Week 2 Lab Report - COMP3331

Exercise 1:
First of all, I put all the domains of links into a single file called `'input.txt'` line by line as the input of my shell script named `'Run.sh'`. The shell script basically runs ping command for each domain name line by line in the `'input.txt'` and generates outputs into a new file with the same name of domains. The followings show my `'Run.sh'` script and an example of result by ping.

```
#!/bin/sh
 while read -r line
do
    ping -s 4 -c 10 $line>$line
done
```

```
PING d3ag4hukkh62yn.cloudfront.net (54.230.135.118) 4(32) bytes of
data.
12 bytes from server-54-230-135-118.syd1.r.cloudfront.net
(54.230.135.118): icmp_req=1 ttl=245
12 bytes from server-54-230-135-118.syd1.r.cloudfront.net
(54.230.135.118): icmp_req=2 ttl=245
12 bytes from server-54-230-135-118.syd1.r.cloudfront.net
(54.230.135.118): icmp_req=3 ttl=245
12 bytes from server-54-230-135-118.syd1.r.cloudfront.net
(54.230.135.118): icmp_req=4 ttl=245
12 bytes from server-54-230-135-118.syd1.r.cloudfront.net
(54.230.135.118): icmp_req=5 ttl=245
12 bytes from server-54-230-135-118.syd1.r.cloudfront.net
(54.230.135.118): icmp_req=6 ttl=245
12 bytes from server-54-230-135-118.syd1.r.cloudfront.net
(54.230.135.118): icmp_req=7 ttl=245
12 bytes from server-54-230-135-118.syd1.r.cloudfront.net
(54.230.135.118): icmp_req=8 ttl=245
12 bytes from server-54-230-135-118.syd1.r.cloudfront.net
(54.230.135.118): icmp_req=9 ttl=245
12 bytes from server-54-230-135-118.syd1.r.cloudfront.net
(54.230.135.118): icmp_req=10 ttl=245

--- d3ag4hukkh62yn.cloudfront.net ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9011ms
```

To check if the addresses are reachable, I wrote another Perl program named ‘check.pl’ to extract the last line of each file. The followings show the ‘check.pl’ and its outputs.

```
#!/usr/bin/perl -w
while ($line = <STDIN>) {
      push(@files, $line);
}

foreach $file (@files) {
      chomp $file;
     open(F, "<", $file) or die "$file fails: $!";
      while ($line = <F>) {
       if ($line =~ /packets transmitted/) {
            print "$file: $line";
       }
     }
     close F;
}
```

```
www.cse.unsw.edu.au: 10 packets transmitted, 10 received, 0%
packet loss, time 8996ms
www.cancercouncil.org.au: 10 packets transmitted, 0 received, 100%
packet loss, time 9070ms
compnet.epfl.ch: 10 packets transmitted, 10 received, 0% packet
loss, time 9013ms
www.intel.com.au: 10 packets transmitted, 10 received, 0% packet
loss, time 9012ms
www.telstra.com.au: 10 packets transmitted, 10 received, 0% packet
loss, time 9011ms
www.amazon.com: 10 packets transmitted, 10 received, 0% packet
loss, time 9011ms
www.wikileaks.org: 10 packets transmitted, 10 received, 0% packet
loss, time 9005ms
www.tsinghua.edu.cn: 10 packets transmitted, 10 received, 0%
packet loss, time 9002ms
www.kremlin.ru: 10 packets transmitted, 0 received, 100% packet
loss, time 9070ms
8.8.8.8: 10 packets transmitted, 10 received, 0% packet loss, time
9014ms
```

From my final result, I can say www.cancercouncil.org.au , www.kremlin.ru and www.hola.hp are not reachable and the rest are reachable by ping.

Surprisingly, www.cse.unsw.edu.au and compnet.epfl.ch are redirected to another domain name when I connected to it from my web browser.
For www.hola.hp, ping gave me the error message, saying it is unknown host. From my searching, it is because the host server name that the user has provided does not exist or match any Domain Name System (DNS) records. Apparently, I could not open it on the web browser either.
For www.kremlin.ru, I got 100% packet loss but I can still connect to it from my web browser. It might be because the server is simply blocking ICMP packets for some security reasons, while other services will work fine. It is not unusual for firewall to be set up to block anything but the port traffic for the services offered, so a web server for example may drop all ping packets and you get 100% packet loss, but still be fine for web services.
For www.cancercouncil.org.au, I also got 100% packet loss and cannot connect to the website on my web browser. The reason may be that although this domain name exists in DNS, it does not connect to any server.

