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 website www.koala.com.au? In your opinion, what is the reason for having several IP addresses as an output?*

The IP addresses of www.koala.com.au are:

104.21.45.21 and **172.67.219.46**

With multiple IP addresses, a service provider can use more than one server to handle the requests. Therefore, they can have a higher throughput capacity. They can also guarantee the connectivity when some of the IP addresses are not working (being banned or servers shut down) by using multiple IP. Moreover, they can provide selective service by binding multiple IP to one domain (for choosing nearest server or using a separate server for mobile access).

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

The name of 127.0.0.1 is **localhost**, and it is the standard loopback address for IPv4. Any packets sent to this address is looped back. This address is commonly used for testing purposes.

Exercise 2: Use ping to test host reachability

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

www.unsw.edu.au
    Yes
www.getfittest.com.au
    No, unknown host
www.mit.edu
    Yes
www.intel.com.au
    Yes
www.tpg.com.au
    Yes
www.hola.hp
    No, unknown host
www.amazon.com
    Yes
www.tsinghua.edu.cn

Yes

www.kremlin.ru

No, with 100% Packet loss

8.8.8.8

Yes

www.getfittest.com.au and www.hola.hp are not reachable from both ping and web browser because they are not registered in the DNS server.

www.kremlin.ru is only reachable by web browser, and having no response to ping command. Because it is a government website, host keeper maybe closed the public ping service for security reason. The common way to do that is to block ICMP at the firewall.

Exercise 3: Use traceroute to understand the network topology

1. *Run traceroute on your machine to www.columbia.edu*

```
z5183946@weber:~/9331$ 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)  0.075 ms  0.072 ms  0.078 ms
 2  129.94.39.17 (129.94.39.17)  0.914 ms  0.926 ms  0.935 ms
 3  libudnex1-vl-3154.gw.unsw.edu.au (149.171.253.34)  1.914 ms ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  11.863 ms libudnex
1-vl-3154.gw.unsw.edu.au (149.171.253.34)  2.521 ms
 4  libcr1-po-6.gw.unsw.edu.au (149.171.255.201)  1.365 ms  1.396 ms  1.406 ms
 5  unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  1.270 ms  1.284 ms unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.316 ms
 6  138.44.5.0 (138.44.5.0)  1.618 ms  1.424 ms  1.423 ms
 7  et-1-1-0.pe1.mcqp.nsw.aarnet.net.au (113.197.15.4)  1.948 ms  1.835 ms  1.895 ms
 8  et-0_0_2.bdr1.guam.gum.aarnet.net.au (113.197.14.137)  71.695 ms  71.794 ms  71.624 ms
 9  * * *
10  fourhundredge-0-0-0-2.4079.core2.salt.net.internet2.edu (163.253.1.115)  236.546 ms  236.415 ms  235.989 ms
11  fourhundredge-0-0-0-21.4079.core1.salt.net.internet2.edu (163.253.1.28)  236.955 ms  236.955 ms fourhundredge-0-0-0-23.4079.core1
.salt.net.internet2.edu (163.253.1.32)  236.791 ms
12  fourhundredge-0-0-0-0.4079.core1.denv.net.internet2.edu (163.253.1.170)  235.992 ms  235.656 ms *
13  fourhundredge-0-0-0-0.4079.core1.chic.net.internet2.edu (163.253.2.28)  237.207 ms * *
14  fourhundredge-0-0-0-3.4079.core2.chic.net.internet2.edu (163.253.1.244)  237.256 ms fourhundredge-0-0-0-22.4079.core2.chic.net.in
ternet2.edu (163.253.1.97)  235.695 ms fourhundredge-0-0-0-3.4079.core2.chic.net.internet2.edu (163.253.1.244)  235.681 ms
15  fourhundredge-0-0-0-3.4079.core2.eqch.net.internet2.edu (163.253.2.19)  236.451 ms  237.639 ms  237.581 ms
16  fourhundredge-0-0-0-0.4079.core2.clev.net.internet2.edu (163.253.2.16)  237.436 ms  237.486 ms  237.423 ms
17  buf-9208-I2-CLEV.nysernet.net (199.109.11.33)  237.888 ms  239.263 ms  237.889 ms
18  syr-55a1-buf-9208.nysernet.net (199.109.7.213)  241.396 ms  241.176 ms  241.421 ms
19  nyc32-55a1-syr-55a1.nysernet.net (199.109.7.206)  246.657 ms  246.505 ms  246.502 ms
20  nyc32-9208-nyc32-55a1.nysernet.net (199.109.7.201)  246.280 ms  247.064 ms  246.428 ms
21  columbia.nyc-9208.nysernet.net (199.109.4.14)  246.297 ms  246.229 ms  246.251 ms
22  cc-core-1-x-nyser32-gw-1.net.columbia.edu (128.59.255.5)  246.636 ms  246.654 ms  247.268 ms
23  cc-conc-1-x-cc-core-1.net.columbia.edu (128.59.255.21)  246.751 ms  246.769 ms  246.755 ms
24  columbiauniversity.org (128.59.105.24)  246.592 ms  246.634 ms  246.623 ms
```

