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zID: 5168080

Exercise 1:

1.

```
Server:             129.94.242.2
Address:     129.94.242.2#53

Non-authoritative answer:
Name:  www.koala.com.au
Address: 172.67.219.46
Name:  www.koala.com.au
Address: 104.18.60.21
Name:  www.koala.com.au
Address: 104.18.61.21
```

- The IP address of the website www.koala.com.au is either `172.67.219.46` or `104.18.60.21` or `104.18.61.21`
- The results why they have multiple IP address are to compensate for a host that's down at that moment, or prevent traffic from being exchanged via the gateway, speeding things up and reducing the load.

2.

```
Server:             129.94.242.2
Address:     129.94.242.2#53

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

- This is the localhost, when we talk about localhost, we are referring to when a server is used on your own computer

Exercise 2: Use ping to test host reachability

- **www.unsw.edu.au** (Reachable by ping command and from Web browser)
```
--- www.unsw.edu.au ping statistics ---
50 packets transmitted, 50 received, 0% packet loss, time 49066ms
rtt min/avg/max/mdev = 24.702/25.749/29.901/1.271 ms
```

- **www.getfittest.com.au** (Unreachable by ping command and from Web browser)
```
weill % ping -c 50 www.getfittest.com.au
ping: unknown host www.getfittest.com.au
```

- **www.mit.edu** (Reachable by ping command and from Web browser)
```
--- e9566.dscb.akamaiedge.net ping statistics ---
50 packets transmitted, 50 received, 0% packet loss, time 49057ms
rtt min/avg/max/mdev = 1.145/1.209/1.326/0.041 ms
```

- **www.intel.com.au** (Reachable by ping command and from Web browser)
```
--- e19235.dsca.akamaiedge.net ping statistics ---
50 packets transmitted, 50 received, 0% packet loss, time 49061ms
rtt min/avg/max/mdev = 1.175/1.270/3.077/0.264 ms
```

- **www.tpg.com.au** (Reachable by ping command and from Web browser)
```
--- www.tpg.com.au ping statistics ---
50 packets transmitted, 50 received, 0% packet loss, time 49077ms
rtt min/avg/max/mdev = 1.489/1.644/3.155/0.235 ms
```

- **www.hola.hp** (Unreachable by ping command and from Web browser)
```
weill % ping -c 50 www.hola.hp
ping: unknown host www.hola.hp
```

- **www.amazon.com** (Reachable by ping command and from Web browser)
```
--- e15316.e22.akamaiedge.net ping statistics ---
50 packets transmitted, 50 received, 0% packet loss, time 49054ms
rtt min/avg/max/mdev = 1.058/1.130/1.377/0.063 ms
```

- **www.tsinghua.edu.cn** (Reachable by ping command and from Web browser)
```
--- www.tsinghua.edu.cn ping statistics ---
50 packets transmitted, 50 received, 0% packet loss, time 49057ms
rtt min/avg/max/mdev = 159.189/159.430/161.121/0.407 ms
```

- **www.kremlin.ru** (Unreachable by ping command and Reachable from Web browser)
```
--- www.kremlin.ru ping statistics ---
50 packets transmitted, 0 received, 100% packet loss, time 49940ms
```

- **8.8.8.8** (Reachable by ping command and from Web browser)

```
--- 8.8.8.8 ping statistics ---
50 packets transmitted, 50 received, 0% packet loss, time 49074ms
rtt min/avg/max/mdev = 1.578/1.838/3.477/0.436 ms
```

- The reason that ping does not work AND the browser cannot reach (like www.getffisttest.com.au and www.hola.hp) is the server might not exist.
- The reason that ping cannot reach BUT the browser can reach (like www.kremlin.ru) is the site's server might no support ICMP protocol.
- The reason that ping can reach BUT the browser cannot reach (like 8.8.8.8) is that server is DNS, not support HTTP access.

Question 3: Use traceroute to understand network topology

1.