Exercise 2:
Q1:

- First of all, I ran the traceroute command and from the output(picture) below, I can only say that at least 23 routers are on the path. However there are more words to talk about this output.
    1. No. 22 router cannot be identified for some reasons, but we can conclude that there must be a router.
    2. However, from No.23 to No.30, there are two different scenarios:
        a. It is more likely that No. 23 is the destination, yet this router has not been set to indicate that it is the destination of the path, that is, ICMP Port Unreachable Messages cannot be returned to signal the traceroute program that it is finish. Meanwhile, my host had been sending datagrams to probe. While reaching No. 23, it only returned ICMP Time Exceeded Message(TEM) which is the each line of output. However, as Time -To-Live(TTL) would not be zero, the datagrams would keep probing beyond this destination, which means after that destination, we cannot tell anything from this output.
        b. There is another possibility that No. 23 is not the destination of the path. However, for some other reasons such as security, the latter routers cannot be identified. Also, traceroute program can only send 30*3 datagrams and list them as output. So, we cannot tell whether we reach the destination or not.
        c. Traceroute does not guarantee to reach the destination because internal routers in the destination side might block these packets. Thus, it is not necessary to exactly reach to the IP of the destination.
- There are 5 routers in total which belong to UNSW network. They are exactly

the first 5 routers in the output. This is because from No. 6 router, the IP addresses are outside UNSW.

- I searched the IP address locations on the list, and found that `9 et-2-1-0.bdr1.a.sea.aarnet.net.au (113.197.15.201)`is in Canberra and `10 abilene-1-lo-jmb-706.sttlwa.pacificwave.net (207.231.240.8)`is in California. Apparently, the packets crossed the Pacific Ocean. I also tried to use the hint provided to find, however, from my output, we can see that the RRT between my host and the server in Canberra and that between my host and California are the same. Hence, I could not justify if the packet crossed Pacific Ocean only based on this round trip time.

```
traceroute to www.nyu.edu (216.165.47.12), 30 hops max, 60 byte packets
 1  cserouter1-server.cse.unsw.EDU.AU (129.94.242.251)  0.082 ms  0.064 ms  0.051
ms
 2  129.94.39.17 (129.94.39.17)  0.983 ms  0.992 ms  1.091 ms
 3  ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  1.932 ms  1.469 ms  1.952
ms
 4  libcr1-po-6.gw.unsw.edu.au (149.171.255.201)  24.763 ms  24.769 ms
ombcr1-po-5.gw.unsw.edu.au (149.171.255.197)  1.320 ms
 5  unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.329 ms
unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  1.298 ms
unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.314 ms
 6  138.44.5.0 (138.44.5.0)  1.393 ms  1.397 ms  1.357 ms
 7  et-1-3-0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.15.149)  2.121 ms  2.217 ms
2.422 ms
 8  et-0-0-0.pe1.a.hnl.aarnet.net.au (113.197.15.99)  95.089 ms  95.081 ms
95.071 ms
 9  et-2-1-0.bdr1.a.sea.aarnet.net.au (113.197.15.201)  146.286 ms  146.255 ms
146.263 ms
10  abilene-1-lo-jmb-706.sttlwa.pacificwave.net (207.231.240.8)  146.416 ms
146.434 ms  146.379 ms
11  et-4-0-0.4079.sdn-sw.miss2.net.internet2.edu (162.252.70.0)  157.112 ms
157.144 ms  157.105 ms
12  et-4-0-0.4079.sdn-sw.minn.net.internet2.edu (162.252.70.58)  180.107 ms
179.928 ms  180.143 ms
13  et-7-0-0.4079.sdn-sw.eqch.net.internet2.edu (162.252.70.106)  187.897 ms
188.136 ms  188.269 ms
14  et-2-3-0.4079.rtsw.clev.net.internet2.edu (162.252.70.130)  196.688 ms
196.840 ms  196.831 ms
15  buf-9208-I2-CLEV.nysernet.net (199.109.11.33)  200.959 ms  200.951 ms
200.913 ms
16  syr-9208-buf-9208.nysernet.net (199.109.7.193)  204.150 ms  204.304 ms
204.295 ms
17  nyc-9208-syr-9208.nysernet.net (199.109.7.162)  209.998 ms  210.166 ms
210.124 ms
18  199.109.5.6 (199.109.5.6)  210.513 ms  210.432 ms  210.514 ms
19  DMZGWA-PTP-EXTGWA.NET.NYU.EDU (128.122.254.65)  210.970 ms  210.928 ms
```

```
211.094 ms
20  NYUGWA-PTP-DMZGWA-NGFW.NET.NYU.EDU (128.122.254.108)  210.675 ms  210.661 ms
210.563 ms
21  NYUFW-OUTSIDE-NGFW.NET.NYU.EDU (128.122.254.116)  211.042 ms  211.170 ms
211.245 ms
22  * * *
23  WSQDCGWA-VL902.NET.NYU.EDU (128.122.1.38)  211.470 ms  211.466 ms  211.418 ms
24  * * *
25  * * *
26  * * *
27  * * *
28  * * *
29  * * *
30  * * *
```

