

Exercise 1

1.

Google's IP address: 216.58.203.110

Reason having several IP addresses is because there are multiple records for a single host.

2.

name = localhost. This IP address is the local computer's IP address.

Exercise 2

- `www.cse.unsw.edu.au` Yes
- `www.getfittest.com.au` No
- `www.mit.edu` Yes
- `www.intel.com.au` Yes
- `www.tpg.com.au` Yes
- `www.hola.hp` No
- `www.amazon.com` Yes
- `www.tsinghua.edu.cn` Yes
- `www.kremlin.ru` No
- `8.8.8.8` Yes

`www.getfittest.com.au` and `www.hola.hp` are not valid hosts and are not reachable from Web browser. `www.kremlin.ru` can be transmitted packets using ping, but 0 packets received; however, it can be reachable by Web browser. Government website has firewall that blocks ping request for security reason.

Exercise 3

1.

There are 22 routers.

There are 4 routers are part of the UNSW network (1, 3, 4, 5).

Crossing the Pacific Ocean is between route 7 (`113.197.15.149`) and route 8 (`113.197.15.99`) because the time is significantly different.

Traceroot result:

```
wagner % traceroute www.columbia.edu
traceroute to www.columbia.edu (128.59.105.24), 30 hops max, 60 byte packets
 1  cserouter1-server.cse.unsw.EDU.AU (129.94.242.251)  0.118 ms  0.141 ms  0.126 ms
 2  129.94.39.17 (129.94.39.17)  1.152 ms  1.118 ms  1.095 ms
 3  libudnex1-v1-3154.gw.unsw.edu.au (149.171.253.34)  3.564 ms  ombudnex1-v1-3154.gw.unsw.edu.au (149.171.253.35)  1.937 ms  1.830 ms
 4  libcr1-po-5.gw.unsw.edu.au (149.171.255.165)  1.296 ms  ombcr1-po-5.gw.unsw.edu.au (149.171.255.197)  1.278 ms  1.278 ms
 5  unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.294 ms  unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  1.356 ms  unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.305 ms
```

```

6 138.44.5.0 (138.44.5.0) 1.650 ms 1.414 ms 1.436 ms
7 et-1-3-0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.15.149) 4.159 ms 2.469 ms
2.367 ms
8 et-0-0-0.pe1.a.hnl.aarnet.net.au (113.197.15.99) 95.732 ms 95.360 ms 95.285
ms
9 et-2-1-0.bdr1.a.sea.aarnet.net.au (113.197.15.201) 146.750 ms 146.805 ms
146.777 ms
10 abilene-1-lo-jmb-706.sttlwa.pacificwave.net (207.231.240.8) 146.760 ms
146.875 ms 146.848 ms
11 et-4-0-0.4079.rtsw.miss2.net.internet2.edu (162.252.70.0) 157.711 ms 157.702
ms 157.817 ms
12 et-4-0-0.4079.rtsw.minn.net.internet2.edu (162.252.70.58) 180.692 ms 180.763
ms 180.829 ms
13 et-1-1-5.4079.rtsw.eqch.net.internet2.edu (162.252.70.106) 229.391 ms
188.866 ms 202.591 ms
14 162.252.70.163 (162.252.70.163) 192.517 ms 188.783 ms 188.774 ms
15 ae-1.4079.rtsw.clev.net.internet2.edu (162.252.70.130) 197.227 ms 197.198 ms
197.159 ms
16 buf-9208-I2-CLEV.nysernet.net (199.109.11.33) 201.526 ms 201.539 ms 201.530
ms
17 syr-9208-buf-9208.nysernet.net (199.109.7.193) 204.785 ms 204.861 ms
204.755 ms
18 nyc-9208-syr-9208.nysernet.net (199.109.7.162) 210.386 ms 210.447 ms
210.432 ms
19 columbia.nyc-9208.nysernet.net (199.109.4.14) 210.521 ms 210.428 ms 210.411
ms
20 cc-core-1-x-nyser32-gw-1.net.columbia.edu (128.59.255.5) 210.590 ms 210.710
ms 210.855 ms
21 cc-conc-1-x-cc-core-1.net.columbia.edu (128.59.255.210) 211.640 ms 211.276
ms 211.191 ms
22 www.neurotheory.columbia.edu (128.59.105.24) 211.014 ms 210.986 ms 211.015
ms

