

Exercise 1: nslookup

1.

```
MacPro:~ macpro$ nslookup www.google.com
Server:          10.0.0.138
Address:         10.0.0.138#53

Non-authoritative answer:
Name:   www.google.com
Address: 216.58.200.100
```

Because this website is used on multiple servers, and each server running on a different end system, and each end system has a different IP address.

2.

```
MacPro:~ macpro$ nslookup 127.0.0.1
Server:          10.0.0.138
Address:         10.0.0.138#53

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

127.0.0.1 is the loopback address, known as localhost. It can be used by the machine to send a packet to itself. It is a non-routable IP address and localhost is often used for testing purpose.

Exercise 2: Using ping to test host reachability

1. www.cse.unsw.edu.au **reachable.**
2. www.getfittest.com.au **unreachable, unknown host.**
3. www.mit.edu **reachable.**
4. www.intel.com.au **reachable.**
5. www.tpg.com.au **reachable.**
6. www.hola.hp **unreachable, unknown host.**
7. www.amazon.com **reachable.**
8. www.tsinghua.edu.cn **reachable.**
9. www.kremlin.ru **unreachable(lost all packets). This is maybe because some organisations prohibit their website reached by ping.**
10. 8.8.8.8 **reachable.**
11. www.getfittest.com.au & www.hola.hp also are unreachable from the web browser.
Because their IP addresses do not exist.
But www.kremlin.ru is reachable from the web browser.

Exercise 3: Use traceroute to understand network topology

Q1:

```
weill % 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) 0.114 ms 0.116 ms 0.100 ms
 2 129.94.39.17 (129.94.39.17) 1.010 ms 0.990 ms 1.009 ms
 3 libudnex1-v1-3154.gw.unsw.edu.au (149.171.253.34) 1.563 ms 1.969 ms 1.726 ms
 4 libcr1-po-5.gw.unsw.edu.au (149.171.255.165) 1.134 ms ombcr1-po-5.gw.unsw.edu.au (149.171.255.197) 1.195 ms 1.212 ms
 5 unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101) 1.331 ms 1.223 ms 1.231 ms
 6 138.44.5.0 (138.44.5.0) 1.376 ms 1.420 ms 1.346 ms
 7 et-1-3-0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.15.149) 2.546 ms 2.388 ms 2.403 ms
 8 et-0-0-0.pe1.a.hnl.aarnet.net.au (113.197.15.99) 95.310 ms 95.273 ms 95.349 ms
 9 et-2-1-0.bdri1.a.sea.aarnet.net.au (113.197.15.201) 146.659 ms 146.750 ms 146.727 ms
10 abilene-1-lo-jmb-706.sttlwa.pacificwave.net (207.231.240.8) 146.807 ms 146.836 ms 146.846 ms
11 et-4-0-0.4079.rtsw.miss2.net.internet2.edu (162.252.70.0) 157.683 ms 157.652 ms 157.710 ms
12 et-4-0-0.4079.rtsw.minn.net.internet2.edu (162.252.70.58) 180.724 ms 180.807 ms 180.914 ms
13 et-1-1-5.4079.rtsw.eqch.net.internet2.edu (162.252.70.106) 188.852 ms 188.711 ms 188.695 ms
14 162.252.70.163 (162.252.70.163) 195.756 ms 188.655 ms 188.869 ms
15 ae-1.4079.rtsw.clev.net.internet2.edu (162.252.70.130) 197.151 ms 198.746 ms 197.096 ms
16 buf-9208-I2-CLEV.nysernet.net (199.109.11.33) 201.397 ms 201.632 ms 201.526 ms
17 syr-9208-buf-9208.nysernet.net (199.109.7.193) 204.662 ms 204.615 ms 204.599 ms
18 nyc-9208-syr-9208.nysernet.net (199.109.7.162) 210.466 ms 210.276 ms 210.901 ms
19 columbia.nyc-9208.nysernet.net (199.109.4.14) 210.524 ms 210.531 ms 210.514 ms
20 cc-core-1-x-nyser32-gw-1.net.columbia.edu (128.59.255.5) 210.906 ms 210.914 ms 210.635 ms
21 cc-conc-1-x-cc-core-1.net.columbia.edu (128.59.255.210) 210.863 ms 210.688 ms 210.818 ms
22 exeas.org (128.59.105.24) 210.577 ms 210.558 ms 210.561 ms
```

There are 21 routers between my workstation and www.columbia.edu. The first 5 routers along the path are part of the UNSW network based on their hostnames. Between 7th router and 10th router, packets cross the Pacific Ocean.

Q2:

1. www.ucla.edu