Traceroute outputs of www.columbia.edu

There are **23** routers between my workstation and www.columbia.edu (excluding the last one). And there are **5** of them are part of UNSW network as the 6th router is already AARNET router suggested by whois command. The packages between **7th** and **10th** routers crossed the Pacific Ocean. It is deduced that 8th and 9th routers are located on the Pacific Ocean while the 10th sits inside the US.

After some trials, the IP address of ninth router is 138.44.228.5. Then, the delay for 7th to 10th routers by pinging are:

7	8	9	10
2ms	72ms	185ms	236ms

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*

```
z5183946@weber:~/9331$ traceroute www.ucla.edu
traceroute to www.ucla.edu (18.65.229.18), 30 hops max, 60 byte packets
 1  cserouter1-server.cse.unsw.EDU.AU (129.94.242.251)  0.196 ms  0.200 ms  0.208 ms
 2  129.94.39.17 (129.94.39.17)  1.174 ms  1.183 ms  1.121 ms
 3  libudnex1-vl-3154.gw.unsw.edu.au (149.171.253.34)  3.046 ms  3.010 ms ombudnex1-vl-3154.gw.unsw.edu.au (149.171.2
53.35)  3.398 ms
 4  libcr1-po-5.gw.unsw.edu.au (149.171.255.165)  2.150 ms libcr1-po-6.gw.unsw.edu.au (149.171.255.201)  2.210 ms omb
cr1-po-6.gw.unsw.edu.au (149.171.255.169)  2.145 ms
 5  unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  2.201 ms unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  2.211
 ms unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  2.197 ms
 6  138.44.5.0 (138.44.5.0)  2.937 ms  2.321 ms  2.279 ms
 7  ae1.170.bdr1.b.sea.aarnet.net.au (113.197.15.63)  141.311 ms  141.193 ms  141.063 ms
 8  xe-4-1-1.mpr1.sea1.us.above.net (64.125.193.129)  141.486 ms  141.285 ms  141.323 ms
 9  ae28.cs2.sea1.us.eth.zayo.com (64.125.29.104)  141.449 ms  141.350 ms  141.300 ms
10  ae27.mpr2.sea1.us.zip.zayo.com (64.125.29.3)  141.340 ms  141.145 ms  141.077 ms
11  99.82.182.102 (99.82.182.102)  141.161 ms  141.172 ms  141.158 ms
12  * * *
13  * * *
14  * * *
15  * * *
16  150.222.214.205 (150.222.214.205)  141.097 ms 150.222.214.204 (150.222.214.204)  141.039 ms  141.076 ms
```