```

Ping result:

```

wagner % ping 113.197.15.99
PING 113.197.15.99 (113.197.15.99) 56(84) bytes of data.
64 bytes from 113.197.15.99: icmp_req=1 ttl=57 time=94.8 ms
64 bytes from 113.197.15.99: icmp_req=2 ttl=57 time=94.9 ms
64 bytes from 113.197.15.99: icmp_req=3 ttl=57 time=94.9 ms
64 bytes from 113.197.15.99: icmp_req=4 ttl=57 time=95.0 ms
64 bytes from 113.197.15.99: icmp_req=5 ttl=57 time=94.9 ms
64 bytes from 113.197.15.99: icmp_req=6 ttl=57 time=95.0 ms
64 bytes from 113.197.15.99: icmp_req=7 ttl=57 time=95.0 ms
64 bytes from 113.197.15.99: icmp_req=8 ttl=57 time=95.1 ms
64 bytes from 113.197.15.99: icmp_req=9 ttl=57 time=94.9 ms
64 bytes from 113.197.15.99: icmp_req=10 ttl=57 time=94.9 ms
^C
--- 113.197.15.99 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9012ms
rtt min/avg/max/mdev = 94.889/94.976/95.136/0.419 ms
wagner % ping 113.197.15.149
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=2.03 ms
64 bytes from 113.197.15.149: icmp_req=2 ttl=58 time=1.93 ms
64 bytes from 113.197.15.149: icmp_req=3 ttl=58 time=1.89 ms
64 bytes from 113.197.15.149: icmp_req=4 ttl=58 time=1.93 ms
64 bytes from 113.197.15.149: icmp_req=5 ttl=58 time=1.84 ms
64 bytes from 113.197.15.149: icmp_req=6 ttl=58 time=1.80 ms

```

```

64 bytes from 113.197.15.149: icmp_req=7 ttl=58 time=2.17 ms
64 bytes from 113.197.15.149: icmp_req=8 ttl=58 time=1.82 ms
64 bytes from 113.197.15.149: icmp_req=9 ttl=58 time=2.04 ms
64 bytes from 113.197.15.149: icmp_req=10 ttl=58 time=2.18 ms
^C
--- 113.197.15.149 ping statistics ---
10 packets transmitted, 10 received, 0% packet loss, time 9014ms
rtt min/avg/max/mdev = 1.809/1.967/2.182/0.139 ms

```

2.

These three paths diverge at 138.44.5.0. The organization of this router is Asia Pacific Network Information Centre (APNIC), and the router locates in Queensland, which makes sense that those three paths diverge here. No, the number of hops on each path is not necessary to be proportional to the physical distance since the number of routers on land is much more than the routers across oceans.

```

wagner % whois 138.44.5.0

#
# ARIN WHOIS data and services are subject to the Terms of Use
# available at: https://www.arin.net/resources/registry/whois/tou/
#
# If you see inaccuracies in the results, please report at
# https://www.arin.net/resources/registry/whois/inaccuracy\_reporting/
#
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#

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-
Comment:           info/whois\_search2/abuse-and-spamming
Ref:               https://rdap.arin.net/registry/ip/138.44.0.0

ResourceLink:      http://wq.apnic.net/whois-search/static/search.html
ResourceLink:      whois.apnic.net

OrgName:           Asia Pacific Network Information Centre

```

OrgId: APNIC
Address: PO Box 3646
City: South Brisbane
StateProv: QLD
PostalCode: 4101
Country: AU
RegDate:
Updated: 2012-01-24
Ref: <https://rdap.arin.net/registry/entity/APNIC>

ReferralServer: [whois://whois.apnic.net](http://whois.apnic.net)
ResourceLink: <http://wq.apnic.net/whois-search/static/search.html>