Q2:

- From my observation, I could say the paths diverge at `138.44.5.0` . Although the path has some difference within UNSW network, they all pass the router at `138.44.5.0` and after `138.44.5.0`, all the paths do not intersect again. Hence, I can conclude that `138.44.5.0` is the router paths began to diverge.
- More details at `138.44.5.0`: The internet service provider is Australian Academic and Research Network. Those details are found when I used `'whois'` command. More interestingly, before this router, it is the UNSW network and after that, it is the AARNET network. I searched this IP address and it is at somewhere in NSW.
- For www.lancaster.ac.uk, there are 26 hops. For www.u-tokyo.ac.jp, there are 15 hops. For www.ucla.edu, there are 14 hops.
  Distance: From Sydney to Tokyo(UT) : 7822 km
  From Sydney to Los Angeles: 12066 km
  From Sydney to Lancaster: 16980 km
  Conclusion: It seems like it is not proportional because the distance between Sydney and Los Angeles is much further than that between Sydney and Tokyo, but the number of hops are similar.
- As I still use traceroute and it has too much information to paste in the report, I would only write the conclusion from my observation.
  - From Singapore Server to my CSE host, it goes through Singapore, HK, America and enter into the border of Australia in Western Australia. However, from my CSE host to Singapore server, it goes through America and Singapore only. On the other hand, It has the same router when the packets enter into the border of Australia (in WA).
  - About the Telstra, there are similar routers from my CSE host to Telstra network and from Telstra network to my CSE host. The only difference is the last three digits of IP address of each router and I believe the reason is that some "internal" routers may be distributed differently.
  - From my Google Search, it seems like when we change another ISP or

connect to global ISP, routing path would be changed. This is because It is where administrative policies are most likely to change. This is also called asymmetric routing.

The following pictures are the traceroute outputs:

www.speedtest.com.sg from Singapore to my CSE host

```
traceroute to 129.94.242.116 (129.94.242.116), 30 hops max, 60 byte
packets
 1  ge2-8.r01.sin01.ne.com.sg (202.150.221.169)  0.237 ms  0.242 ms
0.316 ms
 2  10.12.0.101 (10.12.0.101)  38.340 ms  38.372 ms  38.377 ms
 3  hutchcity3-10g.hkix.net (123.255.90.140)  39.904 ms  39.931 ms
39.934 ms
 4  218.189.5.10 (218.189.5.10)  39.719 ms d1-42-238-143-118-on-nets.com
(118.143.238.42)  39.676 ms d1-10-238-143-118-on-nets.com
(118.143.238.10)  39.654 ms
 5  d1-106-224-143-118-on-nets.com (118.143.224.106)  199.627 ms
d1-6-224-143-118-on-nets.com (118.143.224.6)  186.191 ms
d1-18-224-143-118-on-nets.com (118.143.224.18)  197.210 ms
 6  aarnet.as7575.any2ix.coresite.com (206.72.210.64)  183.303 ms
175.355 ms  182.907 ms
 7  xe-0-0-3.pe1.tkpa.akl.aarnet.net.au (202.158.194.172)  317.805 ms
310.345 ms  317.931 ms
 8  et-0-1-0.200.pe1.wnpa.akl.aarnet.net.au (113.197.15.68)  305.933 ms
302.506 ms  302.476 ms
 9  xe-0-2-2-204.pe1.alxd.nsw.aarnet.net.au (113.197.15.182)  337.941 ms
336.414 ms xe-1-2-1.pe1.msct.nsw.aarnet.net.au (113.197.15.66)  328.468
ms
10  et-8-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.152)  330.561 ms
329.110 ms  361.678 ms
11  138.44.5.1 (138.44.5.1)  321.428 ms  320.279 ms  321.396 ms
12  libcr1-te-1-5.gw.unsw.edu.au (149.171.255.102)  328.833 ms  325.164
ms  325.186 ms
13  ombudnex1-po-1.gw.unsw.edu.au (149.171.255.202)  342.773 ms
libudnex1-po-1.gw.unsw.edu.au (149.171.255.166)  341.411 ms  333.873 ms
14  ufw1-ae-1-3154.gw.unsw.edu.au (149.171.253.36)  343.229 ms  343.030
ms  343.050 ms
15  129.94.39.23 (129.94.39.23)  336.196 ms  336.159 ms  343.345 ms
16  * * *
17  * * *
18  * * *
19  * * *
20  * * *
21  * * *
22  * * *
23  * * *
24  * * *
```

```
25  * * *
26  * * *
27  * * *
28  * * *
29  * * *
30  * * *
```

