Resources / Lab Exercises (/COMP3331/21T1/resources/57481) / Lab Exercise 1: Solutions

Lab Exercise 1: Solutions

Exercise 1: nslookup (Not Marked)

Question 1.

```
$ nslookup www.koala.com.au Server: 129.94.242.2 Address: 129.94.242.2#53 Non-authoritative ans
```

Websites may be replicated on multiple servers, with each server running on a different end system, and each having a different IP address. For replicated Web servers, a set of IP addresses is thus associated with one canonical hostname. This allows for load balancing: the DNS server replies to the DNS requests with one of the listed IPs and the client thus connects to one of them, but not always the same, so the load isn't concentrated always on the same server.

Question 2.

```
$ nslookup 127.0.0.1 Server: 129.94.242.2 Address: 129.94.242.2#53 1.0.0.127.in-addr.arpa name
```

127.0.0.1 is the loopback address, also know as "localhost". The localhost refers to the internal interface used by the machine to send a packet to itself. It is non-routable IP address and refers to any computer that you happen to be sitting in front of now. When it sees "localhost", TCP/IP doesn't try to send information on the network, it sends it locally. localhost is often used for testing purpose.

Exercise 2: Use ping to test host reachability (2 marks)

The following hosts were reachable (at least when I tested with ping, your results may be different): www.unsw.edu.au (http://www.unsw.edu.au/) , www.mit.edu (http://www.mit.edu/) , www.intel.com.au (http://www.intel.com.au/) , www.tpg.com.au (http://www.tpg.com.au/) , www.tsinghua.edu.cn (http://www.tsinghua.edu.cn/) , www.amazon.com (http://www.amazon.com/) and 8.8.8.8

www.hola.hp (http://www.hola.hp/) and www.getfittest.com.au (http://www.getfittest.com.au/) does not exist.

www.kremlin.ru (http://www.kremlin.ru/) was not reachable. This is because some organisations disable their network from replying to ICMP echo request packets which are used by ping. This is an often used security measure.

Note: You may try this from a different network (e.g. your home network) and check if you observe different behaviour.

Exercise 3: Use traceroute to understand network topology (4 marks)

Note: Your answers may vary from the provided solutions.

Question 1.

Here is the output of traceroute:

```
traceroute www.columbia.edu traceroute to www.columbia.edu (128.59.105.24), 30 hops max, 60 byt
```

The output shows that there are 20 routers (21 hops, in last hop we have reached the webserver) between my machine and the columbia web server.

The first five routers appear to be part of the UNSW networks based on their hostnames. A reverse DNS query on the 6th hop router (138.44.5.0) reveals the following

```
dig -x 138.44.5.0 ; <<>> DiG 9.7.3 <<>> -x 138.44.5.0 ;; global options: +cmd ;; Got answer: ;;
```

This suggests that this router is part of the AARNET domain. Hence, the answer to the question would be the first 5 routers are part of the UNSW network.

There is a big difference in the RTTs to the following routers at hop 7-8 and 8-9.

```
7 et-1-3-0.pe1.sxt.bkvl.nsw.aarnet.net.au (113.197.15.149) 2.251 ms 2.249 ms 2.520 ms 8 et-0-0-
```

This suggests that this is where the path crosses the Pacific Ocean. It is interesting to note that the 8th and 9th hop routers are still part of the AARNET network. However, examining the AARNET topology map (https://www.aarnet.edu.au/images/uploads/resources/AARNet_International_Map_-_June_2015.pdf) suggests that these are very likely part of the AARNET PoP (Point of Presence) that are physically located in Honolulu and Seattle (note hostnames have 'hnl' and 'sea'). The 10th hop router (207.231.240.8) is part of the pacificwave network (AARNET equivalent in the US Pacific West) and seems to be located also in Seattle.

Note that the path your trace route takes may vary, but you should be able to identify all relevant routers along the path.

Question 2.

Here are the outputs for the 3 destinations (omitting the non-responsive routers):

www.ucla.edu (http://www.ucla.edu/) :

```
$ traceroute www.ucla.edu traceroute to www.ucla.edu (164.67.228.152), 30 hops max, 40 byte pac
```

www.u-tokyo.ac.jp (http://www.u-tokyo.ac.jp/) :

```
$ traceroute www.u-tokyo.ac.jp traceroute to www.u-tokyo.ac.jp (210.152.135.178), 30 hops max,
```

www.lancaster.ac.uk (http://www.lancaster.ac.uk/) :

```
$ traceroute www.lancaster.ac.uk traceroute to www.lancaster.ac.uk (148.88.2.80), 30 hops max,
```

The first 7 hops are identical on all 3 paths. The 3 paths differ in the next hop following the 138.44.5.0 router. Notice that the Tokyo and Lancaster paths also have a common 8th hop router (113.197.15.12). For all 3 paths, this 8th router belongs to the AARNET network.