OrgTechHandle: AWC12-ARIN
OrgTechName: APNIC Whois Contact
OrgTechPhone: +61 7 3858 3188
OrgTechEmail: search-apnic-not-arin@apnic.net
OrgTechRef: <https://rdap.arin.net/registry/entity/AWC12-ARIN>

OrgAbuseHandle: AWC12-ARIN
OrgAbuseName: APNIC Whois Contact
OrgAbusePhone: +61 7 3858 3188
OrgAbuseEmail: search-apnic-not-arin@apnic.net
OrgAbuseRef: <https://rdap.arin.net/registry/entity/AWC12-ARIN>

ARIN WHOIS data and services are subject to the Terms of Use
available at: <https://www.arin.net/resources/registry/whois/tou/>

If you see inaccuracies in the results, please report at
https://www.arin.net/resources/registry/whois/inaccuracy_reporting/

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#

Found a referral to whois.apnic.net.

% [whois.apnic.net]
% Whois data copyright terms <http://www.apnic.net/db/dbcopyright.html>
% Information related to '138.44.0.0 - 138.44.255.255'
% Abuse contact for '138.44.0.0 - 138.44.255.255' is 'abuse@aarnet.edu.au'

inetnum: 138.44.0.0 - 138.44.255.255
netname: AARNET
descr: Australian Academic and Research Network
descr: Building 9
descr: Banks Street
country: AU
org: ORG-AAAR1-AP
admin-c: SM6-AP
tech-c: ANOC-AP
notify: irrcontact@aarnet.edu.au
mnt-by: APNIC-HM
mnt-lower: MAINT-AARNET-AP

```
mnt-routes:      MAINT-AARNET-AP
mnt-irt:          IRT-AARNET-AU
status:          ALLOCATED PORTABLE
remarks:          -++++-++++-++++-++++-++++-++++-++++-++++-++++-++++-++++-++++-
remarks:          This object can only be updated by APNIC hostmasters.
remarks:          To update this object, please contact APNIC
remarks:          hostmasters and include your organisation's account
remarks:          name in the subject line.
remarks:          -++++-++++-++++-++++-++++-++++-++++-++++-++++-++++-++++-++++-
last-modified:    2017-10-09T13:02:43Z
source:          APNIC

irt:             IRT-AARNET-AU
address:          AARNet Pty Ltd
address:          26 Dick Perry Avenue
address:          Kensington, Western Australia
address:          Australia
e-mail:           abuse@aarnet.edu.au
abuse-mailbox:    abuse@aarnet.edu.au
admin-c:         SM6-AP
tech-c:          ANOC-AP
auth:            # Filtered
mnt-by:          MAINT-AARNET-AP
last-modified:    2010-11-08T08:02:43Z
source:          APNIC

organisation:     ORG-AAAR1-AP
org-name:         Australian Academic and Research Network
country:          AU
address:          Building 9
address:          Banks Street
phone:            +61-2-6222-3530
fax-no:           +61-2-6222-3535
e-mail:           irrcontact@aarnet.edu.au
mnt-ref:          APNIC-HM
mnt-by:           APNIC-HM
last-modified:    2017-10-09T12:56:36Z
source:          APNIC

role:             AARNet Network Operations Centre
remarks:
address:          AARNet Pty Ltd
address:          GPO Box 1559
address:          Canberra
address:          ACT 2601
country:          AU
phone:            +61 1300 275 662
phone:            +61 2 6222 3555
remarks:
e-mail:           noc@aarnet.edu.au
remarks:
remarks:          Send abuse reports to abuse@aarnet.edu.au
remarks:          Please include timestamps and offset to UTC in logs
remarks:          Peering requests to peering@aarnet.edu.au
admin-c:          SM6-AP
tech-c:           BM-AP
nic-hdl:          ANOC-AP
mnt-by:           MAINT-AARNET-AP
```

```
last-modified: 2010-06-30T13:16:48Z
source:        APNIC

person:        Steve Maddocks
remarks:       Director Operations
address:       AARNet Pty Ltd
address:       26 Dick Perry Avenue
address:       Kensington
address:       Perth
address:       WA 6151
country:       AU
phone:         +61-8-9289-2210
fax-no:        +61-2-6222-7509
e-mail:        steve.maddocks@aarnet.edu.au
nic-hdl:       SM6-AP
mnt-by:        MAINT-AARNET-AP
last-modified: 2011-02-01T08:37:06Z
source:        APNIC
```