www.speedtest.com.sg from my CSE host to Singapore

```
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)  0.128 ms  0.110
ms  0.096 ms
 2  129.94.39.17 (129.94.39.17)  1.031 ms  0.998 ms  1.007 ms
 3  ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  1.460 ms  1.903 ms
1.911 ms
 4  ombcr1-po-6.gw.unsw.edu.au (149.171.255.169)  1.281 ms
libcr1-po-6.gw.unsw.edu.au (149.171.255.201)  1.356 ms
ombcr1-po-6.gw.unsw.edu.au (149.171.255.169)  1.290 ms
 5  unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  1.250 ms
unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.298 ms  1.259 ms
 6  138.44.5.0 (138.44.5.0)  1.413 ms  1.406 ms  1.366 ms
 7  et-0-3-0.pe1.alxd.nsw.aarnet.net.au (113.197.15.153)  7.657 ms  4.835
ms  4.865 ms
 8  xe-0-0-3.pe1.wnpa.akl.aarnet.net.au (113.197.15.67)  24.308 ms
xe-0-2-1-204.pe1.wnpa.alxd.aarnet.net.au (113.197.15.183)  24.379 ms
24.356 ms
 9  et-0-1-0.200.pe1.tkpa.akl.aarnet.net.au (113.197.15.69)  24.653 ms
24.662 ms  24.699 ms
10  xe-0-2-6.bdr1.a.lax.aarnet.net.au (202.158.194.173)  148.064 ms
148.068 ms  148.051 ms
11  singtel.as7473.any2ix.coresite.com (206.72.210.63)  301.799 ms
301.823 ms  301.835 ms
12  203.208.172.173 (203.208.172.173)  303.133 ms  302.448 ms  307.111 ms
13  203.208.153.121 (203.208.153.121)  320.546 ms  323.077 ms
203.208.173.73 (203.208.173.73)  333.737 ms
14  202-150-221-170.rev.ne.com.sg (202.150.221.170)  331.368 ms
203.208.182.45 (203.208.182.45)  321.651 ms  319.239 ms
```

www.telstra.net from Telstra to my CSE host

```
 1 gabitethernet3-3.exi2.melbourne.telstra.net (203.50.77.53)  0.621 ms
0.579 ms  0.364 ms
 2  bundle-ether3-100.win-core10.melbourne.telstra.net (203.50.80.129)
1.865 ms  1.478 ms  2.116 ms
 3  bundle-ether12.ken-core10.sydney.telstra.net (203.50.11.122)  12.234
ms  12.098 ms  12.737 ms
 4  bundle-ether1.ken-edge901.sydney.telstra.net (203.50.11.95)  12.108
```

```
ms  11.847 ms  11.986 ms
 5  aarnet6.lnk.telstra.net (139.130.0.78)  11.610 ms  11.599 ms  11.611
ms
 6  ge-6-0-0.bb1.a.syd.aarnet.net.au (202.158.202.17)  11.860 ms  11.850
ms  11.734 ms
 7  ae9.pe2.brwy.nsw.aarnet.net.au (113.197.15.56)  11.985 ms  11.973 ms
11.989 ms
 8  et-3-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.146)  12.107 ms
12.097 ms  12.112 ms
 9  138.44.5.1 (138.44.5.1)  12.361 ms  12.351 ms  12.236 ms
10  ombcr1-te-1-5.gw.unsw.edu.au (149.171.255.106)  12.358 ms  12.349 ms
12.359 ms
11  ombudnex1-po-2.gw.unsw.edu.au (149.171.255.170)  12.735 ms  12.974 ms
12.860 ms
12  ufw1-ae-1-3154.gw.unsw.edu.au (149.171.253.36)  12.858 ms  12.848 ms
12.858 ms
13  129.94.39.23 (129.94.39.23)  12.985 ms  12.977 ms  12.980 ms
```