```
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)  0.123 ms  0.108 ms  0.123 ms
 2  129.94.39.17 (129.94.39.17)  0.923 ms  0.902 ms  1.200 ms
 3  libudnex1-vl-3154.gw.unsw.edu.au (149.171.253.34)  1.563 ms ombudnex1-vl-3154.gw.unsw.edu.au
(149.171.253.35)  1.682 ms  1.662 ms
 4  ombcr1-po-5.gw.unsw.edu.au (149.171.255.197)  1.161 ms ombcr1-po-6.gw.unsw.edu.au (149.171.255.169)
1.286 ms  1.265 ms
 5  unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  1.158 ms  1.175 ms  1.153 ms
 6  138.44.5.0 (138.44.5.0)  1.588 ms  1.443 ms  1.420 ms
 7  et-1-3-0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.15.149)  2.308 ms  2.452 ms  2.365 ms
 8  et-0-0-0.pe1.a.hnl.aarnet.net.au (113.197.15.99)  95.166 ms  95.268 ms  95.162 ms
 9  et-2-1-0.bdr1.a.sea.aarnet.net.au (113.197.15.201)  146.949 ms  146.935 ms  146.913 ms
10  abilene-1-lo-jmb-706.sttlwa.pacificwave.net (207.231.240.8)  160.681 ms  160.644 ms  160.525 ms
11  ae-1.4079.rtsw.minn.net.internet2.edu (162.252.70.173)  193.530 ms  193.348 ms  193.410 ms
12  ae-1.4079.rtsw.eqch.net.internet2.edu (162.252.70.106)  200.865 ms  204.215 ms  203.585 ms
13  ae-0.4079.rtsw3.eqch.net.internet2.edu (162.252.70.163)  248.402 ms  201.182 ms  201.574 ms
14  ae-1.4079.rtsw.clev.net.internet2.edu (162.252.70.130)  209.319 ms  209.875 ms  209.179 ms
15  buf-9208-I2-CLEV.nysernet.net (199.109.11.33)  214.258 ms  214.051 ms  214.008 ms
16  syr-9208-buf-9208.nysernet.net (199.109.7.193)  216.457 ms  216.463 ms  216.464 ms
17  nyc111-9204-syr-9208.nysernet.net (199.109.7.94)  225.742 ms  225.871 ms  225.890 ms
18  nyc-9208-nyc111-9204.nysernet.net (199.109.7.165)  226.665 ms  226.741 ms  226.505 ms
19  columbia.nyc-9208.nysernet.net (199.109.4.14)  226.351 ms  226.470 ms  226.522 ms
20  cc-core-1-x-nyser32-gw-1.net.columbia.edu (128.59.255.5)  226.004 ms  226.028 ms  226.019 ms
21  cc-conc-1-x-cc-core-1.net.columbia.edu (128.59.255.21)  226.913 ms  226.766 ms  226.846 ms
22  www-ltm.cc.columbia.edu (128.59.105.24)  226.889 ms  226.573 ms  226.921 ms
```

- There are 22 routers from workstation and www.columbia.edu.
- There are 5 routers along the path part of the UNSW network.
- Between 7 and 8 the packets cross the Pacific Ocean by looking the difference of round trip times of router number 7 and 8.

2.

```
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)  0.182 ms  0.161 ms  0.167 ms
 2  129.94.39.17 (129.94.39.17)  0.961 ms  1.149 ms  0.929 ms
 3  ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  4.770 ms  4.760 ms  4.868 ms
 4  ombcr1-po-6.gw.unsw.edu.au (149.171.255.169)  6.519 ms libcr1-po-5.gw.unsw.edu.au (149.171.255.165)
1.152 ms libcr1-po-6.gw.unsw.edu.au (149.171.255.201)  1.193 ms
 5  unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  14.064 ms unswbr1-te-2-13.gw.unsw.edu.au
(149.171.255.105)  13.965 ms  14.029 ms
 6  138.44.5.0 (138.44.5.0)  1.332 ms  1.444 ms  1.317 ms
 7  et-1-3-0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.15.149)  2.100 ms  2.191 ms  2.155 ms
 8  et-0-0-0.pe1.a.hnl.aarnet.net.au (113.197.15.99)  96.059 ms  96.048 ms  96.030 ms
 9  et-2-1-0.bdr1.a.sea.aarnet.net.au (113.197.15.201)  146.980 ms  147.109 ms  147.024 ms
10  cenichpr-1-is-jmb-778.snvaca.pacificwave.net (207.231.245.129)  164.303 ms  164.864 ms  165.824 ms
11  hpr-lax-hpr3--svl-hpr3-100ge.cenic.net (137.164.25.73)  160.394 ms  160.743 ms  161.046 ms
12  * * *
13  bd11f1.anderson--cr001.anderson.ucla.net (169.232.4.6)  160.542 ms  161.103 ms bd11f1.anderson--
cr00f2.csb1.ucla.net (169.232.4.4)  161.086 ms
14  cr00f2.csb1--rtr11f4.mathsci.ucla.net (169.232.8.181)  162.030 ms  161.297 ms  161.184 ms
15  * * *
16  * * *
```