Traceroute output of www.ucla.edu

```
z5183946@weber:~/9331$ traceroute www.u-tokyo.ac.jp
traceroute to www.u-tokyo.ac.jp (210.152.243.234), 30 hops max, 60 byte packets
 1  cserouter1-server.cse.unsw.EDU.AU (129.94.242.251)  0.060 ms  0.057 ms  0.066 ms
 2  129.94.39.17 (129.94.39.17)  1.029 ms  1.033 ms  1.042 ms
 3  ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  1.943 ms  1.895 ms  2.206 ms
 4  ombcr1-po-6.gw.unsw.edu.au (149.171.255.169)  1.312 ms ombcr1-po-5.gw.unsw.edu.au (149.171.255.197)  1.265 ms lib
cr1-po-6.gw.unsw.edu.au (149.171.255.201)  1.226 ms
 5  unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  1.316 ms unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.278
 ms unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  1.310 ms
 6  138.44.5.0 (138.44.5.0)  1.370 ms  1.302 ms  1.351 ms
 7  et-0-3-0.pe1.bkvl.nsw.aarnet.net.au (113.197.15.147)  1.824 ms  2.438 ms  2.441 ms
 8  ge-4_0_0.bb1.a.pao.aarnet.net.au (202.158.194.177)  155.242 ms  155.251 ms  155.188 ms
 9  paloalto0.iij.net (198.32.176.24)  156.461 ms  156.544 ms  156.471 ms
10  osk004bb01.IIJ.Net (58.138.88.189)  266.650 ms osk004bb00.IIJ.Net (58.138.88.185)  286.170 ms osk004bb01.IIJ.Net
(58.138.88.189)  266.649 ms
11  osk004ip57.IIJ.Net (58.138.81.78)  276.518 ms  276.459 ms osk004ip57.IIJ.Net (58.138.106.162)  287.148 ms
12  210.130.135.130 (210.130.135.130)  266.866 ms  266.828 ms  276.444 ms
13  124.83.228.58 (124.83.228.58)  286.189 ms  276.556 ms  286.328 ms
14  124.83.252.178 (124.83.252.178)  272.811 ms  282.343 ms  272.641 ms
15  158.205.134.26 (158.205.134.26)  272.891 ms  282.513 ms  272.852 ms
```

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

```
z5183946@weber:~/9331$ traceroute www.lancaster.ac.uk
traceroute to www.lancaster.ac.uk (148.88.65.80), 30 hops max, 60 byte packets
 1  cserouter1-server.cse.unsw.EDU.AU (129.94.242.251)  0.078 ms  0.070 ms  0.078 ms
 2  129.94.39.17 (129.94.39.17)  1.004 ms  0.965 ms  0.998 ms
 3  libudnex1-vl-3154.gw.unsw.edu.au (149.171.253.34)  1.695 ms ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  1.
635 ms libudnex1-vl-3154.gw.unsw.edu.au (149.171.253.34)  1.954 ms
 4  libcr1-po-5.gw.unsw.edu.au (149.171.255.165)  1.198 ms ombcr1-po-6.gw.unsw.edu.au (149.171.255.169)  1.262 ms lib
cr1-po-5.gw.unsw.edu.au (149.171.255.165)  1.207 ms
 5  unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.278 ms  1.303 ms  1.355 ms
 6  138.44.5.0 (138.44.5.0)  1.465 ms  1.343 ms  1.349 ms
 7  et-2-0-5.bdr1.sing.sin.aarnet.net.au (113.197.15.233)  92.994 ms  93.105 ms  93.106 ms
 8  138.44.226.7 (138.44.226.7)  256.790 ms  256.790 ms  256.803 ms
 9  janet-gw.mx1.lon.uk.geant.net (62.40.124.198)  256.850 ms  256.855 ms  256.865 ms
10  ae29.londpg-sbr2.ja.net (146.97.33.2)  257.351 ms  257.362 ms  257.301 ms
11  ae31.erdiss-sbr2.ja.net (146.97.33.22)  261.276 ms  261.697 ms  261.594 ms
12  ae29.manckh-sbr2.ja.net (146.97.33.42)  262.977 ms  262.954 ms  262.927 ms
13  ae25.manckh-ban1.ja.net (146.97.35.50)  263.058 ms  262.950 ms  262.954 ms
14  lancaster-uni.ja.net (146.97.40.178)  278.839 ms  278.842 ms  278.778 ms
```