www.telstra.net from my CSE host to Telstra

```
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)  0.111 ms  0.092
ms  0.084 ms
 2  129.94.39.17 (129.94.39.17)  1.003 ms  0.947 ms  0.999 ms
 3  libudnex1-vl-3154.gw.unsw.edu.au (149.171.253.34)  1.722 ms  1.720 ms
ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  1.516 ms
 4  libcr1-po-5.gw.unsw.edu.au (149.171.255.165)  1.217 ms
ombcr1-po-5.gw.unsw.edu.au (149.171.255.197)  1.219 ms  1.224 ms
 5  unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  1.325 ms  1.323 ms
1.335 ms
 6  138.44.5.0 (138.44.5.0)  1.432 ms  1.416 ms  1.403 ms
 7  et-0-3-0.pe1.alxd.nsw.aarnet.net.au (113.197.15.153)  1.503 ms  1.633
ms  1.626 ms
 8  ae9.bb1.b.syd.aarnet.net.au (113.197.15.65)  1.793 ms  1.869 ms
1.826 ms
 9  gigabitethernet1-1.pe1.b.syd.aarnet.net.au (202.158.202.18)  1.927 ms
1.952 ms  2.011 ms
10  gigabitethernet3-11.ken37.sydney.telstra.net (139.130.0.77)  2.563 ms
2.817 ms  2.722 ms
11  bundle-ether13.ken-core10.sydney.telstra.net (203.50.11.94)  4.052 ms
3.180 ms  4.333 ms
12  bundle-ether12.win-core10.melbourne.telstra.net (203.50.11.123)
15.451 ms  15.454 ms  15.445 ms
13  gigabitethernet5-0.exi-service2.melbourne.telstra.net (203.50.80.132)
13.714 ms  13.503 ms  13.605 ms
14  * * *
15  * * *
```

```
16  * * *
17  * * *
18  * * *
19  * * *
20  * * *
21  * * *
22  * * *
23  * * *
24  * * *
25  * * *
26  * * *
27  * * *
28  * * *
29  * * *
30  * * *
```

The following pictures show all the outputs of traceroute for each website given.
Traceroute program of www.lancaster.ac.uk

```
traceroute to www.lancaster.ac.uk (148.88.2.80), 30 hops max, 60 byte
packets
 1  cserouter1-server.cse.unsw.EDU.AU (129.94.242.251)  0.082 ms  0.062
ms  0.069 ms
 2  129.94.39.17 (129.94.39.17)  1.032 ms  1.001 ms  1.008 ms
 3  ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  1.708 ms  1.707 ms
libudnex1-vl-3154.gw.unsw.edu.au (149.171.253.34)  1.559 ms
 4  libcr1-po-5.gw.unsw.edu.au (149.171.255.165)  1.260 ms
libcr1-po-6.gw.unsw.edu.au (149.171.255.201)  1.229 ms
libcr1-po-5.gw.unsw.edu.au (149.171.255.165)  1.252 ms
 5  unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.259 ms  1.252 ms
unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  1.324 ms
 6  138.44.5.0 (138.44.5.0)  1.322 ms  1.368 ms  1.382 ms
 7  et-1-3-0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.15.149)  2.321 ms
2.343 ms  2.305 ms
 8  et-0-0-0.pe1.a.hnl.aarnet.net.au (113.197.15.99)  94.960 ms  95.039
ms  94.996 ms
 9  et-2-1-0.bdr1.a.sea.aarnet.net.au (113.197.15.201)  146.356 ms
146.323 ms  146.327 ms
10  abilene-1-lo-jmb-706.sttlwa.pacificwave.net (207.231.240.8)  146.346
ms  146.322 ms  146.323 ms
11  et-4-0-0.4079.sdn-sw.miss2.net.internet2.edu (162.252.70.0)  157.049
ms  157.226 ms  157.041 ms
12  et-4-0-0.4079.sdn-sw.minn.net.internet2.edu (162.252.70.58)  180.109
ms  180.070 ms  180.159 ms
13  et-7-0-0.4079.sdn-sw.eqch.net.internet2.edu (162.252.70.106)  187.886
ms  187.973 ms  187.864 ms
14  et-4-1-0.4079.rtsw.clev.net.internet2.edu (162.252.70.112)  198.791
ms  196.851 ms  196.837 ms
```

```
15  et-2-0-0.4079.sdn-sw.ashb.net.internet2.edu (162.252.70.54)  204.349
ms  204.454 ms  204.414 ms
16  et-4-1-0.4079.rtsw.wash.net.internet2.edu (162.252.70.65)  204.830 ms
204.805 ms  204.794 ms
17  internet2.mx1.lon.uk.geant.net (62.40.124.44)  279.604 ms  279.584 ms
279.547 ms
18  janet-gw.mx1.lon.uk.geant.net (62.40.124.198)  279.950 ms  279.928 ms
279.930 ms
19  ae29.londpg-sbr2.ja.net (146.97.33.2)  280.512 ms  280.514 ms
280.479 ms
20  ae31.erdiss-sbr2.ja.net (146.97.33.22)  283.770 ms  283.809 ms
283.773 ms
21  ae29.manckh-sbr1.ja.net (146.97.33.42)  285.589 ms  285.558 ms
285.641 ms
22  cnl.manckh-sbr1.ja.net (146.97.41.54)  287.879 ms  287.862 ms
287.852 ms
23  * * *
24  ismx-issrx.rtr.lancs.ac.uk (148.88.255.17)  319.758 ms  318.856 ms
318.819 ms
25  dc.iss.srv.rtrcloud.lancs.ac.uk (148.88.253.3)  303.271 ms  312.249
ms  312.187 ms
26  www-ha.lancs.ac.uk (148.88.2.80)  289.220 ms !X  289.251 ms !X
289.238 ms !X
```