```
weill % traceroute 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) 0.131 ms 0.109 ms 0.086 ms
 2 129.94.39.17 (129.94.39.17) 1.016 ms 1.001 ms 0.999 ms
 3 ombudnex1-v1-3154.gw.unsw.edu.au (149.171.253.35) 115.268 ms 115.245 ms 115.223 ms
 4 libcr1-po-6.gw.unsw.edu.au (149.171.255.201) 1.209 ms libcr1-po-5.gw.unsw.edu.au (149.171.255.165) 1.212 ms ombcr1-po-5.gw.unsw.edu.au (149.171.255.197) 1.265 ms
 5 unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101) 1.252 ms unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105) 1.267 ms 1.271 ms
 6 138.44.5.0 (138.44.5.0) 1.403 ms 1.403 ms 1.414 ms
 7 et-1-3-0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.15.149) 2.331 ms 2.220 ms 2.206 ms
 8 et-0-0-0.pe1.a.hnl.aarnet.net.au (113.197.15.99) 95.273 ms 95.294 ms 95.354 ms
 9 et-2-1-0.bdri1.a.sea.aarnet.net.au (113.197.15.201) 146.739 ms 146.717 ms 146.662 ms
10 cenichpr-1-is-jmb-778.snvaca.pacificwave.net (207.231.245.129) 163.237 ms 163.194 ms 163.225 ms
11 hpr-lax-hpr3-svl-hpr3-100ge.cenich.net (137.164.25.73) 171.074 ms 171.068 ms 170.998 ms
12 * * *
13 bd11f1.anderson--cr001.anderson.ucla.net (169.232.4.6) 171.513 ms 171.431 ms bd11f1.anderson--cr00f2.csb1.ucla.net (169.232.4.4) 171.498 ms
14 cr00f2.csb1--dr00f2.csb1.ucla.net (169.232.4.53) 171.420 ms 171.583 ms 171.501 ms
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weill %
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2. www.u-tokyo.ac.jp

```
weill % traceroute www.u-tokyo.ac.jp
traceroute to www.u-tokyo.ac.jp (218.152.243.234), 30 hops max, 60 byte packets
 1 cserouter1-server.cse.unsw.edu.au (129.94.242.251) 0.131 ms 0.105 ms 0.082 ms
 2 129.94.39.17 (129.94.39.17) 1.012 ms 1.052 ms 0.992 ms
 3 libudnex1-v1-3154.gw.unsw.edu.au (149.171.253.34) 1.718 ms libudnex1-v1-3154.gw.unsw.edu.au (149.171.253.34) 1.415 ms libudnex1-v1-3154.gw.unsw.edu.au (149.171.253.34) 1.667 ms
 4 ombcr1-po-5.gw.unsw.edu.au (149.171.255.197) 1.232 ms libcr1-po-6.gw.unsw.edu.au (149.171.255.201) 1.230 ms ombcr1-po-5.gw.unsw.edu.au (149.171.255.197) 1.205 ms
 5 unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105) 1.273 ms 1.351 ms 1.357 ms
 6 138.44.5.0 (138.44.5.0) 1.406 ms 1.371 ms 1.385 ms
 7 et-0-3-0-pe1.bkvl.nsw.aarnet.net.au (113.197.15.147) 1.796 ms 1.829 ms 1.823 ms
 8 ge-4-0-bb1.a.pao.aarnet.net.au (202.158.194.177) 156.116 ms 156.137 ms 156.181 ms
 9 paloalto0.iiij.net (198.32.176.24) 157.984 ms 158.008 ms 158.070 ms
10 osk004bb00.IIJ.Net (58.138.88.185) 288.995 ms 288.858 ms 288.793 ms
11 osk004ix51.IIJ.Net (58.138.106.126) 288.513 ms osk004ix51.IIJ.Net (58.138.106.130) 279.633 ms osk004ix51.IIJ.Net (58.138.106.126) 288.736 ms
12 219.130.135.190 (219.130.135.190) 279.813 ms 288.421 ms 279.761 ms
13 124.83.228.58 (124.83.228.58) 288.474 ms 288.550 ms 288.584 ms
14 124.83.252.178 (124.83.252.178) 323.371 ms 323.321 ms 323.329 ms
15 158.205.134.26 (158.205.134.26) 294.367 ms 285.720 ms 294.427 ms
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3. www.lancaster.ac.uk

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weill % 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) 0.109 ms 0.121 ms 0.098 ms
 2 129.94.39.17 (129.94.39.17) 1.040 ms 0.977 ms 0.949 ms
 3 libudnex1-v1-3154.gw.unsw.edu.au (149.171.253.34) 4.325 ms 4.381 ms 4.361 ms
 4 ombcr1-po-5.gw.unsw.edu.au (149.171.255.197) 1.246 ms ombcr1-po-6.gw.unsw.edu.au (149.171.255.169) 1.261 ms ombcr1-po-5.gw.unsw.edu.au (149.171.255.197) 1.271 ms
 5 unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105) 1.311 ms 1.350 ms unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101) 1.409 ms
 6 138.44.5.0 (138.44.5.0) 1.307 ms 1.318 ms 1.476 ms
 7 et-1-3-0-pe1.ext.bkvl.nsw.aarnet.net.au (113.197.15.149) 2.289 ms 2.070 ms 2.084 ms
 8 et-0-0-0-pe1.a.hnl.aarnet.net.au (113.197.15.90) 95.340 ms 95.266 ms 95.322 ms
 9 et-2-1-0-bdr1.a.saa.aarnet.net.au (113.197.15.201) 146.696 ms 146.682 ms 146.689 ms
10 abilene-1-to-jmb-700.sttlwa.pacificwave.net (207.231.240.8) 146.799 ms 146.679 ms 146.665 ms
11 et-4-0-0.4079.rtsw.miss2.net.internet2.edu (162.252.70.0) 157.477 ms 157.507 ms 157.489 ms
12 et-4-0-0.4079.rtsw.minn.net.internet2.edu (162.252.70.58) 180.591 ms 181.742 ms 180.551 ms
13 et-1-1-5.4079.rtsw.mqch.net.internet2.edu (162.252.70.106) 189.379 ms 188.819 ms 188.685 ms
14 162.252.70.163 (162.252.70.163) 188.819 ms 191.553 ms 191.527 ms
15 ae-1.4079.rtsw.clev.net.internet2.edu (162.252.70.130) 197.798 ms 197.617 ms 197.596 ms
16 et-2-0-0.4079.rtsw.asnb.net.internet2.edu (162.252.70.54) 205.120 ms 205.332 ms 205.094 ms
17 ae-2.4079.rtsw.wash.net.internet2.edu (162.252.70.136) 205.203 ms 205.254 ms 205.289 ms
18 internet2-gw.mx1.lon.uk.geant.net (62.40.124.44) 200.297 ms 200.576 ms 200.548 ms
19 janet-gw.mx1.lon.uk.geant.net (62.40.124.198) 200.450 ms 200.665 ms 200.933 ms
20 ae29.londpg-sbr2.ja.net (146.97.33.2) 285.843 ms 285.107 ms 285.140 ms
21 ae31.erdiss-sbr2.ja.net (146.97.33.22) 284.730 ms 284.759 ms 284.801 ms
22 ae29.manckh-sbr2.ja.net (146.97.33.42) 286.809 ms 286.677 ms 286.816 ms
23 ae24.lancu-rbr1.ja.net (146.97.38.58) 288.791 ms 288.963 ms 288.828 ms
24 lancaster-university.ja.net (194.81.46.2) 300.142 ms 300.126 ms 304.418 ms
25 * * *
26 ism-xrxx.rtr.lancs.ac.uk (148.88.255.17) 290.466 ms 290.558 ms 290.679 ms
27 dc-iss.srv.rtrcloud.lancs.ac.uk (148.88.253.3) 313.822 ms 310.540 ms 310.612 ms
28 www.lancs.ac.uk (148.88.65.80) 290.761 ms !X 290.769 ms !X 290.741 ms !X
weill %
```