Traceroute output of www.lancaster.ac.uk

It can be observed from the outputs of traceroute command to these three destinations diverges **after 6th** router (138.44.5.0). The Whois command shows that this address

sits in the address range of Australian Academic and Research Network (AARN) owned by Asia Pacific Network Information Centre (APNIC).

The number of hops is not proportional to the physical distance. Because although the three path have similar lengths, the distance to the destinations are significantly different as shown below:

Destination	www.ucla.edu	www.u-tokyo.ac.jp	www.lancaster.ac.uk
# of hops	16	15	14
Physical Distance	10659.1 miles	4369.9 miles	9542.7 miles

3. *Several servers distributed around the world provide a web interface from which you can perform a traceroute to any other host on the Internet. Here are two examples: (i) http://www.speedtest.com.sg/tr.php and (ii) https://www.telstra.net/cgi-bin/trace.*

My IP address: **129.94.242.53**

```
z5183946@weber:~/9331/lab1$ cat speedtest
traceroute to 129.94.242.53 (129.94.242.53), 30 hops max, 60 byte packets
 1  202.150.221.169 (202.150.221.169)  0.130 ms  0.143 ms  0.163 ms
 2  10.11.34.146 (10.11.34.146)  0.413 ms  0.507 ms  0.594 ms
 3  aarnet.sgix.sg (103.16.102.67)  212.745 ms  212.761 ms  212.780 ms
 4  et-7-3-0.pe1.nsw.brwy.aarnet.net.au (113.197.15.232)  214.797 ms  214.778 ms  214.823 ms
 5  138.44.5.1 (138.44.5.1)  214.995 ms  215.032 ms  214.924 ms
 6  ombcr1-te-1-5.gw.unsw.edu.au (149.171.255.106)  209.281 ms  209.417 ms  209.268 ms
 7  ombudnex1-po-2.gw.unsw.edu.au (149.171.255.170)  211.458 ms  211.432 ms  211.321 ms
 8  ufw1-ae-1-3154.gw.unsw.edu.au (149.171.253.36)  210.007 ms  209.986 ms  210.034 ms
 9  129.94.39.23 (129.94.39.23)  210.395 ms  210.175 ms  210.292 ms
```

Traceroute output from *http://www.speedtest.com.sg/tr.php*

```
z5183946@wagner:~/9331$ 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)  0.078 ms  0.077 ms  0.081 ms
 2  129.94.39.17 (129.94.39.17)  0.905 ms  1.014 ms  0.896 ms
 3  ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  1.707 ms  1.794 ms libudnex1-vl-3154.gw.unsw.edu.au (149.171.253.34)  1.336 ms
 4  libcr1-po-6.gw.unsw.edu.au (149.171.255.201)  1.269 ms  1.280 ms  1.312 ms
 5  unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.345 ms  1.307 ms unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  1.370 ms
 6  138.44.5.0 (138.44.5.0)  1.498 ms  1.421 ms  1.438 ms
 7  et-0-3-0.pe1.alxd.nsw.aarnet.net.au (113.197.15.153)  13.857 ms  10.846 ms  8.116 ms
 8  xe-0-2-7.bdr1.a.lax.aarnet.net.au (202.158.194.173)  147.895 ms  147.839 ms  147.793 ms
 9  singtel.as7473.any2ix.coresite.com (206.72.210.63)  148.994 ms  148.954 ms  148.988 ms
10  203.208.171.117 (203.208.171.117)  148.199 ms  148.206 ms 203.208.173.21 (203.208.173.21)  322.162 ms
11  203.208.172.145 (203.208.172.145)  250.388 ms  250.347 ms 203.208.173.73 (203.208.173.73)  252.648 ms
12  203.208.182.253 (203.208.182.253)  320.521 ms *  332.879 ms
13  202.150.221.170 (202.150.221.170)  209.336 ms  213.748 ms  212.714 ms
```