% This query was served by the APNIC Whois Service version 1.88.15-46 (WHOIS-NODE1)

Running traceroute to www.ucla.edu, www.u-tokyo.ac.jp, www.lancaster.ac.uk.

```
z5211336@drum00:~$ traceroute www.ucla.edu
traceroute to www.ucla.edu (164.67.228.152), 30 hops max, 60 byte packets
 1 cserouter1-trusted.cse.unsw.EDU.AU (129.94.208.251) 0.141 ms 0.105 ms 0.114
ms
 2 129.94.39.17 (129.94.39.17) 1.092 ms 1.086 ms 1.053 ms
 3 libudnex1-vl-3154.gw.unsw.edu.au (149.171.253.34) 1.578 ms ombudnex1-vl-
3154.gw.unsw.edu.au (149.171.253.35) 1.681 ms 1.493 ms
 4 ombcr1-po-6.gw.unsw.edu.au (149.171.255.169) 1.347 ms libcr1-po-
6.gw.unsw.edu.au (149.171.255.201) 1.418 ms 1.409 ms
 5 unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101) 1.412 ms unswbr1-te-2-
13.gw.unsw.edu.au (149.171.255.105) 1.515 ms 1.469 ms
 6 138.44.5.0 (138.44.5.0) 1.594 ms 1.452 ms 1.536 ms
 7 et-1-3-0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.15.149) 2.381 ms 2.360 ms
2.371 ms
 8 et-0-0-0.pe1.a.hnl.aarnet.net.au (113.197.15.99) 95.444 ms 95.289 ms 95.286
ms
 9 et-2-1-0.bdr1.a.sea.aarnet.net.au (113.197.15.201) 146.681 ms 146.753 ms
146.715 ms
10 cenichpr-1-is-jmb-778.snvac.pacificwave.net (207.231.245.129) 163.484 ms
163.421 ms 163.433 ms
11 hpr-lax-hpr3--svl-hpr3-100ge.cenic.net (137.164.25.73) 171.203 ms 171.205 ms
170.956 ms
12 * * *
13 bd11f1.anderson--cr00f2.csb1.ucla.net (169.232.4.4) 173.630 ms 171.594 ms
bd11f1.anderson--cr001.anderson.ucla.net (169.232.4.6) 171.579 ms
14 cr00f2.csb1--dr00f2.csb1.ucla.net (169.232.4.53) 171.622 ms cr00f1.anderson--
dr00f2.csb1.ucla.net (169.232.4.55) 171.657 ms 171.561 ms
15 * * *
16 * * *
17 * * *
18 * * *
19 * * *
20 * * *
21 * * *
22 * * *
23 * * *
```

```

24 * * *
25 * * *
26 * * *
27 * * *
28 * * *
29 * * *
30 * * *
z5211336@drum00:~$ 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-trusted.cse.unsw.EDU.AU (129.94.208.251) 0.139 ms 0.137 ms 0.112
ms
 2 129.94.39.17 (129.94.39.17) 1.070 ms 1.053 ms 1.032 ms
 3 libudnex1-v1-3154.gw.unsw.edu.au (149.171.253.34) 1.609 ms ombudnex1-v1-
3154.gw.unsw.edu.au (149.171.253.35) 1.526 ms 1.678 ms
 4 libcr1-po-5.gw.unsw.edu.au (149.171.255.165) 1.159 ms ombcr1-po-
5.gw.unsw.edu.au (149.171.255.197) 1.318 ms 1.228 ms
 5 unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105) 1.381 ms 1.369 ms 1.335 ms
 6 138.44.5.0 (138.44.5.0) 1.432 ms 1.453 ms 1.465 ms
 7 et-0-3-0.pe1.bkvl.nsw.aarnet.net.au (113.197.15.147) 1.947 ms 1.980 ms
1.997 ms
 8 ge-4_0_0.bb1.a.pao.aarnet.net.au (202.158.194.177) 156.231 ms 156.382 ms
156.331 ms
 9 paloalto0.iij.net (198.32.176.24) 158.168 ms 158.184 ms 158.270 ms
10 osk004bb00.IIJ.Net (58.138.88.185) 289.198 ms 289.223 ms 289.222 ms
11 osk004ix51.IIJ.Net (58.138.106.126) 279.974 ms 279.918 ms 279.789 ms
12 210.130.135.130 (210.130.135.130) 280.030 ms 280.046 ms 280.045 ms
13 124.83.228.58 (124.83.228.58) 288.997 ms 289.022 ms 280.143 ms
14 124.83.252.178 (124.83.252.178) 285.947 ms 277.103 ms 285.917 ms
15 158.205.134.26 (158.205.134.26) 285.619 ms 285.827 ms 285.746 ms
16 * * *
17 * * *
18 * * *
19 * * *
20 * * *
21 * * *
22 * * *
23 * * *
24 * * *
25 * * *
26 * * *
27 * * *
28 * * *
29 * * *
30 * * *
z5211336@drum00:~$ traceroute www.lancaster.ac.uk
traceroute to www.lancaster.ac.uk (148.88.65.80), 30 hops max, 60 byte packets
 1 cserouter1-trusted.cse.unsw.EDU.AU (129.94.208.251) 0.217 ms 0.178 ms 0.150
ms
 2 129.94.39.17 (129.94.39.17) 1.106 ms 1.055 ms 1.090 ms
 3 ombudnex1-v1-3154.gw.unsw.edu.au (149.171.253.35) 1.742 ms 1.710 ms
libudnex1-v1-3154.gw.unsw.edu.au (149.171.253.34) 1.403 ms
 4 ombcr1-po-6.gw.unsw.edu.au (149.171.255.169) 1.259 ms libcr1-po-
5.gw.unsw.edu.au (149.171.255.165) 1.296 ms 1.217 ms
 5 unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105) 1.303 ms unswbr1-te-1-
9.gw.unsw.edu.au (149.171.255.101) 1.328 ms 1.357 ms
 6 138.44.5.0 (138.44.5.0) 1.442 ms 1.467 ms 1.414 ms
 7 et-1-3-0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.15.149) 2.424 ms 2.235 ms
2.252 ms

