Exercise 1: nslookup

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

1. Which is the IP address of the Google site (www.google.com)? In your opinion, what is the reason of having several IP addresses as an output?
2. Find out name of the IP address 127.0.0.1. What is special about this IP address?

Answer 1:

1. The Google site's IP address is 216.58.196.132, here is the picture:

```
Non-authoritative answer:
Name:    www.google.com
Address: 216.58.196.132
```

I think the reason of having several IP addresses is for load balancing. In fact, there are many servers in some companies and each one will get an IP address, which means every server will get their own IP address. Therefore, when some clients ask for service at the same time, they will get different servers' respond. However, Google.com does not have many IP addresses, so I give another example from youtube.com. Here is the picture:

```
Name:    youtube-ui.l.google.com
Address: 172.217.25.142
Name:    youtube-ui.l.google.com
Address: 172.217.25.174
Name:    youtube-ui.l.google.com
Address: 216.58.196.142
Name:    youtube-ui.l.google.com
Address: 216.58.199.78
Name:    youtube-ui.l.google.com
Address: 216.58.200.110
Name:    youtube-ui.l.google.com
Address: 216.58.203.110
Name:    youtube-ui.l.google.com
Address: 172.217.25.46
```

2. The IP address 127.0.0.1 is localhost, here is the picture:

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

127.0.0.1 always means the IP address from local machine. It is very useful IP address in testing connection of network and it is called loop back address. It cannot be forwarded in the Internet.

Exercise 2: Use ping to test host reachability

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

- www.cse.unsw.edu.au
- www.getfittest.com.au
- www.mit.edu
- www.intel.com.au
- www.tpg.com.au
- www.hola.hp
- www.amazon.com
- www.tsinghua.edu.cn
- www.kremlin.ru
- 8.8.8.8

If you observe that some hosts are not reachable, then can you explain why? Check if the addresses unreachable by the ping command are reachable from the Web browser.

Answer 2:

When we ping www.getfittest.com.au and www.hola.hp, we will find they cannot be connected via ping:

```
weill % ping -c 3 www.hola.hp
ping: unknown host www.hola.hp
weill % ping -c 3 www.getfittest.com.au
ping: unknown host www.getfittest.com.au
```

There two websites are also unreachable from Web browser because these two websites do not exist. However, when we ping www.kremlin.ru , we will find all packets are lost:

```
PING www.kremlin.ru (95.173.136.70) 56(84) bytes of data.

--- www.kremlin.ru ping statistics ---
3 packets transmitted, 0 received, 100% packet loss, time 2015ms
```

We can access this website from browser. I think this is because www.kremlin.ru prohibit ICMP protocol, which is the tool for ping. It is an effective way to prevent some attacks from Internet, such as DoS and ICMP-redirect attack.

All other websites can be reachable from ping.

Exercise 3: Use traceroute to understand network topology

Note: Include all traceroute outputs in your report.

1. Run traceroute on your machine to www.columbia.edu . How many routers are there between your workstation andwww.columbia.edu ? How many routers along the path are part of the UNSW network? Between which two routers do packets cross the Pacific Ocean? Hint: compare the round trip times from your machine to the routers using ping.
2. Run traceroute from your machine to the following destinations: (i) www.ucla.edu (ii) www.u-tokyo.ac.jp and (iii)www.lancaster.ac.uk . At which router do the paths from your machine to these three destinations diverge? Find out further details about this router. (HINT: You can find out more about a router by running the whois command: whois router-IP-address). Is the number of hops on each path proportional the physical distance? HINT: You can find out geographical location of a server using the following tool - http://www.yougetsignal.com/tools/network-location/
3. Several servers distributed around the world provide a web interface from which you can perform a traceroute to any other host in the Internet. Here are two examples: (i) http://www.speedtest.com.sg/tr.php and (ii) https://www.telstra.net/cgi-bin/trace . Run traceroute from both these servers towards your machine and in the reverse direction (i.e. from your machine to these servers). 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. Does the reverse path go through the same routers as the forward path? 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 3:

1. When we traceroute to www.columbia.edu, we can find there are 21 routers between my workstation and this site. Here is the picture:

```
 1  cserouter1-server.cse.unsw.EDU.AU (129.94.242.251)  0.135 ms  0.106 ms  0.094 ms
 2  129.94.39.17 (129.94.39.17)  1.006 ms  0.978 ms  1.047 ms
 3  ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  1.721 ms  1.707 ms libudnex1-vl-3154.gw.unsw
 4  ombcr1-po-5.gw.unsw.edu.au (149.171.255.197)  1.208 ms libcr1-po-5.gw.unsw.edu.au (149.171.255.
 5  unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.308 ms  1.307 ms  1.347 ms
 6  138.44.5.0 (138.44.5.0)  1.383 ms  1.452 ms  1.428 ms
 7  et-1-3-0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.15.149)  2.274 ms  2.359 ms  2.782 ms
 8  et-0-0-0.pe1.a.hnl.aarnet.net.au (113.197.15.99)  95.306 ms  95.294 ms  95.377 ms
 9  et-2-1-0.bdr1.a.sea.aarnet.net.au (113.197.15.201)  146.450 ms  146.480 ms  146.434 ms
10  abilene-1-lo-jmb-706.sttlwa.pacificwave.net (207.231.240.8)  146.573 ms  146.511 ms  146.448 ms
11  et-4-0-0.4079.rtsw.miss2.net.internet2.edu (162.252.70.0)  157.300 ms  157.271 ms  157.346 ms
12  et-4-0-0.4079.rtsw.minn.net.internet2.edu (162.252.70.58)  180.819 ms  180.792 ms  180.739 ms
13  et-1-1-2.4079.rtsw.eqch.net.internet2.edu (162.252.70.106)  188.537 ms  188.563 ms  188.665 ms
14  ae-1.4079.rtsw.clev.net.internet2.edu (162.252.70.130)  196.845 ms  197.224 ms  197.154 ms
15  buf-9208-I2-CLEV.nysernet.net (199.109.11.33)  201.246 ms  201.226 ms  201.119 ms
16  syr-9208-buf-9208.nysernet.net (199.109.7.193)  205.013 ms  205.050 ms  205.034 ms
17  nyc-9208-syr-9208.nysernet.net (199.109.7.162)  217.481 ms  210.364 ms  210.330 ms
18  columbia.nyc-9208.nysernet.net (199.109.4.14)  495.362 ms  487.616 ms  398.477 ms
19  cc-core-1-x-nyser32-gw-1.net.columbia.edu (128.59.255.5)  210.684 ms  210.737 ms  210.666 ms
20  cc-conc-1-x-cc-core-1.net.columbia.edu (128.59.255.210)  211.001 ms  210.951 ms  210.880 ms
21  cuf.columbia.edu (128.59.105.24)  210.597 ms  210.453 ms  210.528 ms
```

We can find that some sites have ‘unsw.edu.au’, so there are 5 routers which are part of UNSW network.

I think the 9th and 10th are two routers taking packets cross the Pacific Ocean. First, we can find that some sites have ‘net.au’, so we can confirm that 9th router is in Australia. And then, we can use ping to ping 113.197.15. x and 207.231.240.x. and we can find:

```
PING 113.197.15.149 (113.197.15.149) 56(84) bytes of data.
64 bytes from 113.197.15.149: icmp_req=1 ttl=58 time=2.09 ms
64 bytes from 113.197.15.149: icmp_req=2 ttl=58 time=1.98 ms
64 bytes from 113.197.15.149: icmp_req=3 ttl=58 time=2.17 ms
64 bytes from 113.197.15.149: icmp_req=4 ttl=58 time=9.71 ms
64 bytes from 113.197.15.149: icmp_req=5 ttl=58 time=2.05 ms
64 bytes from 113.197.15.149: icmp_req=6 ttl=58 time=2.04 ms
64 bytes from 113.197.15.149: icmp_req=7 ttl=58 time=2.41 ms
64 bytes from 113.197.15.149: icmp_req=8 ttl=58 time=2.05 ms
64 bytes from 113.197.15.149: icmp_req=9 ttl=58 time=1.98 ms
```

```
PING 207.231.240.8 (207.231.240.8) 56(84) bytes of data.
64 bytes from 207.231.240.8: icmp_req=1 ttl=55 time=146 ms
64 bytes from 207.231.240.8: icmp_req=2 ttl=55 time=146 ms
64 bytes from 207.231.240.8: icmp_req=3 ttl=55 time=147 ms
64 bytes from 207.231.240.8: icmp_req=4 ttl=55 time=146 ms
64 bytes from 207.231.240.8: icmp_req=5 ttl=55 time=149 ms
```