```
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)  0.189 ms  0.171 ms  0.150 ms
 2  129.94.39.17 (129.94.39.17)  0.914 ms  0.917 ms  1.060 ms
 3  ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  1.850 ms  1.710 ms libudnex1-vl-3154.gw.unsw.edu.au
(149.171.253.34)  5.500 ms
 4  libcr1-po-5.gw.unsw.edu.au (149.171.255.165)  1.412 ms ombcr1-po-6.gw.unsw.edu.au (149.171.255.169)
1.476 ms ombcr1-po-5.gw.unsw.edu.au (149.171.255.197)  1.361 ms
 5  unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.344 ms unswbr1-te-1-9.gw.unsw.edu.au
(149.171.255.101)  1.363 ms unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.390 ms
 6  138.44.5.0 (138.44.5.0)  1.523 ms  1.655 ms  1.702 ms
 7  et-0-3-0.pe1.bkvl.nsw.aarnet.net.au (113.197.15.147)  1.766 ms  1.966 ms  1.739 ms
 8  ge-4_0_0.bb1.a.pao.aarnet.net.au (202.158.194.177)  155.779 ms  155.741 ms  155.717 ms
 9  paloalto0.iij.net (198.32.176.24)  156.570 ms  157.692 ms  156.761 ms
10  osk004bb00.IIJ.Net (58.138.88.185)  287.486 ms osk004bb01.IIJ.Net (58.138.88.189)  270.428 ms  270.394
ms
11  osk004ip57.IIJ.Net (58.138.106.166)  278.849 ms osk004ip57.IIJ.Net (58.138.106.162)  287.452 ms
osk004ip57.IIJ.Net (58.138.106.166)  278.317 ms
12  210.130.135.130 (210.130.135.130)  287.403 ms  287.913 ms  287.804 ms
13  124.83.228.58 (124.83.228.58)  269.450 ms  279.119 ms  269.361 ms
14  124.83.252.178 (124.83.252.178)  284.168 ms  285.063 ms  275.792 ms
15  158.205.134.26 (158.205.134.26)  293.658 ms  285.123 ms  293.821 ms
16  158.205.121.46 (158.205.121.46)  278.774 ms  276.723 ms  276.778 ms
17  * * *
18  * * *
```