All 3 paths have same first 7 hops. The 3 paths differ in the next hop(8th hop) following the 138.44.5.0 router. The Los Angeles(ucla) and Lancaster paths also have a same 8th hop router (113.197.15.99). For all 3 paths, this 8th router belongs to the AARNET network.

No, the number of hops on each path is not proportional to the physical distance. The path to Tokyo (closer to Sydney than Los Angeles) has about 15 hops while to Los Angeles only has 14 hops.

Q3:

My IP address: 129.94.242.2

www.speedtest.com.sg IP address: 202.150.221.170

www.telstra.net IP address: 203.50.5.178

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

```
3 libudnex1-v1-3154.gw.unsw.edu.au (149.171.253.34) 1.933 ms 1.980 ms 1.952 ms
4 libcr1-po-5.gw.unsw.edu.au (149.171.255.165) 1.277 ms ombcr1-po-6.gw.unsw.edu.au (149.171.255.169) 1.189 ms
5 unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101) 1.286 ms unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)
6 138.44.5.0 (138.44.5.0) 1.779 ms 1.429 ms 1.438 ms
7 et-0-3-0.pe1.alxd.nsw.aarnet.net.au (113.197.15.153) 1.821 ms 1.904 ms 1.943 ms
8 xe-0-2-1-204.pe1.wnppa.alxd.aarnet.net.au (113.197.15.183) 24.278 ms 24.324 ms xe-0-3-pe1.wnppa.akl.aarnet
9 et-0-1-0.200.pe1.tkpa.akl.aarnet.net.au (113.197.15.69) 24.646 ms 24.626 ms 24.492 ms
10 xe-0-2-6.bdr1.a.lax.aarnet.net.au (202.158.194.173) 148.071 ms 148.014 ms 148.029 ms
11 singtel.as7473.any2ix.coresite.com (206.72.210.63) 148.098 ms 148.104 ms 148.293 ms
12 203.208.151.181 (203.208.151.181) 317.261 ms 203.208.182.153 (203.208.182.153) 335.932 ms 203.208.172.173
13 203.208.171.85 (203.208.171.85) 328.833 ms 203.208.177.110 (203.208.177.110) 224.693 ms 203.208.182.41 (20
14 203.208.182.45 (203.208.182.45) 320.421 ms 202-150-221-170.rev.ne.com.sg (202.150.221.170) 236.786 ms 236
```