Ping 207.231.240. x cost more time than ping 113.197.15.x, so we can sure that 9th and 10th routers are the two routers. As for reason, I think the two routers doing packets cross the Pacific Ocean should have more time to process lots of different packets from different spots. Not only propagation delay is increasing, but also queueing delay (There are lots of different packets) and transmission delay are probably increasing. Therefore, I can sure these two routers through the two obvious delay.

2.Through comparing these three destinations, I think the router which has 138.44.5.0 is the separated router. There are more details about this router:

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

…

The number of hops is independent of the physical distance. For example, using the result from traceroute www.columbia.edu, we can find:

network information	network information
IP Address **149.171.253.34**	IP Address **113.197.15.201**
Base Domain **unsw.edu.au**	Base Domain **aarnet.net.au**
Country **Australia**	Country **Australia**
Region **02**	Region **Unknown**
City **Sydney**	City **Unknown**
Latitude **-33.8833**	Latitude **-27**
Longitude **151.2167**	Longitude **133**
Area Code **Unknown**	Area Code **Unknown**
Postal Code **Unknown**	Postal Code **Unknown**
Distance from Last (as the crow flies) **9948.7 miles**	Distance from Last (as the crow flies) **10643.4 miles**
Source **MaxMind**	Source **MaxMind**

The 3rd hop(149.171.253.34) is closer than the 9th hop(113.197.15.201) in physical distance.

3.The IP addresses of the two servers are 202.150.221.169 and 203.50.77.53 respectively because when using the two servers to run traceroute, it shows the two servers' source IP addresses. There are two pictures from these two websites:

```
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)  0.143 ms  0.163 ms  0.177 ms
```

```
1  gigabitethernet3-3.exi2.melbourne.telstra.net (203.50.77.53)  0.310 ms  0.222 ms  0.244 ms
```

Result from my machine (129.94.242.251) to www.speedtest.com.sg (202.150.221.169) as below:

```
traceroute to 202.150.221.169 (202.150.221.169), 30 hops max, 60 byte packets
 1  cserouter1-server.cse.unsw.EDU.AU (129.94.242.251)  0.136 ms  0.125 ms  0.11
4 ms
 2  129.94.39.17 (129.94.39.17)  1.124 ms  1.109 ms  1.083 ms
 3  ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  1.826 ms libudnex1-vl-315
4.gw.unsw.edu.au (149.171.253.34)  1.495 ms ombudnex1-vl-3154.gw.unsw.edu.au (14
9.171.253.35)  1.815 ms
 4  ombcr1-po-6.gw.unsw.edu.au (149.171.255.169)  1.278 ms libcr1-po-6.gw.unsw.e
du.au (149.171.255.201)  1.238 ms ombcr1-po-5.gw.unsw.edu.au (149.171.255.197)
1.296 ms
 5  unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.522 ms  1.506 ms unswbr1
-te-1-9.gw.unsw.edu.au (149.171.255.101)  1.448 ms
 6  138.44.5.0 (138.44.5.0)  1.513 ms  1.391 ms  1.401 ms
 7  et-0-3-0.pe1.alxd.nsw.aarnet.net.au (113.197.15.153)  1.771 ms  1.819 ms  1.
837 ms
 8  xe-0-0-3.pe1.wnpa.akl.aarnet.net.au (113.197.15.67)  24.301 ms  24.329 ms xe
-0-2-1-204.pe1.wnpa.alxd.aarnet.net.au (113.197.15.183)  24.138 ms
 9  et-0-1-0.200.pe1.tkpa.akl.aarnet.net.au (113.197.15.69)  24.681 ms  24.513 m
s  24.563 ms
10  xe-0-2-6.bdr1.a.lax.aarnet.net.au (202.158.194.173)  148.045 ms  148.107 ms
 148.084 ms
11  singtel.as7473.any2ix.coresite.com (206.72.210.63)  310.260 ms  310.342 ms
310.224 ms
12  203.208.151.181 (203.208.151.181)  323.622 ms 203.208.172.173 (203.208.172.1
73)  338.700 ms 203.208.182.153 (203.208.182.153)  334.987 ms
13  * * *
14  * 203.208.182.45 (203.208.182.45)  330.482 ms *
15  * * *
16  * * *
17  * * *
18  * * *
19  * * *
20  * * *
21  * * *
22  * * *
23  * * *
24  * * *
25  * * *
26  * * *
27  * * *
28  * * *
29  * * *
30  * * *
```