Traceroute output in the reverse direction

```
z5183946@wagner:~/9331/lab1$ cat telstra
 1  gigabitethernet3-3.exi2.melbourne.telstra.net (203.50.77.53)  1.029 ms  0.722 ms  0.618 ms
 2  TenGigE0-0-0-21.win-dlr20.melbourne.telstra.net (203.50.233.148)  0.618 ms  0.488 ms  0.495 ms
 3  bundle-ether30.win-core10.melbourne.telstra.net (203.50.11.248)  2.372 ms  1.738 ms  2.119 ms
 4  bundle-ether12.ken-core10.sydney.telstra.net (203.50.11.122)  11.989 ms  12.232 ms  13.112 ms
 5  bundle-ether1.ken-edge903.sydney.telstra.net (203.50.11.173)  12.114 ms  12.107 ms  12.114 ms
 6  139.130.0.78 (139.130.0.78)  20.857 ms  127.545 ms  35.097 ms
 7  et-7-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.13)  21.108 ms  15.979 ms  11.863 ms
 8  138.44.5.1 (138.44.5.1)  11.988 ms  12.106 ms  12.113 ms
 9  ombcr1-te-1-5.gw.unsw.edu.au (149.171.255.106)  12.113 ms  12.107 ms  12.113 ms
10  ombudnex1-po-2.gw.unsw.edu.au (149.171.255.170)  12.487 ms  15.105 ms  12.363 ms
11  ufw1-ae-1-3154.gw.unsw.edu.au (149.171.253.36)  12.863 ms  12.856 ms  12.863 ms
12  129.94.39.23 (129.94.39.23)  12.988 ms  13.106 ms  12.986 ms
```

Traceroute output from *https://www.telstra.net/cgi-bin/trace*

```
z5183946@wagner:~/9331/lab1$ 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)  0.067 ms  0.074 ms  0.076 ms
 2  129.94.39.17 (129.94.39.17)  0.996 ms  1.003 ms  1.012 ms
 3  libudnex1-vl-3154.gw.unsw.edu.au (149.171.253.34)  3.937 ms  3.800 ms ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  1.861 ms
 4  ombcr1-po-6.gw.unsw.edu.au (149.171.255.169)  1.243 ms libcr1-po-6.gw.unsw.edu.au (149.171.255.201)  1.199 ms ombcr1-po-6.gw.unsw
.edu.au (149.171.255.169)  1.271 ms
 5  unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.394 ms unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  1.421 ms  1.386 ms
 6  138.44.5.0 (138.44.5.0)  1.448 ms  1.386 ms  1.327 ms
 7  et-1-1-0.pe1.rsby.nsw.aarnet.net.au (113.197.15.12)  2.410 ms  2.077 ms  2.062 ms
 8  xe-0-0-3.bdr1.rsby.nsw.aarnet.net.au (113.197.15.31)  1.823 ms  1.780 ms  1.802 ms
 9  139.130.0.77 (139.130.0.77)  2.232 ms  2.229 ms  2.228 ms
10  bundle-ether2.chw-edge903.sydney.telstra.net (203.50.11.175)  2.821 ms bundle-ether17.ken-core10.sydney.telstra.net (203.50.11.17
2)  4.409 ms bundle-ether2.chw-edge903.sydney.telstra.net (203.50.11.175)  2.540 ms
11  bundle-ether17.chw-core10.sydney.telstra.net (203.50.11.176)  2.801 ms  2.738 ms bundle-ether10.win-core10.melbourne.telstra.net
(203.50.11.123)  13.562 ms
12  bundle-ether1-2.exi-core10.melbourne.telstra.net (203.50.6.40)  15.022 ms  14.983 ms bundle-ether8.exi-core10.melbourne.telstra.n
et (203.50.11.125)  15.259 ms
13  203.50.11.209 (203.50.11.209)  15.055 ms  14.989 ms  14.470 ms
14  www.telstra.net (203.50.5.178)  14.282 ms  14.639 ms  14.601 ms
```