No, the number of hops is clearly not proportional to the physical distance. The path to Tokyo (which is closer to Sydney as compared to LA) takes about 21 hops while that to Los Angeles is only 15 hops.

Question 3.

IP address of my machine: 129.94.8.24, IP address of www.telstra.net (http://www.telstra.net/) : 203.50.5.178

Traceroute from Telstra to my machine:

```
 1  gigabitethernet3-3.exi2.melbourne.telstra.net (203.50.77.53)  0.398 ms  0.330 ms  0.241 ms
 2  bundle-ether3-100.win-core10.melbourne.telstra.net (203.50.80.129)  0.989 ms  1.605 ms  1.989 ms
 3  bundle-ether12.ken-core10.sydney.telstra.net (203.50.11.122)  12.735 ms  11.972 ms  12.736 ms
 4  bundle-ether1.ken-edge901.sydney.telstra.net (203.50.11.95)  11.861 ms  11.973 ms  11.863 ms
 5  aarnet6.lnk.telstra.net (139.130.0.78)  11.610 ms  11.598 ms  11.613 ms
 6  ge-6-0-0.bb1.a.syd.aarnet.net.au (202.158.202.17)  11.858 ms  11.847 ms  11.735 ms
 7  ae9.pe2.brwy.nsw.aarnet.net.au (113.197.15.56)  11.862 ms  11.724 ms  11.735 ms
 8  ae5.pe1.brwy.nsw.aarnet.net.au (113.197.15.54)  12.485 ms  11.848 ms  11.861 ms
 9  138.44.5.1 (138.44.5.1)  12.112 ms  12.100 ms  12.112 ms
10  libcr1-te-1-1.gw.unsw.edu.au (149.171.255.102)  24.729 ms  12.097 ms  12.109 ms
11  ombudnex1-po-1.gw.unsw.edu.au (149.171.255.202)  12.487 ms  12.473 ms  12.360 ms
12  ufw1-ae-1-3154.gw.unsw.edu.au (149.171.253.36)  12.359 ms  12.350 ms  12.361 ms
13  129.94.39.21 (129.94.39.21)  12.611 ms  12.475 ms  12.486 ms
```

Traceroute from my machine to Telstra:

```
1 vlan385.gaszr1.gw.unsw.EDU.AU (129.94.242.1) 1.012 ms 1.155 ms 1.373 ms 2 129.94.6.122 (129.9
```

First observe that the 6th hop router is different for each of the 3 ping packets. This behaviour is not uncommon as packets on the Internet are routed independently of each other.

A general rule of thumb is that routes on the Internet do not need to be symmetric. For example, an administrative entity may choose to employ separate routers to handle ingoing and outgoing connections, to achieve better load balancing. Nevertheless, even when both the forward and the reverse path cross the same router, it is possible that different IP addresses are observed. For example, both paths cross a router named ae9.bb1.a.syd.aarnet.net.au; however, we observe different IP address in the two paths (Telstra to my machine: 113.197.15.56, my machine to Telstra: 113.197.15.57). The reason behind this is that the names we see 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. A similar conclusion can be made for the IP address 138.44.5.1 (Telstra to my machine) and 138.44.5.0 (my machine to Telstra). It is likely that this is the router that connects UNSW to the AARNET network.

IP address of my machine: 129.94.8.24, IP address of www.speedtest.com.sg (http://www.speedtest.com.sg/) : 202.150.221.170

traceroute from speedtest.com.sg to my machine:

```
traceroute to 129.94.8.24 (129.94.8.24), 30 hops max, 60 byte packets
 1  ge2-8.r01.sin01.ne.com.sg (202.150.221.169)  0.263 ms  0.286 ms  0.263 ms
 2  10.11.34.14 (10.11.34.14)  3.736 ms  3.833 ms  3.941 ms
 3  sin-a-bb1.aarnet.net.au (103.16.102.67)  222.836 ms  222.848 ms  223.041 ms
 4  so-6-0-0.bb1.b.per.aarnet.net.au (202.158.194.145)  221.180 ms  221.184 ms  221.182 ms
 5  xe-0-0-0.pe1.knsg.wa.aarnet.net.au (113.197.15.252)  208.598 ms  208.611 ms  208.677 ms
 6  et-1-3-0.pe1.prka.sa.aarnet.net.au (113.197.15.44)  218.336 ms  217.567 ms et-0-1-0.pe1.eper.wa.aarnet.net.au (113.197
 7  et-1-3-0.pe1.adel.sa.aarnet.net.au (113.197.15.40)  217.043 ms  215.371 ms  215.354 ms
 8  et-7-3-0.pe1.wmlb.vic.aarnet.net.au (113.197.15.28)  215.955 ms  213.315 ms  213.213 ms
 9  et-1-3-0.pe1.mcqp.nsw.aarnet.net.au (113.197.15.8)  213.203 ms  213.832 ms  213.560 ms
10  et-5-1-0.pe1.brwy.nsw.aarnet.net.au (113.197.15.5)  219.023 ms  219.006 ms  218.566 ms
11  138.44.5.1 (138.44.5.1)  215.685 ms  215.311 ms  215.312 ms
12  libcr1-te-1-1.gw.unsw.edu.au (149.171.255.102)  218.378 ms  218.462 ms  218.436 ms
13  libwdr1-te-1-1.gw.unsw.edu.au (149.171.255.90)  232.145 ms * ombwdr1-te-1-1.gw.unsw.edu.au (149.171.255.94)  208.394 m
```