```
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)  0.160 ms  0.135 ms  0.130 ms
 2  129.94.39.17 (129.94.39.17)  0.923 ms  0.900 ms  0.873 ms
 3  libudnex1-vl-3154.gw.unsw.edu.au (149.171.253.34)  5.392 ms  5.355 ms ombudnex1-vl-3154.gw.unsw.edu.au
(149.171.253.35)  1.400 ms
 4  libcr1-po-5.gw.unsw.edu.au (149.171.255.165)  1.209 ms  1.214 ms libcr1-po-6.gw.unsw.edu.au
(149.171.255.201)  1.325 ms
 5  unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  124.640 ms  124.628 ms  124.565 ms
 6  138.44.5.0 (138.44.5.0)  1.368 ms  1.310 ms  1.316 ms
 7  et-1-1-0.pe1.rsby.nsw.aarnet.net.au (113.197.15.12)  1.673 ms  1.715 ms  1.764 ms
 8  xe-1-1-0.pe1.eskp.nsw.aarnet.net.au (113.197.15.199)  3.322 ms  3.308 ms  3.383 ms
 9  et-0-3-0.pe1.prka.sa.aarnet.net.au (113.197.15.42)  20.819 ms  20.882 ms  20.864 ms
10  et-0-3-0.pe1.knsg.wa.aarnet.net.au (113.197.15.45)  46.996 ms  47.019 ms  47.256 ms
11  et-2-1-2.bdr2.sing.sin.aarnet.net.au (113.197.15.247)  92.065 ms  92.006 ms  92.086 ms
12  ae1.bdr1.sing.sin.aarnet.net.au (113.197.15.234)  91.827 ms  91.753 ms  91.815 ms
13  138.44.226.7 (138.44.226.7)  255.067 ms  255.262 ms  255.163 ms
14  janet-gw.mx1.lon.uk.geant.net (62.40.124.198)  255.518 ms  255.525 ms  255.463 ms
15  ae29.londpg-sbr2.ja.net (146.97.33.2)  256.101 ms  255.967 ms  255.949 ms
16  ae31.erdiss-sbr2.ja.net (146.97.33.22)  259.468 ms  259.413 ms  259.398 ms
17  ae29.manckh-sbr2.ja.net (146.97.33.42)  261.515 ms  261.523 ms  261.597 ms
18  ae24.lanclu-rbr1.ja.net (146.97.38.58)  263.548 ms  263.671 ms  263.669 ms
19  lancaster-university.ja.net (194.81.46.2)  289.375 ms  288.973 ms  284.731 ms
20  is-border01.bfw01.rtr.lancs.ac.uk (148.88.253.202)  264.086 ms  264.046 ms  264.020 ms
21  bfw01.iss-servers.is-core01.rtr.lancs.ac.uk (148.88.250.98)  269.865 ms  266.618 ms  266.941 ms
22  * * *
23  www.lancs.ac.uk (148.88.65.80)  264.076 ms !X  264.073 ms !X  264.170 ms !X
```

- We can see that at IP address start with 113.196.15.* the paths from my machine to these destinations diverge. (They basically are in the same router but different interfaces).
- Using whois 113.196.15.99, we can see the router belong to AARNet Network Operation Center.
- From the information above, we have:
    - UCLA: 14 hops ~ 7499 miles
    - U-TOKYO: 16 hops ~ 4908 miles
    - LANCASTER: 23 hops ~ 10569.8 miles

    From the above data, the number of hoops on each path is not proportional the physical distance. Cause U-TOKYO has shorter path than UCLA, but the number of hops are greater than UCLA.

3.

- **Trace from www.speedtest.com.sg to home** (8 hops)

Traceroute Result:

```
traceroute to 129.94.8.213 (129.94.8.213), 30 hops max, 60 byte packets
1  ge2-8.r01.sin01.ne.com.sg (202.150.221.169)  0.180 ms  0.192 ms  0.200 ms
2  10.11.34.146 (10.11.34.146)  0.465 ms  0.697 ms  0.767 ms
3  aarnet.sgix.sg (103.16.102.67)  207.536 ms  207.544 ms  207.654 ms
4  et-5-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.5)  234.644 ms  234.671 ms  234.689 ms
5  138.44.5.1 (138.44.5.1)  203.845 ms  204.092 ms  204.146 ms
6  ombcr1-te-1-5.gw.unsw.edu.au (149.171.255.106)  207.897 ms  207.766 ms  207.804 ms
7  libwdr1-te-1-2.gw.unsw.edu.au (149.171.255.78)  203.788 ms  204.127 ms  204.067 ms
8  cfw1-ae-1-3090.gw.unsw.edu.au (149.171.253.68)  201.800 ms  201.848 ms  201.883 ms
9  * * *
```

- **Trace from home to www.speedtest.com.sg** (13 hops)