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

```
traceroute to 129.94.242.2 (129.94.242.2), 30 hops max, 60 byte packets
 1 ge2-8.r01.sin01.ne.com.sg (202.150.221.169) 0.190 ms 0.229 ms 0.244 ms
 2 10.11.33.30 (10.11.33.30) 0.256 ms 0.268 ms 0.278 ms
 3 10.11.33.74 (10.11.33.74) 0.726 ms 0.737 ms 0.741 ms
 4 aarnet.sgix.sg (103.16.102.67) 225.726 ms 225.674 ms 225.747 ms
 5 xe-3-0-3.pe1.brwy.nsw.aarnet.net.au (113.197.15.206) 235.265 ms 235.313 ms 235.336 ms
 6 138.44.5.1 (138.44.5.1) 225.862 ms 225.915 ms 225.916 ms
 7 ombcr1-te-1-5.gw.unsw.edu.au (149.171.255.106) 235.778 ms 235.733 ms 235.777 ms
 8 libudnex1-po-2.gw.unsw.edu.au (149.171.255.198) 226.566 ms 226.586 ms 226.622 ms
 9 ufw1-ae-1-3154.gw.unsw.edu.au (149.171.253.36) 236.577 ms 236.568 ms 236.512 ms
10 129.94.39.23 (129.94.39.23) 224.837 ms 224.773 ms 224.825 ms
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```

Traceroute Completed.

In this case, the forward and reverse paths are very different. The path from my machine to speedtest.com.sg appears to go through routers in Auckland (113.197.15.69) and LA (202.158.194.173) whereas the path from speedtest.com.sg to my machine appears to go through south Australia(113.197.15.206) and then arrive at Sydney.

Traceroute 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) 0.140 ms 0.118 ms 0.096 ms
 2 129.94.39.17 (129.94.39.17) 1.058 ms 1.050 ms 1.005 ms
 3 onbudner1-1-3154.gw.unsw.edu.au (149.171.253.35) 1.542 ms libudnex1-v1-3154.gw.unsw.edu.au (149.171.253.34) 1.681 ms 1.681 ms
 4 libcr1-po-6.gw.unsw.edu.au (149.171.255.201) 1.261 ms 1.253 ms 1.285 ms
 5 unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105) 1.265 ms unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101) 1.334 ms 1.365 ms
 6 138.44.5.0 (138.44.5.0) 1.446 ms 1.400 ms 1.406 ms
 7 et-0-3-0.pel.aixd.nsw.aarnet.net.au (113.197.15.153) 1.577 ms 1.735 ms 1.713 ms
 8 ae9.bb1.0.syd.aarnet.net.au (113.197.15.05) 1.964 ms 1.926 ms 2.017 ms
 9 gigabitethernet1-1.pel.b.syd.aarnet.net.au (202.158.202.18) 1.947 ms 2.032 ms 1.953 ms
10 gigabitethernet3-11.ken37.sydnet.telstra.net (139.130.0.77) 8.213 ms 8.218 ms 9.513 ms
11 bundle-ether13.ken-core10.sydnet.telstra.net (203.50.11.94) 4.122 ms bundle-ether2.cdw-edge901.sydnet.telstra.net (203.50.11.103) 2.686 ms 2.667 ms
12 bundle-ether10.win-core10.melbourne.telstra.net (203.50.11.123) 15.410 ms bundle-ether13.cdw-core10.sydnet.telstra.net (203.50.11.98) 3.852 ms bundle-ether10.win-core10.melbourne.telstra.net (203.50.11.123) 15.298 ms
13 203.50.6.40 (203.50.6.40) 14.841 ms bundle-ether8.exi-core10.melbourne.telstra.net (203.50.11.125) 15.604 ms 203.50.6.40 (203.50.6.40) 15.323 ms
14 bundle-ether2.exi-nctrouter101.melbourne.telstra.net (203.50.11.209) 15.202 ms 15.467 ms 15.321 ms
15 www.telstra.net (203.50.5.178) 15.001 ms 14.399 ms 14.905 ms
wagner %
```

Traceroute www.telstra.net to my machine:

```
 1 gigabitethernet3-3.exi2.melbourne.telstra.net (203.50.77.53) 0.339 ms 0.222 ms 0.244 ms
 2 bundle-ether3-100.win-core10.melbourne.telstra.net (203.50.80.129) 2.493 ms 1.487 ms 2.245 ms
 3 bundle-ether12.ken-core10.sydnet.telstra.net (203.50.11.122) 12.737 ms 12.231 ms 12.988 ms
 4 bundle-ether1.ken-edge901.sydnet.telstra.net (203.50.11.95) 11.989 ms 12.105 ms 11.988 ms
 5 aarnet6.lnk.telstra.net (139.130.0.78) 11.614 ms 11.607 ms 11.613 ms
 6 ge-6-0-0.bb1.a.syd.aarnet.net.au (202.158.202.17) 11.864 ms 11.732 ms 11.739 ms
 7 ae9.pe2.brwy.nsw.aarnet.net.au (113.197.15.56) 11.988 ms 12.107 ms 11.988 ms
 8 et-3-1-0.pel.brwy.nsw.aarnet.net.au (113.197.15.146) 12.115 ms 12.107 ms 12.116 ms
 9 138.44.5.1 (138.44.5.1) 12.361 ms 12.357 ms 12.360 ms
10 libcr1-te-1-5.gw.unsw.edu.au (149.171.255.102) 12.363 ms 12.356 ms 12.362 ms
11 libudnex1-po-1.gw.unsw.edu.au (149.171.255.166) 12.613 ms
12 ufw1-ae-1-3154.gw.unsw.edu.au (149.171.253.36) 29.977 ms 28.599 ms 31.726 ms
13 129.94.39.23 (129.94.39.23) 44.843 ms 49.960 ms 44.095 ms
```

In this case, the reverse path does not go through the same routers as the forward path. But in many conditions, although when both the forward and the reverse path cross the same router, it is possible that different IP addresses are used. The reason is that the names in the traceroute output are the names of the router interfaces and not of routers. So, both IP addresses indeed belong to the same route but have been allocated to different interfaces of it.