```

```

 8  et-0-0-0.pe1.a.hnl.aarnet.net.au (113.197.15.99) 102.347 ms 102.260 ms
102.224 ms
 9  et-2-1-0.bdr1.a.sea.aarnet.net.au (113.197.15.201) 146.741 ms 147.279 ms
146.651 ms
10  abilene-1-lo-jmb-706.sttlwa.pacificwave.net (207.231.240.8) 147.195 ms
147.167 ms 146.768 ms
11  et-4-0-0.4079.rtsw.miss2.net.internet2.edu (162.252.70.0) 157.767 ms 157.784
ms 157.541 ms
12  et-4-0-0.4079.rtsw.minn.net.internet2.edu (162.252.70.58) 180.850 ms 180.845
ms 180.771 ms
13  et-1-1-5.4079.rtsw.eqch.net.internet2.edu (162.252.70.106) 188.502 ms
188.784 ms 188.770 ms
14  162.252.70.163 (162.252.70.163) 213.152 ms 188.920 ms 188.893 ms
15  ae-1.4079.rtsw.clev.net.internet2.edu (162.252.70.130) 198.006 ms 197.980 ms
197.515 ms
16  et-2-0-0.4079.rtsw.ashb.net.internet2.edu (162.252.70.54) 204.977 ms 205.403
ms 205.310 ms
17  ae-2.4079.rtsw.wash.net.internet2.edu (162.252.70.136) 205.461 ms 205.557 ms
205.680 ms
18  internet2-gw.mx1.lon.uk.geant.net (62.40.124.44) 280.438 ms 280.425 ms
280.670 ms
19  janet-gw.mx1.lon.uk.geant.net (62.40.124.198) 280.919 ms 280.795 ms 280.698
ms
20  ae29.londpg-sbr2.ja.net (146.97.33.2) 281.449 ms 281.037 ms 281.068 ms
21  ae31.erdiss-sbr2.ja.net (146.97.33.22) 284.913 ms 285.137 ms 284.906 ms
22  ae29.manckh-sbr2.ja.net (146.97.33.42) 286.665 ms 286.715 ms 286.641 ms
23  ae24.lanclu-rbr1.ja.net (146.97.38.58) 289.066 ms 289.204 ms 289.061 ms
24  lancaster-university.ja.net (194.81.46.2) 307.719 ms 307.120 ms 300.330 ms
25  isbfw01-isborder01.rtr.lancs.ac.uk (148.88.253.198) 289.303 ms 289.469 ms *
26  ismx-issrx.rtr.lancs.ac.uk (148.88.255.17) 293.785 ms 290.758 ms 291.006 ms
27  dc.iss.srv.rtrcloud.lancs.ac.uk (148.88.253.3) 312.759 ms 310.652 ms
310.524 ms
28  www.lancs.ac.uk (148.88.65.80) 290.909 ms !X 290.703 ms !X 290.946 ms !X