Result from http://www.speedtest.com.sg/tr.php to my machine (129.94.242.251) as below:

Traceroute Result:

```
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)  0.199 ms  0.204 ms  0.214 ms
 2  10.11.33.38 (10.11.33.38)  32.882 ms  32.890 ms  32.896 ms
 3  hutchcity3-10g.hkix.net (123.255.90.140)  34.453 ms  34.490 ms  34.465 ms
 4  218.189.5.42 (218.189.5.42)  34.385 ms d1-42-238-143-118-on-nets.com (118.143.238.42)  34.340 ms  34.313 ms
 5  d1-26-224-143-118-on-nets.com (118.143.224.26)  189.287 ms d1-6-224-143-118-on-nets.com (118.143.224.6)  180.799 ms d1-2-224-143-118-on-nets.cc
 6  aarnet.as7575.any2ix.coresite.com (206.72.210.64)  179.572 ms  181.357 ms  173.060 ms
 7  xe-0-0-3.pe1.tkpa.akl.aarnet.net.au (202.158.194.172)  294.912 ms  303.394 ms  294.800 ms
 8  et-0-1-0.200.pe1.wnpa.akl.aarnet.net.au (113.197.15.68)  305.633 ms  303.336 ms  303.699 ms
 9  xe-1-2-1.pe1.msct.nsw.aarnet.net.au (113.197.15.66)  325.813 ms xe-0-2-2-204.pe1.alxd.nsw.aarnet.net.au (113.197.15.182)  333.393 ms  324.551 r
10  et-8-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.152)  339.969 ms  341.301 ms  331.034 ms
11  138.44.5.1 (138.44.5.1)  325.963 ms  325.948 ms  318.721 ms
12  ombcr1-te-1-5.gw.unsw.edu.au (149.171.255.106)  326.223 ms  326.189 ms  319.259 ms
13  libudnex1-po-2.gw.unsw.edu.au (149.171.255.198)  338.455 ms  330.175 ms  338.406 ms
14  ufw1-ae-1-3154.gw.unsw.edu.au (149.171.253.36)  328.860 ms  327.232 ms  328.271 ms
15  * * *
16  * * *
17  * * *
18  * * *
19  * * *
20  * * *
21  * * *
22  * * *
23  * * *
24  * * *
25  * * *
26  * * *
27  * * *
28  * * *
29  * * *
30  * * *
```

Traceroute Completed.