Exercise 4: Use ping to gain insights into network performance

./runping.sh www.abc.net

```
wagner % ./runping.sh www.abc.net

ping -s 22 -c 50 -i 1 www.abc.net > www.abc.net-p50
ping -s 222 -c 50 -i 1 www.abc.net > www.abc.net-p250
ping -s 472 -c 50 -i 1 www.abc.net > www.abc.net-p500
ping -s 722 -c 50 -i 1 www.abc.net > www.abc.net-p750
ping -s 972 -c 50 -i 1 www.abc.net > www.abc.net-p1000
ping -s 1222 -c 50 -i 1 www.abc.net > www.abc.net-p1250
ping -s 1472 -c 50 -i 1 www.abc.net > www.abc.net-p1500
```

(i) www.uq.edu.au

```
wagner % ./runping.sh www.uq.edu.au

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

(ii) www.nus.edu.sg

```
[wagner % ./runping.sh www.nus.edu.sg

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

(iii) www.tu-berlin.de

```
[wagner % ./runping.sh www.tu-berlin.de  
ping -s 22 -c 50 -i 1 www.tu-berlin.de > www.tu-berlin.de-p50  
ping -s 222 -c 50 -i 1 www.tu-berlin.de > www.tu-berlin.de-p250  
ping -s 472 -c 50 -i 1 www.tu-berlin.de > www.tu-berlin.de-p500  
ping -s 722 -c 50 -i 1 www.tu-berlin.de > www.tu-berlin.de-p750  
ping -s 972 -c 50 -i 1 www.tu-berlin.de > www.tu-berlin.de-p1000  
ping -s 1222 -c 50 -i 1 www.tu-berlin.de > www.tu-berlin.de-p1250  
ping -s 1472 -c 50 -i 1 www.tu-berlin.de > www.tu-berlin.de-p1500
```

Q1.

Distance between UNSW and the 3 destinations (based on flight path between them) are: **Brisbane: 735km, Singapore: 6310km, Berlin: 16,099.**

The shortest possible time that a packet will take to reach these 3 destinations are:

(assuming propagation speed: 3×10^8 m/s)

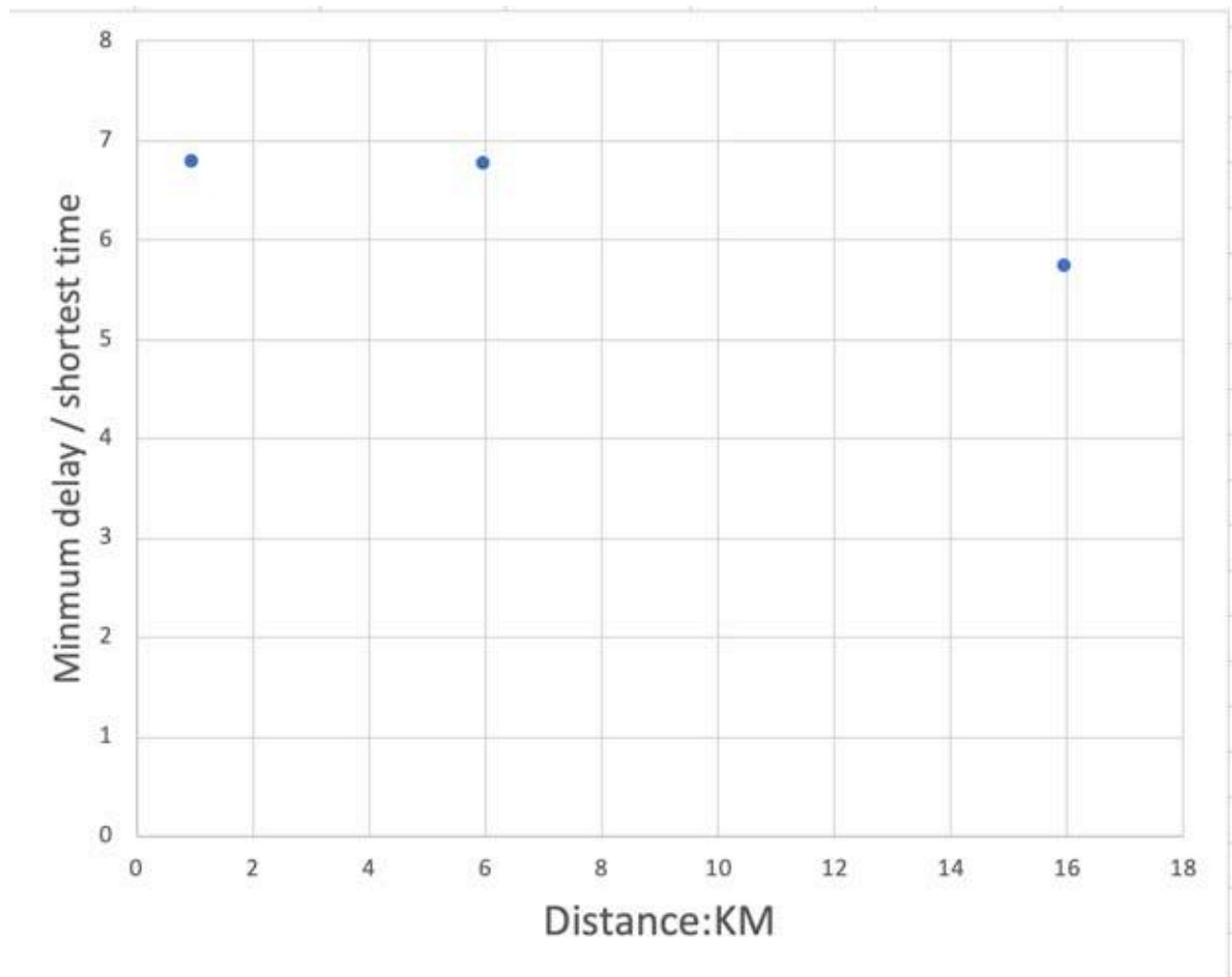
Brisbane: 2.45ms, Singapore: 21ms, Berlin: 53.66ms