```

3.

`www.speedtest.com.sg` has IP address `202.150.221.170`, `www.telstra.net` has IP address `203.50.5.178`.

No, the reverse path doesn't go through the same route. It might because the routes go through the same ISP, but it's not necessary to go through the same router. Hence, the IP addresses for forward and reverse routes are similar but not the same.

traceroute to speedtest:

```

traceroute to www.speedtest.com.sg (202.150.221.170), 30 hops max, 60 byte packets
 1  cserouter1-trusted.cse.unsw.EDU.AU (129.94.208.251) 0.233 ms 0.193 ms 0.169
ms
 2  129.94.39.17 (129.94.39.17) 1.218 ms 1.127 ms 1.173 ms
 3  ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35) 1.798 ms libudnex1-vl-
3154.gw.unsw.edu.au (149.171.253.34) 1.570 ms ombudnex1-vl-3154.gw.unsw.edu.au
(149.171.253.35) 1.752 ms
 4  libcr1-po-5.gw.unsw.edu.au (149.171.255.165) 1.337 ms libcr1-po-
6.gw.unsw.edu.au (149.171.255.201) 1.237 ms 1.340 ms
 5  unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105) 1.417 ms unswbr1-te-1-
9.gw.unsw.edu.au (149.171.255.101) 1.401 ms 1.474 ms
 6  138.44.5.0 (138.44.5.0) 1.641 ms 1.581 ms 1.530 ms

```



```

7  et-0-3-0.pe1.alxd.nsw.aarnet.net.au (113.197.15.153)  1.829 ms  1.928 ms
1.905 ms
8  xe-0-0-3.pe1.wnpa.akl.aarnet.net.au (113.197.15.67)  24.588 ms  24.634 ms xe-
0-2-1-204.pe1.wnpa.alxd.aarnet.net.au (113.197.15.183)  24.617 ms
9  et-0-1-0.200.pe1.tkpa.akl.aarnet.net.au (113.197.15.69)  24.761 ms  24.805 ms
24.772 ms
10 xe-0-2-6.bdr1.a.lax.aarnet.net.au (202.158.194.173)  148.387 ms  148.386 ms
148.360 ms
11 singtel.as7473.any2ix.coresite.com (206.72.210.63)  170.484 ms  170.499 ms
170.466 ms
12 203.208.178.185 (203.208.178.185)  332.284 ms 203.208.172.173
(203.208.172.173)  148.423 ms  148.369 ms
13 203.208.153.121 (203.208.153.121)  310.093 ms 203.208.173.73 (203.208.173.73)
337.156 ms 203.208.177.110 (203.208.177.110)  237.028 ms
14 203.208.182.45 (203.208.182.45)  308.363 ms 308.109 ms 310.329 ms
15 203.208.177.110 (203.208.177.110)  224.735 ms 202-150-221-170.rev.ne.com.sg
(202.150.221.170)  224.978 ms 203.208.177.110 (203.208.177.110)  240.213 ms