```
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)  0.124 ms  0.138 ms  0.114 ms
 2  129.94.39.17 (129.94.39.17)  0.927 ms  0.897 ms  0.822 ms
 3  libudnex1-vl-3154.gw.unsw.edu.au (149.171.253.34)  1.726 ms  1.741 ms  1.714 ms
 4  libcr1-po-6.gw.unsw.edu.au (149.171.255.201)  1.181 ms  1.190 ms  1.248 ms
 5  unswbr1-te-1-9.gw.unsw.edu.au (149.171.255.101)  1.242 ms  1.223 ms  1.215 ms
 6  138.44.5.0 (138.44.5.0)  1.322 ms  1.308 ms  1.324 ms
 7  et-0-3-0.pe1.alxd.nsw.aarnet.net.au (113.197.15.153)  1.775 ms  1.922 ms  1.833 ms
 8  xe-0-2-7.bdr1.a.lax.aarnet.net.au (202.158.194.173)  147.669 ms  147.662 ms  147.622 ms
 9  singtel.as7473.any2ix.coresite.com (206.72.210.63)  147.951 ms  147.921 ms  147.853 ms
10  203.208.171.117 (203.208.171.117)  148.025 ms  148.065 ms  148.104 ms
11  203.208.166.213 (203.208.166.213)  240.954 ms 203.208.177.110 (203.208.177.110)  324.288 ms
203.208.166.213 (203.208.166.213)  240.922 ms
12  203.208.183.250 (203.208.183.250)  240.570 ms  237.465 ms 203.208.182.253 (203.208.182.253)  327.917 ms
13  202-150-221-170.rev.ne.com.sg (202.150.221.170)  213.411 ms * *
```

- **Trace from www.telstra.net to home** (10 hops)

```
 1  gigabitethernet3-3.exi2.melbourne.telstra.net (203.50.77.53)  0.437 ms  0.327 ms  0.242 ms
 2  bundle-ether3-100.win-core10.melbourne.telstra.net (203.50.80.129)  2.614 ms  1.601 ms  2.119 ms
 3  bundle-ether12.ken-core10.sydney.telstra.net (203.50.11.122)  13.731 ms  12.222 ms  12.861 ms
 4  bundle-ether1.ken-edge903.sydney.telstra.net (203.50.11.173)  12.110 ms  11.974 ms  11.985 ms
 5  aar3533567.lnk.telstra.net (139.130.0.78)  11.611 ms  11.598 ms  11.609 ms
 6  et-7-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.13)  11.857 ms  11.848 ms  11.862 ms
 7  138.44.5.1 (138.44.5.1)  19.603 ms  11.974 ms  11.985 ms
 8  libcr1-te-1-5.gw.unsw.edu.au (149.171.255.102)  45.591 ms  12.096 ms  11.984 ms
 9  ombwdr1-te-1-1.gw.unsw.edu.au (149.171.255.94)  11.986 ms  12.099 ms
10  cfw1-ae-1-3090.gw.unsw.edu.au (149.171.253.68)  12.715 ms  12.727 ms  12.607 ms
```

- **Trace from home to www.telstra.net** (14 hops)