The minimum RTT (for 50 byte packets) to these 3 destinations from the corresponding *avg.txt files are:

Brisbane: 16.580ms, Singapore: 141.836ms, Berlin: 307.059ms

The ratios of the minimum RTT to the minimum propagation delay for these 3 destinations are: **Brisbane: 6.77, Singapore: 6.75, Berlin: 5.72.**

The following graph shows the relations between this ratio and distance.



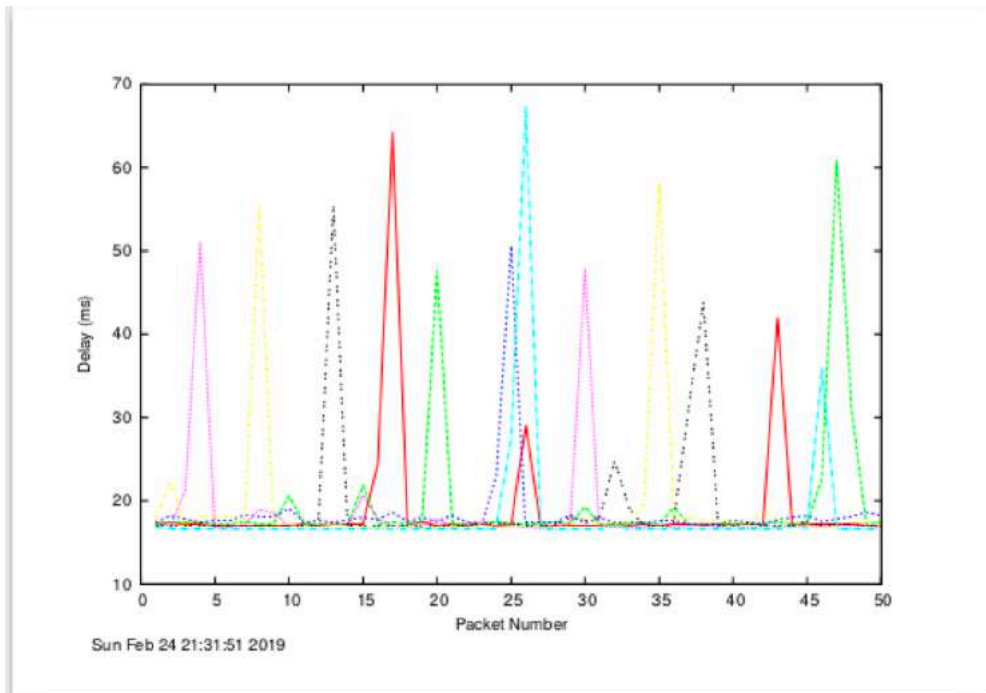
Reasons for this ratio is always > 2 . As following:

1. speed of light should be take into account for transmission delays.
2. Routing method(ISP-level) may result in paths are not the shortest hop paths.
3. It is impossible for packets to travel at the full speed of light in real medium.

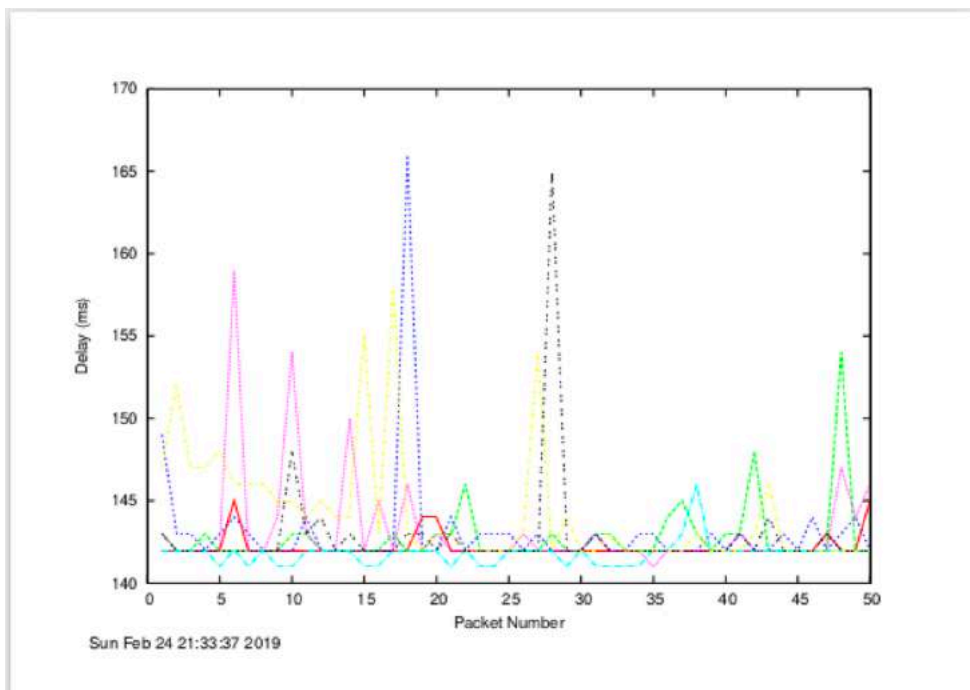
Q2:

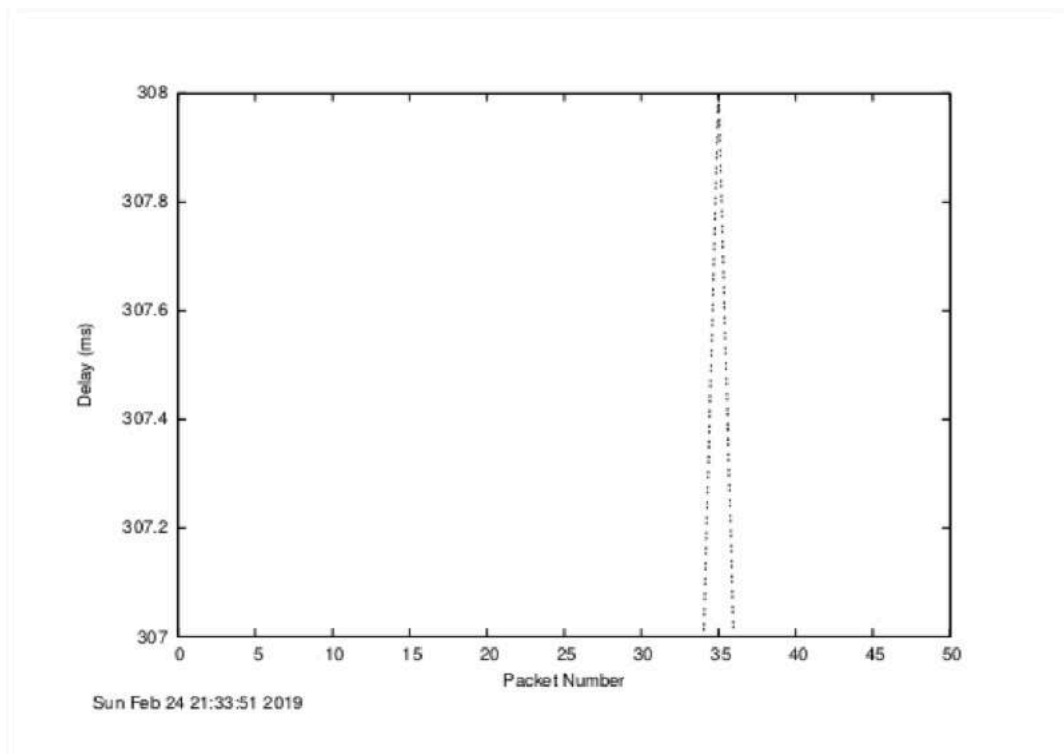
Each of the following plots (destination_delay.pdf) show the delay of consecutive packets of same size:

www.uq.edu.au



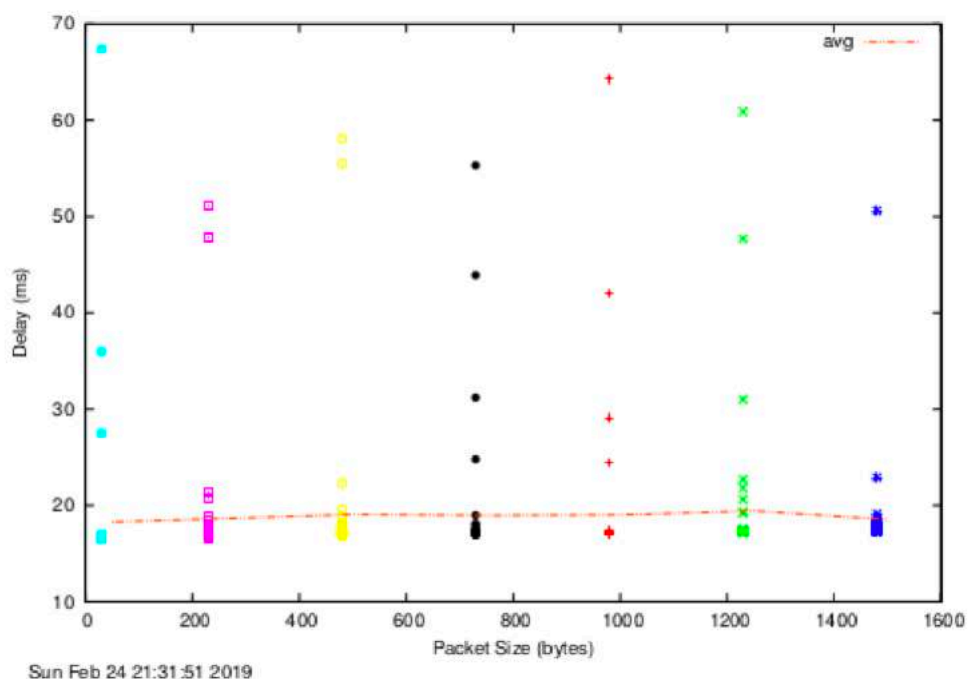
www.nus.edu.sg

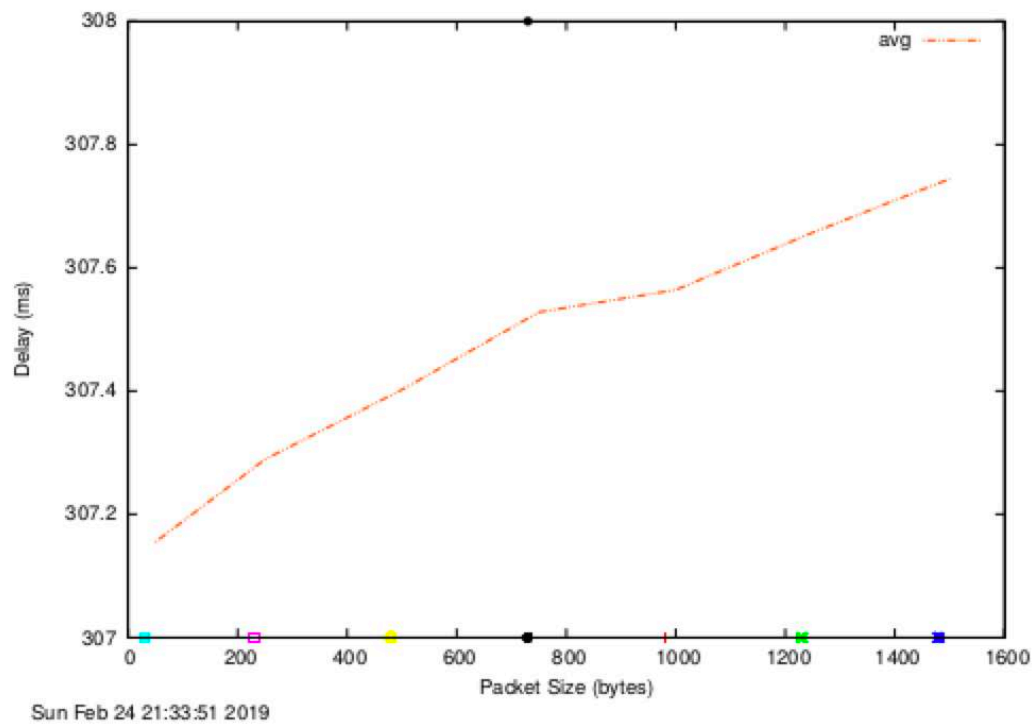
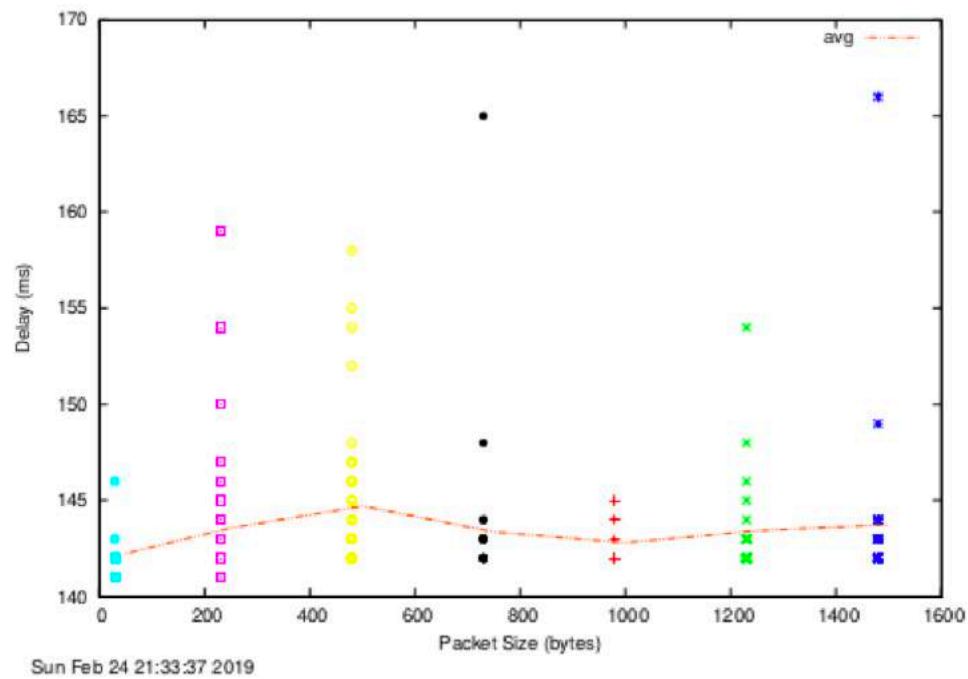




For these 3 destinations, the delay randomly varies over time. This is mostly due to the variability of processing and queuing delays. The degree of variability is related to the quality of the end-to-end path.

The following plots (destination_scatter.pdf) show the various measurements of delay as a scatter plot for different packet sizes.





For www.tu-berlin.de, the delay depends on the size of the packets. Because the transmission delay for larger packets is greater which will increase the overall delay. However, this trend is not obvious for www.uq.edu.au and www.nus.edu.sg. The average delay does not seem to vary much for different packet sizes.

The reasons are:

- a) the destination is far away, and therefore the propagation delay (independent from the packet size) is significantly higher than the transmission delay (dependent on the packet size)
- b) there is high congestion in the network, so the queueing delay may take up a significant part of the total delay.

Q3.

Depend on the packet size : transmission delay.

Not depend on the packet size: processing delay, queueing delay, propagation delay.

The transmission delay is almost completely depend on the packet size.

The processing delay depend on the header packet size.

The queueing delay depends on the congestion in the network.

The propagation delay depends on the link.