Traceroute output in the reverse direction

The IP address of **speedtest** server is **202.150.221.170** and the IP address of **Telstra** server is **203.50.5.178**. The reverse path went through different routers as forward path. Although they don't have any routers in common, they still have some very similar addresses, for example, 138.44.5.0 versus 138.44.5.1. The reason why the reverse path is different from forward may be different routers or router interfaces are used to handle outgoing and incoming requests.

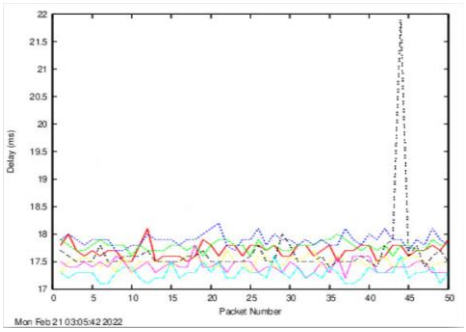
Exercise 4: Use ping to gain insights into network performance

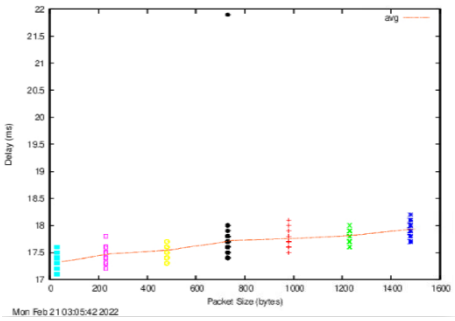
Use runping.sh for the following destinations:

(i) www.uq.edu.au (ii) www.upm.edu.my (iii) www.tu-berlin.de.

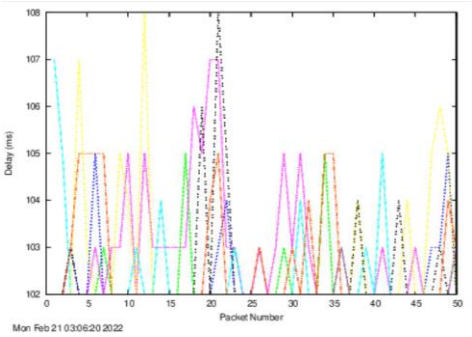
And then plot the results using plot.sh:

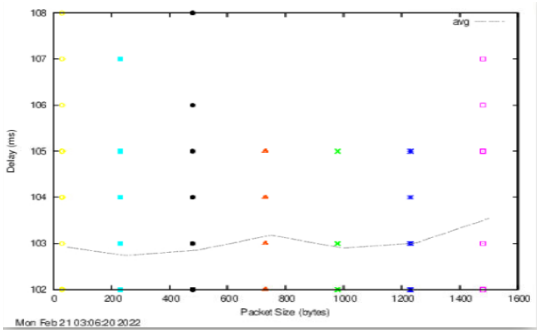
www.uq.edu.au:



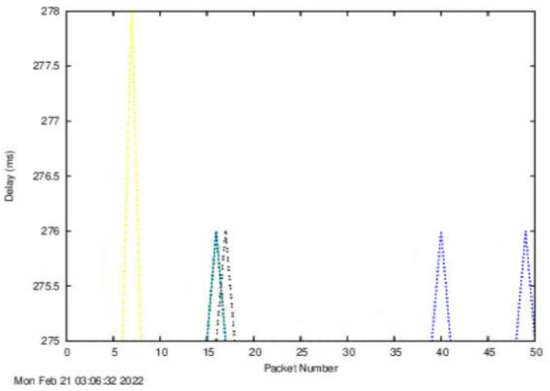


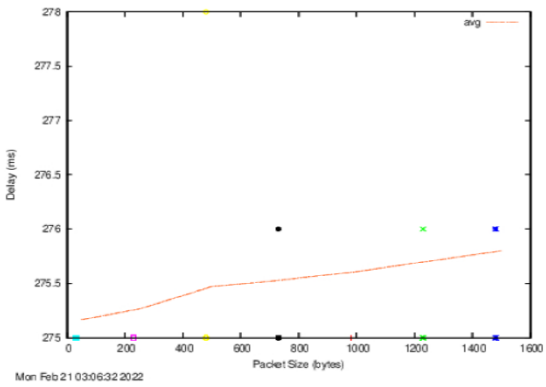
www.upm.edu.my:





www.tu-berlin.de:

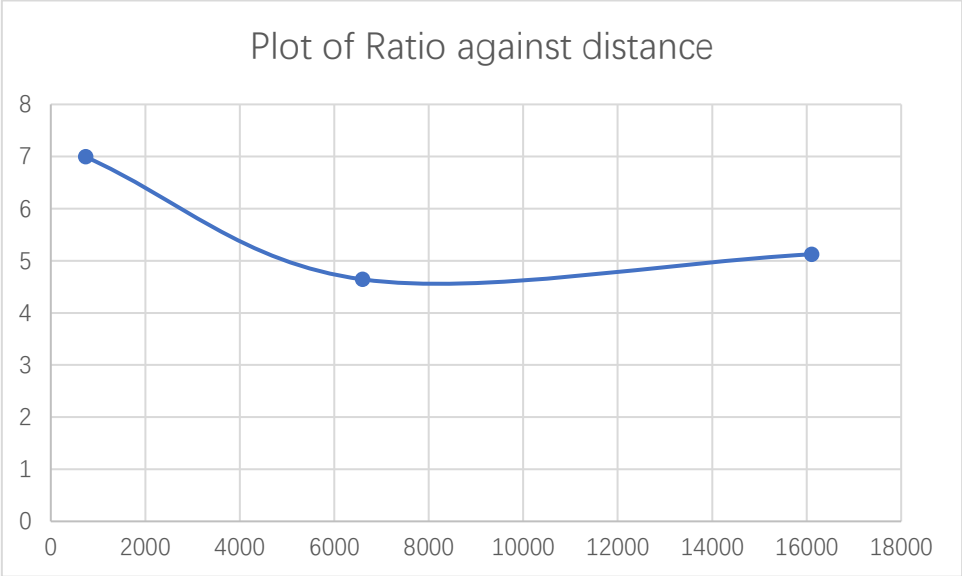




Q1:

Approximate Physical distance and Shortest possible time are shown below:

Institutions	UQ	UPM	TU-Berlin
Distance (km)	733.5	6600	16100
Shortest Time (ms)	2.45	22	53.67



There are two possible reasons why the ratios are greater than 2:

i) The physical route is longer than the shortest distance, in real life, it usually takes detours to meet different needs.

ii) Delay consists of processing, queueing, transmission and propagation delay, while the calculated delay is only propagation delay. So, the measured delay is certainly higher. Moreover, because processing, queueing and transmission time are not obviously positive related to distance, the ratio tend to be larger when distance is short.

iii) The signal may not travel in the full light speed because of the medium used.

Q2: Is the delay to the destinations constant or does it vary over time? Explain why.

As observed from the graphs, **the delay varied over time**. It is because delay is affected by the internet traffic which keeps varying from time to time. And the traffic influences queueing time the most.

Q3: The measured delay 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?

Only **processing delay** and **transmission delay** are directly affected by the packet size because each bit takes approximately constant time to be processed. Although they both depend on the packet size, processing delay is of a much lower order of magnitude than the other one. The other two delays are not positively correlated with packet size.