```
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)  0.110 ms  0.116 ms  0.094 ms
 2  129.94.39.17 (129.94.39.17)  0.838 ms  0.955 ms  0.808 ms
 3  ombudnex1-vl-3154.gw.unsw.edu.au (149.171.253.35)  3.113 ms  2.955 ms  3.079 ms
 4  libcr1-po-6.gw.unsw.edu.au (149.171.255.201)  1.103 ms ombcr1-po-6.gw.unsw.edu.au (149.171.255.169)
1.159 ms  1.178 ms
 5  unswbr1-te-2-13.gw.unsw.edu.au (149.171.255.105)  1.157 ms unswbr1-te-1-9.gw.unsw.edu.au
(149.171.255.101)  1.174 ms  1.184 ms
 6  138.44.5.0 (138.44.5.0)  1.362 ms  1.400 ms  1.387 ms
 7  et-1-1-0.pe1.rsby.nsw.aarnet.net.au (113.197.15.12)  1.985 ms  1.912 ms  1.968 ms
 8  xe-0-0-3.bdr1.rsby.nsw.aarnet.net.au (113.197.15.31)  1.479 ms  1.439 ms  1.465 ms
 9  HundredGigE0-1-0-4.ken-edge903.sydney.telstra.net (139.130.0.77)  2.116 ms  2.288 ms  2.264 ms
10  bundle-ether2.chw-edge903.sydney.telstra.net (203.50.11.175)  2.347 ms  2.541 ms  2.580 ms
11  bundle-ether10.win-core10.melbourne.telstra.net (203.50.11.123)  14.376 ms  14.049 ms  13.819 ms
12  bundle-ether8.exi-core10.melbourne.telstra.net (203.50.11.125)  14.033 ms 203.50.6.40 (203.50.6.40)
14.465 ms bundle-ether8.exi-core10.melbourne.telstra.net (203.50.11.125)  13.954 ms
13  bundle-ether2.exi-ncprouter101.melbourne.telstra.net (203.50.11.209)  14.274 ms  15.008 ms  14.296 ms
14  www.telstra.net (203.50.5.178)  12.901 ms  13.715 ms  12.602 ms
```

- We can see that the routes from forward and backward are not the same. Because there are multiple routes from a source to destination and each router can use different interfaces which lead to different IP address.

Exercise 4: Use ping to gain insights into network performance

- Assume the speed of light is $3 * 10^8\ m/s$.
- Shortest times:
  - University of Queensland:

$$T = \frac{892\ km}{speed\ of\ light} = 2.9733\ ms \text{ and } Ratio = \frac{16.962}{2.9733} = 5.70$$

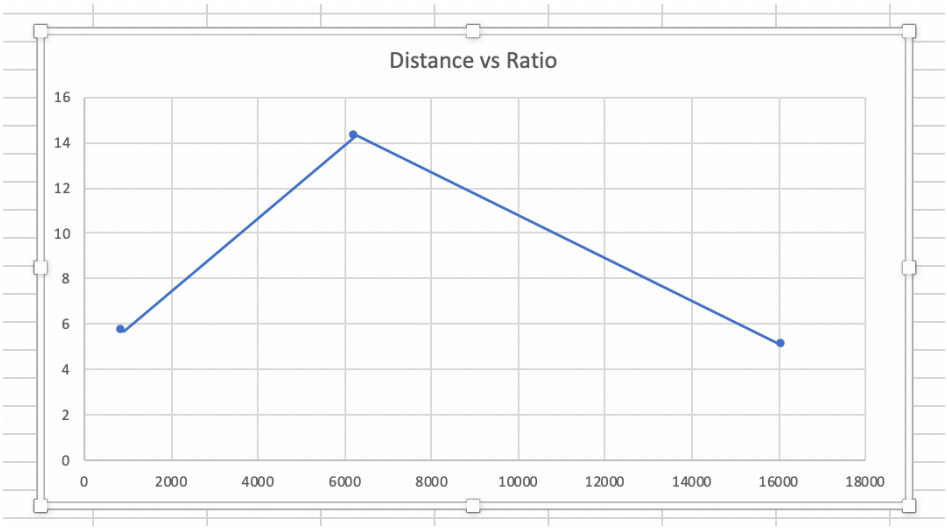
  - De La Salle university:

$$T = \frac{6266\ km}{speed\ of\ light} = 20.886\ ms \text{ and } Ratio = \frac{298.549}{20.886} = 14.29$$

  - Technical University of Berlin:

$$T = \frac{16095}{speed\ of\ light} = 53.65\ ms \text{ and } Ration = \frac{273.444}{53.65} = 5.09$$

- Graph:



- The y-axis values are greater than 2 is because the packet can be delayed by queueing + transition delay + propagation speed along the links, also the time is calculated from the source to the destination and from the destination back to the source. So, in the ideal case (no delay) the ratio would be 2. In the real world, the ratio always greater than 2.
- The delay to the destinations varies over time due to the use of packet switching, in which the resources are allocated dynamically to avoid overloading.
- Using traceroute to get the IP address of the website www.eth.ch and then use the link http://www.yougetsignal.com/tools/network-location/ to get where the server is located at Zurich (a city of Switzerland).
- Transmission delay depends on the size of the packet as it is calculated by $\frac{size\ of\ the\ packet}{the\ link\ bandwidth}$
- Propagation delay depends on the length of the link, the material of the link. So it does not depend of the size of the packet.
- Processing delay is just checking the error, it depends of the amount of errors.
- Queuing delay depends of the traffic at the routers.