Result from my machine (129.94.242.251) to https://www.telstra.net (203.50.77.53) as below:

```
traceroute to 203.50.77.53 (203.50.77.53), 30 hops max, 60 byte packets
 1  cserouter1-server.cse.unsw.EDU.AU (129.94.242.251)  0.112 ms  0.120 ms  0.142 ms
 2  129.94.39.17 (129.94.39.17)  1.143 ms  1.108 ms  1.090 ms
 3  ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  9.635 ms  9.268 ms libudnex1-vl-3154.gw.unsw.edu.a
 4  ombcr1-po-6.gw.unsw.edu.au (149.171.255.169)  1.299 ms libcr1-po-6.gw.unsw.edu.au (149.171.255.201)
 5  unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.380 ms unswbr1-te-1-9.gw.unsw.edu.au (149.171.25
 6  138.44.5.0 (138.44.5.0)  1.516 ms  1.566 ms  1.587 ms
 7  et-0-3-0.pe1.bkvl.nsw.aarnet.net.au (113.197.15.147)  1.753 ms  1.761 ms  1.705 ms
 8  ae9.bb1.a.syd.aarnet.net.au (113.197.15.57)  2.034 ms  2.118 ms  2.019 ms
 9  gigabitethernet1-1.pe1.b.syd.aarnet.net.au (202.158.202.18)  2.291 ms  2.218 ms  2.282 ms
10  gigabitethernet3-11.ken37.sydney.telstra.net (139.130.0.77)  2.888 ms  3.056 ms  2.901 ms
11  bundle-ether13.ken-core10.sydney.telstra.net (203.50.11.94)  3.495 ms  3.469 ms  3.297 ms
12  bundle-ether10.win-core10.melbourne.telstra.net (203.50.11.123)  14.476 ms  14.463 ms  15.925 ms
13  tengigabitethernet8-1.exi2.melbourne.telstra.net (203.50.80.154)  13.729 ms * *
```

Result from https://www.telstra.net/cgi-bin/trace to my machine (129.94.242.251) as below:

```
 1  gigabitethernet3-3.exi2.melbourne.telstra.net (203.50.77.53)  0.393 ms  0.328 ms  0.241 ms
 2  bundle-ether3-100.win-core10.melbourne.telstra.net (203.50.80.129)  1.489 ms  1.354 ms  2.117 ms
 3  bundle-ether12.ken-core10.sydney.telstra.net (203.50.11.122)  12.235 ms  12.225 ms  12.984 ms
 4  bundle-ether1.ken-edge901.sydney.telstra.net (203.50.11.95)  12.110 ms  11.974 ms  11.861 ms
 5  aarnet6.lnk.telstra.net (139.130.0.78)  11.734 ms  11.601 ms  11.610 ms
 6  ge-6-0-0.bb1.a.syd.aarnet.net.au (202.158.202.17)  11.735 ms  11.723 ms  11.737 ms
 7  ae9.pe2.brwy.nsw.aarnet.net.au (113.197.15.56)  12.109 ms  17.471 ms  12.106 ms
 8  et-3-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.146)  12.360 ms  12.349 ms  12.360 ms
 9  138.44.5.1 (138.44.5.1)  12.612 ms  12.600 ms  12.610 ms
10  ombcr1-te-1-5.gw.unsw.edu.au (149.171.255.106)  12.612 ms  12.599 ms  12.610 ms
11  libudnex1-po-2.gw.unsw.edu.au (149.171.255.198)  29.974 ms  12.849 ms  12.984 ms
12  ufw1-ae-1-3154.gw.unsw.edu.au (149.171.253.36)  13.235 ms  13.225 ms  13.359 ms
```

According to above, the forward and reverse path are different. This is because network environment is random and congestion cannot be predicted which may impact on routers' chosen path. There are common routers (i.e. bundle-ether 12 (or 13) .ken-core10.sydney.telstra.net) but the IP addresses are different because there are different interfaces. This means that the up link and down link are random and it may depend on congestion of network on the Internet.

Exercise 4: Use ping to gain insights into network performance

Note: Include all graphs in your report.

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 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 will have to 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 and with 50 ping packets per size. Note, since a ping is sent once per second, this script will take a few minutes to finish. Basically, this script only executes the commands:

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

...