```

traceroute from speedtest:

```

traceroute to 129.94.209.30 (129.94.209.30), 30 hops max, 60 byte packets
1  ge2-8.r01.sin01.ne.com.sg (202.150.221.169)  0.195 ms  0.212 ms  0.222 ms
2  10.11.33.30 (10.11.33.30)  0.264 ms  0.274 ms  0.282 ms
3  10.11.33.74 (10.11.33.74)  0.745 ms  0.757 ms  0.762 ms
4  aarnet.sgix.sg (103.16.102.67)  225.569 ms  225.639 ms  225.653 ms
5  xe-3-0-3.pe1.brwy.nsw.aarnet.net.au (113.197.15.206)  232.832 ms  232.847 ms
232.912 ms
6  138.44.5.1 (138.44.5.1)  225.837 ms  225.935 ms  226.023 ms
7  libcr1-te-1-5.gw.unsw.edu.au (149.171.255.102)  225.983 ms  226.061 ms
226.082 ms
8  ombudnex1-po-1.gw.unsw.edu.au (149.171.255.202)  236.181 ms libudnex1-po-
1.gw.unsw.edu.au (149.171.255.166)  224.035 ms ombudnex1-po-1.gw.unsw.edu.au
(149.171.255.202)  236.084 ms
9  ufw1-ae-1-3154.gw.unsw.edu.au (149.171.253.36)  236.452 ms  236.447 ms
236.421 ms
10 129.94.39.23 (129.94.39.23)  224.832 ms  224.691 ms  224.786 ms
11 * * *
12 * * *
13 * * *
14 * * *
15 * * *
16 * * *
17 * * *
18 * * *
19 * * *
20 * * *
21 * * *
22 * * *
23 * * *
24 * * *
25 * * *
26 * * *
27 * * *
28 * * *
29 * * *
30 * * *

```

traceroute to telstra:

```
traceroute to www.telstra.net (203.50.5.178), 30 hops max, 60 byte packets
 1 cserouter1-trusted.cse.unsw.EDU.AU (129.94.208.251) 0.119 ms 0.101 ms 0.161 ms
 2 129.94.39.17 (129.94.39.17) 1.003 ms 1.110 ms 0.969 ms
 3 ombudnex1-v1-3154.gw.unsw.edu.au (149.171.253.35) 1.775 ms libudnex1-v1-3154.gw.unsw.edu.au (149.171.253.34) 1.973 ms 2.022 ms
 4 ombcr1-po-6.gw.unsw.edu.au (149.171.255.169) 1.364 ms 1.342 ms 1.355 ms
 5 unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101) 1.303 ms unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105) 1.301 ms unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101) 1.281 ms
 6 138.44.5.0 (138.44.5.0) 1.457 ms 1.421 ms 1.402 ms
 7 et-0-3-0.pe1.alxd.nsw.aarnet.net.au (113.197.15.153) 4.912 ms 3.634 ms 3.612 ms
 8 ae9.bb1.b.syd.aarnet.net.au (113.197.15.65) 2.028 ms 1.984 ms 1.988 ms
 9 gigabitethernet1-1.pe1.b.syd.aarnet.net.au (202.158.202.18) 1.973 ms 2.035 ms 1.954 ms
10 gigabitethernet3-11.ken37.sydney.telstra.net (139.130.0.77) 2.594 ms 2.696 ms 2.782 ms
11 bundle-ether2.chw-edge901.sydney.telstra.net (203.50.11.103) 2.898 ms bundle-ether13.ken-core10.sydney.telstra.net (203.50.11.94) 3.506 ms 3.977 ms
12 bundle-ether13.chw-core10.sydney.telstra.net (203.50.11.98) 3.446 ms bundle-ether10.win-core10.melbourne.telstra.net (203.50.11.123) 15.277 ms bundle-ether13.chw-core10.sydney.telstra.net (203.50.11.98) 2.812 ms
13 bundle-ether8.exi-core10.melbourne.telstra.net (203.50.11.125) 17.291 ms 17.245 ms 203.50.6.40 (203.50.6.40) 16.293 ms
14 bundle-ether2.exi-ncprouter101.melbourne.telstra.net (203.50.11.209) 14.485 ms 14.578 ms 13.830 ms
15 www.telstra.net (203.50.5.178) 14.239 ms 15.108 ms 15.101 ms
```