Traceroute program of www.u-tokyo.ac.jp

```
traceroute to www.u-tokyo.ac.jp (210.152.135.178), 30 hops max, 60 byte
packets
 1  cserouter1-server.cse.unsw.EDU.AU (129.94.242.251)  0.106 ms  0.088
ms  0.076 ms
 2  129.94.39.17 (129.94.39.17)  1.024 ms  0.987 ms  0.990 ms
 3  ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  16.109 ms
libudnex1-vl-3154.gw.unsw.edu.au (149.171.253.34)  1.675 ms  1.684 ms
 4  ombcr1-po-5.gw.unsw.edu.au (149.171.255.197)  1.214 ms
ombcr1-po-6.gw.unsw.edu.au (149.171.255.169)  1.224 ms  1.158 ms
 5  unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.201 ms
unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  1.148 ms  1.180 ms
 6  138.44.5.0 (138.44.5.0)  1.383 ms  1.340 ms  1.275 ms
 7  et-0-3-0.pe1.bkvl.nsw.aarnet.net.au (113.197.15.147)  1.780 ms  1.865
ms  1.849 ms
 8  ge-4_0_0.bb1.a.pao.aarnet.net.au (202.158.194.177)  156.642 ms
156.557 ms  156.571 ms
 9  paloalto0.iij.net (198.32.176.24)  158.312 ms  158.317 ms  158.388 ms
10  osk004bb01.IIJ.Net (58.138.88.189)  271.636 ms osk004bb00.IIJ.Net
(58.138.88.185)  290.701 ms osk004bb01.IIJ.Net (58.138.88.189)  271.726
ms
11  osk004ix51.IIJ.Net (58.138.106.126)  290.451 ms  290.451 ms
osk004ix51.IIJ.Net (58.138.106.130)  271.302 ms
```

```
12  210.130.135.130 (210.130.135.130)  290.409 ms  292.482 ms  292.469 ms
13  124.83.228.78 (124.83.228.78)  290.568 ms  281.001 ms  290.581 ms
14  124.83.252.250 (124.83.252.250)  296.915 ms  287.452 ms  296.820 ms
15  158.205.134.26 (158.205.134.26)  296.804 ms  296.956 ms  296.928 ms
16  * * *
17  * * *
18  * * *
19  * * *
20  * * *
21  * * *
22  * * *
23  * * *
24  * * *
25  * * *
26  * * *
27  * * *
28  * * *
29  * * *
30  * * *
```

Traceroute program of www.ucla.edu

```
traceroute to www.ucla.edu (164.67.228.152), 30 hops max, 60 byte packets
 1  cserouter1-server.cse.unsw.EDU.AU (129.94.242.251)  0.102 ms  0.085
ms  0.073 ms
 2  129.94.39.17 (129.94.39.17)  0.993 ms  0.982 ms  0.954 ms
 3  ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  1.793 ms
libudnex1-vl-3154.gw.unsw.edu.au (149.171.253.34)  1.349 ms
ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  1.770 ms
 4  ombcr1-po-5.gw.unsw.edu.au (149.171.255.197)  1.126 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)  1.211 ms
 5  unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.197 ms  1.219 ms
1.214 ms
 6  138.44.5.0 (138.44.5.0)  1.339 ms  1.314 ms  1.336 ms
 7  et-1-3-0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.15.149)  2.209 ms
2.182 ms  2.180 ms
 8  et-0-0-0.pe1.a.hnl.aarnet.net.au (113.197.15.99)  94.966 ms  95.059
ms  95.016 ms
 9  et-2-1-0.bdr1.a.sea.aarnet.net.au (113.197.15.201)  146.325 ms
146.335 ms  146.318 ms
10  cenichpr-1-is-jmb-778.snvaca.pacificwave.net (207.231.245.129)
164.112 ms  164.103 ms  164.067 ms
11  hpr-lax-hpr3--svl-hpr3-100ge.cenic.net (137.164.25.73)  170.837 ms
170.784 ms  170.846 ms
12  * * *
13  bd11f1.anderson--cr00f2.csb1.ucla.net (169.232.4.4)  171.092 ms
bd11f1.anderson--cr001.anderson.ucla.net (169.232.4.6)  172.284 ms
```

```
bd11f1.anderson--cr00f2.csb1.ucla.net (169.232.4.4)  171.354 ms
14  cr00f2.csb1--dr00f2.csb1.ucla.net (169.232.4.53)  171.264 ms
cr00f1.anderson--dr00f2.csb1.ucla.net (169.232.4.55)  171.414 ms  171.403
ms
15  * * *
16  * * *
17  * * *
18  * * *
19  * * *
20  * * *
21  * * *
22  * * *
23  * * *
24  * * *
25  * * *
26  * * *
27  * * *
28  * * *
29  * * *
30  * * *
```