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

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

Use this script for the following destinations:

(i) www.uq.edu.au (ii) www.nus.edu.sg and (iii) www.tu-berlin.de

In other words, execute the following commands

```
$ ./runping.sh www.uq.edu.au

$ ./runping.sh www.nus.edu.sg

$ ./runping.sh www.tu-berlin.de
```

In case you notice one of the hosts above is not responsive, select the following alternate destinations: (i) within Australia (www.uow.edu.au , www.flinders.edu.au , www.uws.edu.au) (ii) Asia (www.tsinghua.edu.cn , www.sutd.edu.sg , www.iit.ac.in) (iii) Europe (www.epfl.ch , www.aau.dk , www.uio.no)

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

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

```
$ ./plot.sh www.uq.edu.au-p*

$ ./plot.sh www.nus.edu.sg-p*

$ ./plot.sh www.tu-berlin.de-p*
```

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

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

The script plot.sh will produce the following files: destination_delay.pdf, destination_scatter.pdf, and destination_avg.txt for each of the destinations (e.g., for www.nus.edu.sg we have *www.nus.edu.sg_delay.pdf* , *www.nus.edu.sg_scatter.pdf* and *www.nus.edu.sug_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 of these locations find the (approximate) physical distance from UNSW using Google Maps and compute the shortest possible time T for a packet to reach that location from UNSW. You should assume that the packet moves (i.e. propagates) at the speed of light, 3×10^8 m/s. Note that the shortest possible time will simply be the distance divided by the propagation speed. Plot a graph where the x-axis represents the distance to each city (i.e. Adelaide, Singapore and Berlin), and the y-axis represents the ratio between the minimum delay (i.e. RTT) as 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 get back). Can you think of at least two reasons why the y-axis values that you plot are greater than 2?
2. Is the delay to the destinations constant or does it vary over time? Explain why.
3. The measured delay (i.e., the delay you can see in the graphs) is composed of propagation delay, transmission delay, processing delay and queuing delay. Which of these delays depend on the packet size and which do not?

Answer 4:

1. From Google map, Adelaide, Singapore and Berlin have approximate 1200km, 6300km and 16200km to UNSW. That means:

   Ta = 1.2*10^6 / c = 4 ms

   Ts= 6.3*10^6/c = 21 ms

   Tb= 1.62*10^7/c = 54 ms

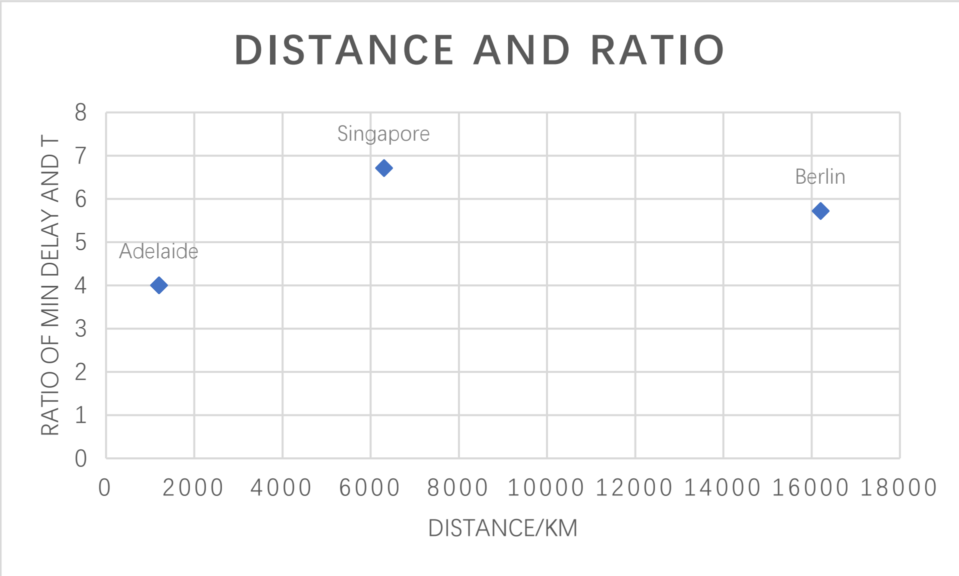
   We can find that in plot, Adelaide, Singapore and Berlin have approximate 16ms, 141ms and 309ms delay to UNSW respectively. And the ratios are:

   Adelaide: 16/4 = 4

   Singapore: 141/21 = 6.71

   Berlin: 309/54 = 5.72

So we can get this plot:



The reasons of y-axis values that are greater than 2 are:

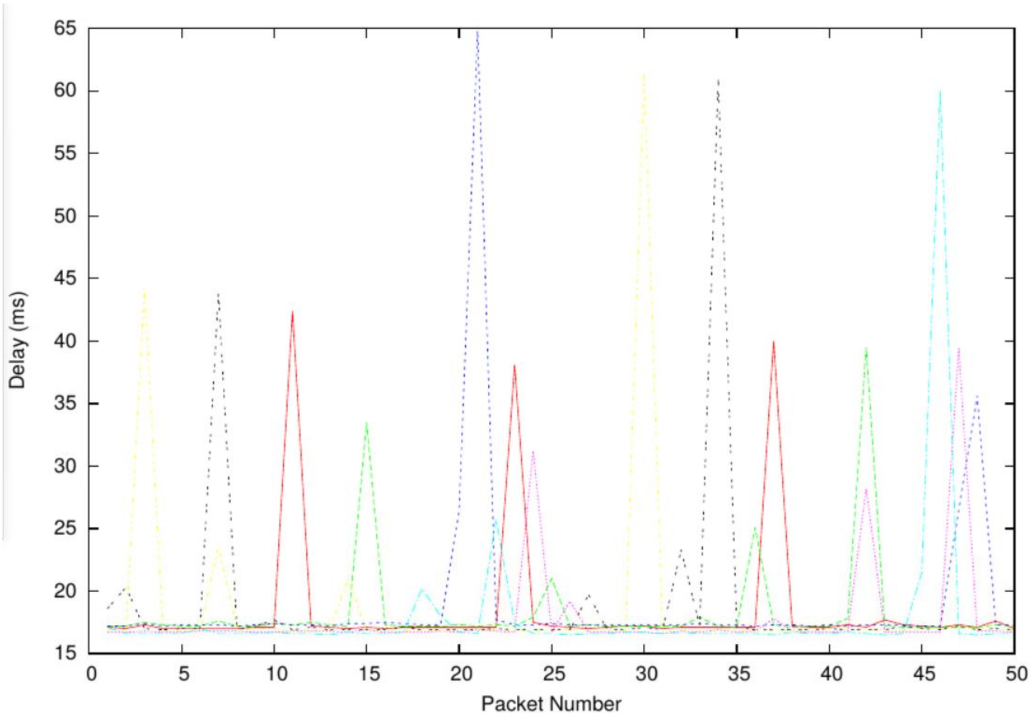
① It is impossible that the packets' crossing path's distances from UNSW to other cities is equal to physical distances which are straight-line distances from UNSW to other cities. There are lots of routers and the paths are random.

② Every router or switch has its own delay when it processes packets, that is called nodal delay.

③ Some network may process lots of data, whose routers have lots of data and their queues are full so routers can not process data. It is called queueing delay.

④ There is also transmission delay which depends on packet length and link bandwidth, and propagation delay which depends on length of physical link and the link's medium.

2.The delay to destination varies over time because there are lots of different nodal points on the Internet, which means the network environment are always changing. For example, some routers may get instant information which may have higher priority so they cannot process our packets immediately. In addition, the paths chosen by routers are also random, so we cannot ensure that the time to destination is constant. Here is the picture from www.uq.edu.au_delay.pdf:



3. The transmission delay and processing delay depend on packet size, others do not depend on packet size. As for transmission delay, it depends on packet length and link bandwidth. Processing delay, which can be called nodal processing delay, also depends on packet size. This is because nodal processing will check bits errors and it will spend more time if packets are larger.