traceroute from telstra:

```
 1 gigabitethernet3-3.exi2.melbourne.telstra.net (203.50.77.53) 0.271 ms 0.216 ms 0.243 ms
 2 bundle-ether3-100.win-core10.melbourne.telstra.net (203.50.80.129) 2.866 ms 1.486 ms 2.118 ms
 3 bundle-ether12.ken-core10.sydney.telstra.net (203.50.11.122) 13.112 ms 11.980 ms 12.861 ms
 4 bundle-ether1.ken-edge901.sydney.telstra.net (203.50.11.95) 11.862 ms 11.856 ms 11.986 ms
 5 aarnet6.lnk.telstra.net (139.130.0.78) 11.612 ms 11.606 ms 11.612 ms
 6 ge-6-0-0.bb1.a.syd.aarnet.net.au (202.158.202.17) 11.863 ms 12.105 ms 11.736 ms
 7 ae9.pe2.brwy.nsw.aarnet.net.au (113.197.15.56) 12.861 ms 12.107 ms 11.986 ms
 8 et-3-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.146) 12.113 ms 12.106 ms 12.111 ms
 9 138.44.5.1 (138.44.5.1) 12.362 ms 12.356 ms 12.237 ms
10 libcr1-te-1-5.gw.unsw.edu.au (149.171.255.102) 12.362 ms 12.356 ms 12.362 ms
11 libudnex1-po-1.gw.unsw.edu.au (149.171.255.166) 12.612 ms
12 ufw1-ae-1-3154.gw.unsw.edu.au (149.171.253.36) 13.106 ms 13.105 ms 13.005 ms
13 129.94.39.23 (129.94.39.23) 13.208 ms 13.226 ms 13.236 ms
```

Exercise 4:

*Notes: all graphs and ping results are in *result.tar*.

1.

Physical distance from UNSW:

- to UQ: 743.01 km (456.09 mi)
- to NUS: 6603.49 km (4103.22 mi)
- to TUB: 16104.74 km (1007.02 mi)

Shortest possible time T from UNSW:

- to UQ: 2.4767 ms
- to NUS: 22.011633 ms
- to TUB: 53.682467 ms

Possible reasons for greater than 2:

1. We assume that the packet moves at the speed of light, but in reality, the propagation speed is impossible to reach the speed of light. Hence, the delay will be greater.
2. Only propagation delay is counting for T, but actually there are also processing delay, queueing delay and transmission delay, so the minimum delay is greater than assumption.
3. The shortest distance measured using google map is straight-line distance, but in reality, the path that packets go through is not straight line, which means it takes longer for propagation, hence the delay is greater.

2.

The delay varies over time, because except for propagation delay, there are also: processing delay and transmission delay, which depends on the specific router; and queueing delay, which depends on the load of the router. Hence, the total delay varies over time.

3.

The one mainly depends on packet size is transmission delay as it is calculated from $\text{packet size} / \text{bandwidth}$. Queueing delay mainly depends on the load but it is relevant to packet size because it is calculated from $\text{packets size} * \text{packets arrival rate} / \text{bandwidth}$.

Processing delay and propagation delay don't depend on packet size since processing delay depends on content complexity (as it has to scan and check error) and propagation delay depends on physical distance.