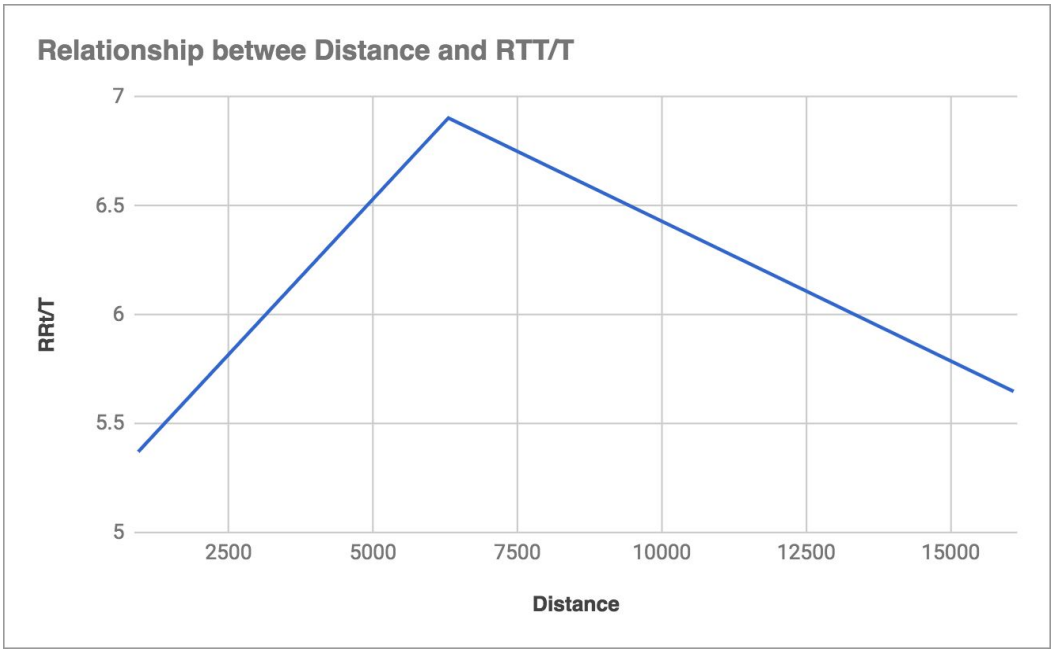
Exercise 3:

To do this exercise, I used the commands given in instruction to generate graphs. The following results are based on those graphs. These graphs are separate files and attached to this report.

Q1:

- Calculation:
  - **UNSW --- UQ:**
    T = (938 x 10^3/(3 x 10^8)) x 1000 = 3.127 ms
    RTT: 16.796/3.127 = 5.37
  - **UNSW --- NUS:**
    T = (6307 x 10^3/(3 x 10^8)) x 1000 = 21.023 ms
    RTT: 145.150/21.023 = 6.904
  - **UNSW --- Berlin:**
    T = (16090 x 10^3/(3 x 10^8)) x 1000 = 53.633 ms
    RTT: 302.928/53.633 = 5.648

The graph is plotted as below.



Rationale:

1. For some routers, they may be very busy, so some packets may be retained in the Queue and it may result in Queue Delay.
2. There may have propagation delay and materials may affect this propagation delay. For example, delay in copper may be longer that in fiber material.

- Based on my observation from the relationship between packet number and time of delay in those graphs, I think the delay of ping for www.uq.edu.au and www.nus.edu.sg varied over time, while there was roughly constant for www.tu-berlin.de though there had some minor fluctuation.

  The main reason to explain is that the perhaps at any time for each router, There may have different Queues, resulting in different Queuing delay. This does not depend on physical distance or the number of hops.

  As to Berlin's website, some minor fluctuation can be explained by the above reason and the only reason for constant delay in other time may be that the there may be not much queue in the router. One possible rationale is that the speeds of router processing packets are very quick and another one is likely that at the time of ping, there is not much traffic in this path. Therefore, for the same packet size, the total delay is roughly the same.

  To answer if the delay depend on the size of the ping packets, I used some statistical knowledge. Normally, when people would like to figure out two variables' relationship, they use regression to do that. And we analyse the coefficient of linear model. Apparently, the mathematics behind building this model can be replaced by our friendly software called Stata. This is learnt from my Econometrics course. The data given can be seen as the sample. So I

wrote a Perl program called ‘suffix.pl’to gather all the data in three separate files which refer to each university. The following attachments are the Perl program and Stata outputs.

