms  209.897 ms
```

The path from my machine to speedtest.com.sg go through routers in Singapore (103.16.102.67). However, the path from speedtest.com.sg to my machine go through LA (203.208.171.117).

There is a same router but with different IP address, speedtest.com.sg to my machine: 138.44.5.1, my machine to speedtest.com.sg: 138.44.5.0 both IP address belongs to the same route but have been allocated to a different interface.

ii. The IP address of my machine is 129.94.242.251, the IP address of www.telstra.net is 203.50.5.178

Traceroute from my machine to www.telstra.net:

```
wagner % traceroute www.telstra.net
traceroute to www.telstra.net (203.50.5.178), 30 hops max, 60 byte packets
 1  cserouter1-server.cse.unsw.EDU.AU (129.94.242.251)  0.134 ms  0.101 ms  0.091 ms
 2  129.94.39.17 (129.94.39.17)  0.867 ms  0.836 ms  0.869 ms
 3  ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  1.624 ms  1.577 ms  1.787 ms
 4  ombcr1-po-6.gw.unsw.edu.au (149.171.255.169)  1.113 ms libcr1-po-5.gw.unsw.edu.au (149.171.255.165)  1.170 ms ombcr1-po-6.gw.unsw.edu.
 5  unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.193 ms unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  1.178 ms unswbr1-te-2-13.g
 6  138.44.5.0 (138.44.5.0)  1.224 ms  1.276 ms  1.285 ms
 7  et-1-1-0.pe1.rsby.nsw.aarnet.net.au (113.197.15.12)  1.665 ms  1.748 ms  1.762 ms
 8  xe-0-0-3.bdr1.rsby.nsw.aarnet.net.au (113.197.15.31)  1.491 ms  3.011 ms  2.993 ms
 9  HundredGigE0-1-0-4.ken-edge903.sydney.telstra.net (139.130.0.77)  2.570 ms  2.564 ms  2.685 ms
10  bundle-ether2.chw-edge903.sydney.telstra.net (203.50.11.175)  2.310 ms  2.186 ms bundle-ether17.ken-core10.sydney.telstra.net (203.50.
11  bundle-ether17.chw-core10.sydney.telstra.net (203.50.11.176)  2.636 ms  4.259 ms bundle-ether10.win-core10.melbourne.telstra.net (203.
12  bundle-ether8.exi-core10.melbourne.telstra.net (203.50.11.125)  15.980 ms  15.651 ms  15.639 ms
13  bundle-ether2.exi-ncprouter101.melbourne.telstra.net (203.50.11.209)  15.066 ms  15.079 ms  14.332 ms
14  www.telstra.net (203.50.5.178)  13.580 ms  14.338 ms  13.678 ms
```

Traceroute from www.telstra.net to my machine:

```
 1  gigabitethernet3-3.exi2.melbourne.telstra.net (203.50.77.53)  0.294 ms  0.200 ms  0.242 ms
 2  bundle-ether3-100.win-core10.melbourne.telstra.net (203.50.80.129)  1.114 ms  1.603 ms  2.117 ms
 3  bundle-ether12.ken-core10.sydney.telstra.net (203.50.11.122)  13.110 ms  12.598 ms  12.736 ms
 4  bundle-ether1.ken-edge903.sydney.telstra.net (203.50.11.173)  11.986 ms  11.973 ms  11.986 ms
 5  aar3533567.lnk.telstra.net (139.130.0.78)  13.234 ms  25.093 ms  11.484 ms
 6  et-7-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.13)  11.860 ms  11.846 ms  11.860 ms
 7  138.44.5.1 (138.44.5.1)  12.109 ms  12.101 ms  11.988 ms
 8  libcr1-te-1-5.gw.unsw.edu.au (149.171.255.102)  12.108 ms  12.099 ms  12.110 ms
 9  ombudnex1-po-1.gw.unsw.edu.au (149.171.255.202)  12.486 ms
10  ufw1-ae-1-3154.gw.unsw.edu.au (149.171.253.36)  12.723 ms  12.723 ms  12.735 ms
11  129.94.39.23 (129.94.39.23)  12.859 ms  12.849 ms  12.860 ms
```

It is obvious that routers on the internet do not need to be symmetric. This is helpful for a better load balance, so entity would like to have separate routers to handle ingoing and outgoing connections. However, even forward, and reverse path cross the same router, it is possible that different IP address are observed, we observe different IP address in the two paths (Telstra to my machine: 113.197.15.13, my machine to Telstra: 113.197.15.12). The traceroute output are the names of the router interfaces, but not the name of routers. Thus, both IP address belongs to the same route but have been allocated to a different interface. For example, Telstra to my machine: 138.44.5.1, my machine to Telstra: 138.44.5.0.

Exercise 4: Use ping to gain insights into network performance

1. Physical distance from UNSW to each location:

Brisbane: 737km, Kuala Lumpur: 6620km, Berlin: 16100km

Let us assume that the packet moves at the speed of light, $\mathbf{3} \times \mathbf{10^8}\ \boldsymbol{m/s}$.The shortest possible time from UNSW to each location:

Brisbane: 2.5ms, Kuala Lumpur: 22.1ms, Berlin: 53.7ms

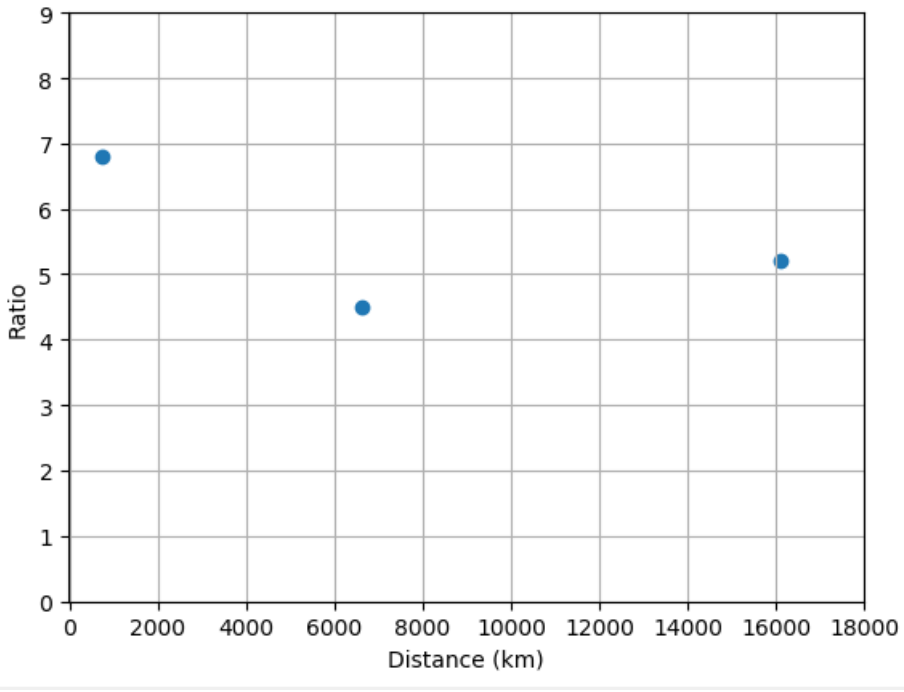
Minimum RTT (for 50 bytes packets) to each location (from the corresponding *avg.txt file):

Brisbane: 16.983ms, Kuala Lumpur: 100.637ms, Berlin: 281.910ms

Thus, the ratios of the minimum RTT to the minimum propagation delay for each location:

Brisbane: 6.8, Kuala Lumpur: 4.5, Berlin: 5.2

The following plot show the ratio as a function of distance:



There are lots of reasons why the y-axis values are greater than 2:

- The speed of light does not consider for the transmission delays.
- Packets do not travel as the full speed of light
- Packets may traverse low bandwidth links such that it takes considerably extra time for the full packet to transit the link.

2. The delay of the destination vary over time, because the speed of delay might treat as the speed of light, it is vary when going through different objects.

3. The website for www.epfl.ch is not hosted in Switzerland, I confirm this from ping, traceroute, and research on the website. It is hosted in www.epfl.ch.cdn.cloudflare.net which is 12 hops away from UNSW.

```
weber % traceroute www.epfl.ch.cdn.cloudflare.net
traceroute to www.epfl.ch.cdn.cloudflare.net (104.20.228.42), 30 hops max, 60 byte packets
 1  cserouter1-server.cse.unsw.EDU.AU (129.94.242.251)  0.495 ms  0.486 ms  0.471 ms
 2  129.94.39.17 (129.94.39.17)  1.209 ms  1.213 ms  1.240 ms
 3  libudnex1-vl-3154.gw.unsw.edu.au (149.171.253.34)  1.721 ms  1.948 ms ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  1.860 ms
 4  ombcr1-po-5.gw.unsw.edu.au (149.171.255.197)  1.508 ms  1.540 ms libcr1-po-5.gw.unsw.edu.au (149.171.255.165)  1.503 ms
 5  unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  1.547 ms unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.571 ms  1.599 ms
 6  138.44.5.0 (138.44.5.0)  1.780 ms  1.576 ms  1.599 ms
 7  ae2.bdr1.msc4.nsw.aarnet.net.au (113.197.15.77)  1.768 ms  1.794 ms  1.760 ms
 8  as4826.bdr1.msc4.nsw.aarnet.net.au (138.44.10.45)  2.439 ms  2.467 ms  2.549 ms
 9  be107.cor01.syd11.nsw.vocus.network (114.31.192.80)  2.241 ms be107.cor02.syd04.nsw.vocus.network (114.31.192.82)  2.205 ms  2.278 ms
10  be100.bdr02.syd03.nsw.vocus.network (114.31.192.39)  2.324 ms be101.bdr02.syd03.nsw.vocus.network (114.31.192.37)  2.644 ms  2.582 ms
11  as13335.bdr02.syd03.nsw.VOCUS.net.au (175.45.124.197)  12.624 ms  14.718 ms  14.441 ms
12  104.20.228.42 (104.20.228.42)  1.681 ms  1.538 ms  1.628 ms
```

4.

The propagation delay does not depend on the packet size.

The transmission delay is almost proportional to the packet size.

The processing delay can depend on the packet size, but less dependence than the transmission delay.

The queuing delay only depends on the congestion in the network.