Summary of the output:
In practical view, as the coefficient is really small and although it seems like that the delay will increase with the increase of the size of the ping packet. However, the magnitude is really small.

```
#!/usr/bin/perl -w
@array = (50,250,500,750,1000,1250,1500);
foreach $size (@array) {
    $file = "www.".$ARGV[0].$size.".csv";
    open(F, "<", $file) or die "$file fails: $!";
    $time = 1;
    while ($line = <F>) {
        $line = $size." ".$line;
        $line =~ s/\n//;
        $line = $line . " ".$time."\n";
        print $line;
        $time++;
    }
    close F;
}
```

UQ Stata Output

```
-------------------------------------------------------------------------------
name:  <unnamed>
log: \\Client\H$\Desktop\uq.txt
log type: text
opened on: 5 Aug 2017, 17:25:19

. reg rrt size packetNum

      Source |       SS           df       MS      Number of obs   =       350
-------------+----------------------------------   F(2, 347)       =      0.66
       Model |  74.5960429         2  37.2980215   Prob > F        =    0.5167
    Residual |  19565.4863       347  56.3846869   R-squared       =    0.0038
-------------+----------------------------------   Adj R-squared   =   -0.0019
       Total |  19640.0824       349  56.2753077   Root MSE        =     7.509

------------------------------------------------------------------------------
         rrt |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        size |  -.0001482     .00082    -0.18   0.857     -.001761    .0014646
   packetNum |  -.0315939   .0278134    -1.14   0.257     -.086298    .0231102
       _cons |   19.98871    1.02449    19.51   0.000     17.97371     22.0037
------------------------------------------------------------------------------
```

```
. log close
      name:  <unnamed>
       log:  \\Client\H$\Desktop\uq.txt
  log type:  text
 closed on:   5 Aug 2017, 17:26:49
-------------------------------------------------------------------------------
```

NUS Stata Output

```
-------------------------------------------------------------------------------
      name:  <unnamed>
       log:  \\Client\H$\Desktop\nus.txt
  log type:  text
 opened on:   5 Aug 2017, 17:40:49

. reg rrt size packetNum

      Source |       SS           df       MS      Number of obs   =       350
-------------+----------------------------------   F(2, 347)       =     23.57
       Model |  50.4033244         2  25.2016622   Prob > F        =    0.0000
    Residual |  371.070961       347  1.06936876   R-squared       =    0.1196
-------------+----------------------------------   Adj R-squared   =    0.1145
       Total |  421.474286       349  1.20766271   Root MSE        =    1.0341

------------------------------------------------------------------------------
         rrt |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        size |    .000773   .0001129     6.85   0.000     .0005509    .0009951
   packetNum |  -.0020168   .0038303    -0.53   0.599    -.0095504    .0055168
       _cons |   145.1176   .1410883  1028.56   0.000     144.8401    145.3951
------------------------------------------------------------------------------

. log close
      name:  <unnamed>
       log:  \\Client\H$\Desktop\nus.txt
  log type:  text
 closed on:   5 Aug 2017, 17:41:06
-------------------------------------------------------------------------------
```

Tu-Berlin Stata Output

```
-------------------------------------------------------------------------------
      name:  <unnamed>
       log:  \\Client\H$\Desktop\tub.txt
  log type:  text
 opened on:   5 Aug 2017, 17:32:25

. reg rrt size packetNum

      Source |       SS           df       MS      Number of obs   =       350
```

```
-------------+----------------------------------   F(2, 347)       =      4.92
       Model |  .082071529         2  .041035764   Prob > F        =    0.0078
    Residual |  2.89221419       347  .008334911   R-squared       =    0.0276
-------------+----------------------------------   Adj R-squared   =    0.0220
       Total |  2.97428571       349  .008522309   Root MSE        =     .0913

------------------------------------------------------------------------------
         rrt |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        size |   .0000253   9.97e-06     2.54   0.012     5.69e-06    .0000449
   packetNum |   .0006242   .0003382     1.85   0.066    -.0000409    .0012894
       _cons |   302.9564    .012456  2.4e+04   0.000     302.9319    302.9809
------------------------------------------------------------------------------

. log close
      name:  <unnamed>
       log:  \\Client\H$\Desktop\tub.txt
  log type:  text
 closed on:   5 Aug 2017, 17:32:56
-------------------------------------------------------------------------------
```

-
    - Propagation delay does not depend on the packet size and it is related to the distance and the material of the medium.
    - Queuing delay only depends on the congestion level of the network.
    - Transmission delay is nearly proportional to packet size. Transmission delay will be constant for a fixed packet size.
    - Processing delay is slightly dependent on the packet size. Yet, usually it has roughly the same delay time for any packet size.