traceroute from my machine to speedtest.com.sg:

```
traceroute to www.speedtest.com.sg (202.150.221.172), 30 hops max, 40 byte packets 1 vlan385.ga
```

In this instance, the forward and reverse paths appear to be 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 pass through Western Australia (202.158.194.145), South Australia (113.197.15.44) and Victoria (113.197.15.28).

Observe the same router - 138.44.5.0/138.44.5.1 as in the previous example.

Exercise 4: Use ping to gain insights into network performance (4 marks)

Note: The hosting arrangements for www.dlsu.edu.ph (http://www.dlsu.edu.ph/) have changed since the results below were compiled. You were asked to use www.upm.edu.my (http://www.upm.edu.my/) located in Serdang, Selangoor in its place. Your results will vary slightly from those shown for that domain. In general, the exact numbers will obviously vary but the relative values and general trend across the 3 locations should be similar.

Question 1.

Distance between Sydney and the 3 destinations (based on flight path between them) are:

Brisbane: 750km, Manila: 6260km, Berlin: 16,084.

Assuming propagation speed of 3 x 10^8 m/s, the shortest possible time that a packet will take to reach these 3 destinations are:

Brisbane: 2.5ms, Manila: 20.86ms, Berlin: 53.61ms

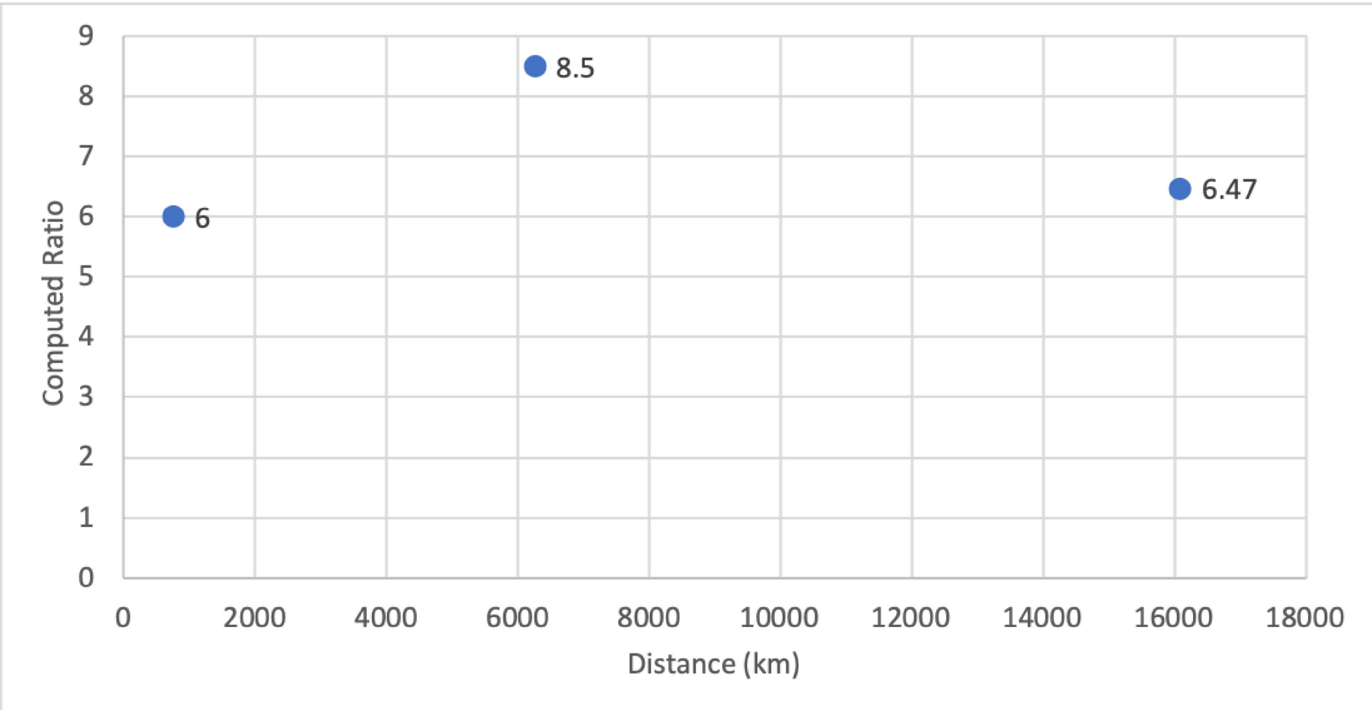
The minimum RTT (for 50 byte packets) to these 3 destinations from the corresponding *avg.txt files are:

Brisbane: 14.993ms, Manila: 177.5ms, Berlin: 346.893ms

As such, the ratios of the minimum RTT to the minimum propagation delay for these 3 destinations are:

Brisbane: 6, Manila: 8.50, Berlin: 6.47

The following plot illustrates this ratio as a function of distance.



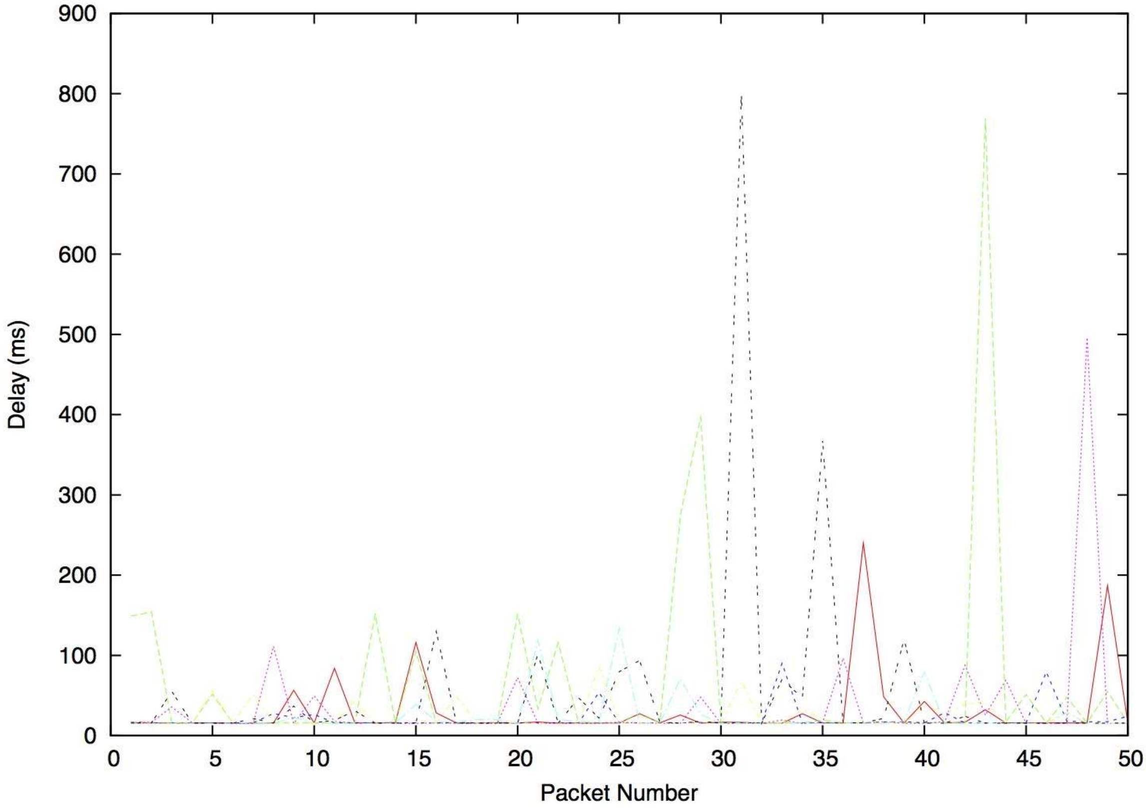
There are several reasons that this ratio is always > 2. Here are some:

- packets travel along cables and across multiple hops, rather than 'as the crow flies', i.e. directly
- speed of light does not take into account for transmission delays, congestion/queueing delay
- ISP-level routing may lead to paths that are not necessarily the shortest hop paths
- packets don't travel at the full speed of light through any real medium
- packets may traverse low bandwidth links such that it takes considerably extra time for the full packet to transit the link.

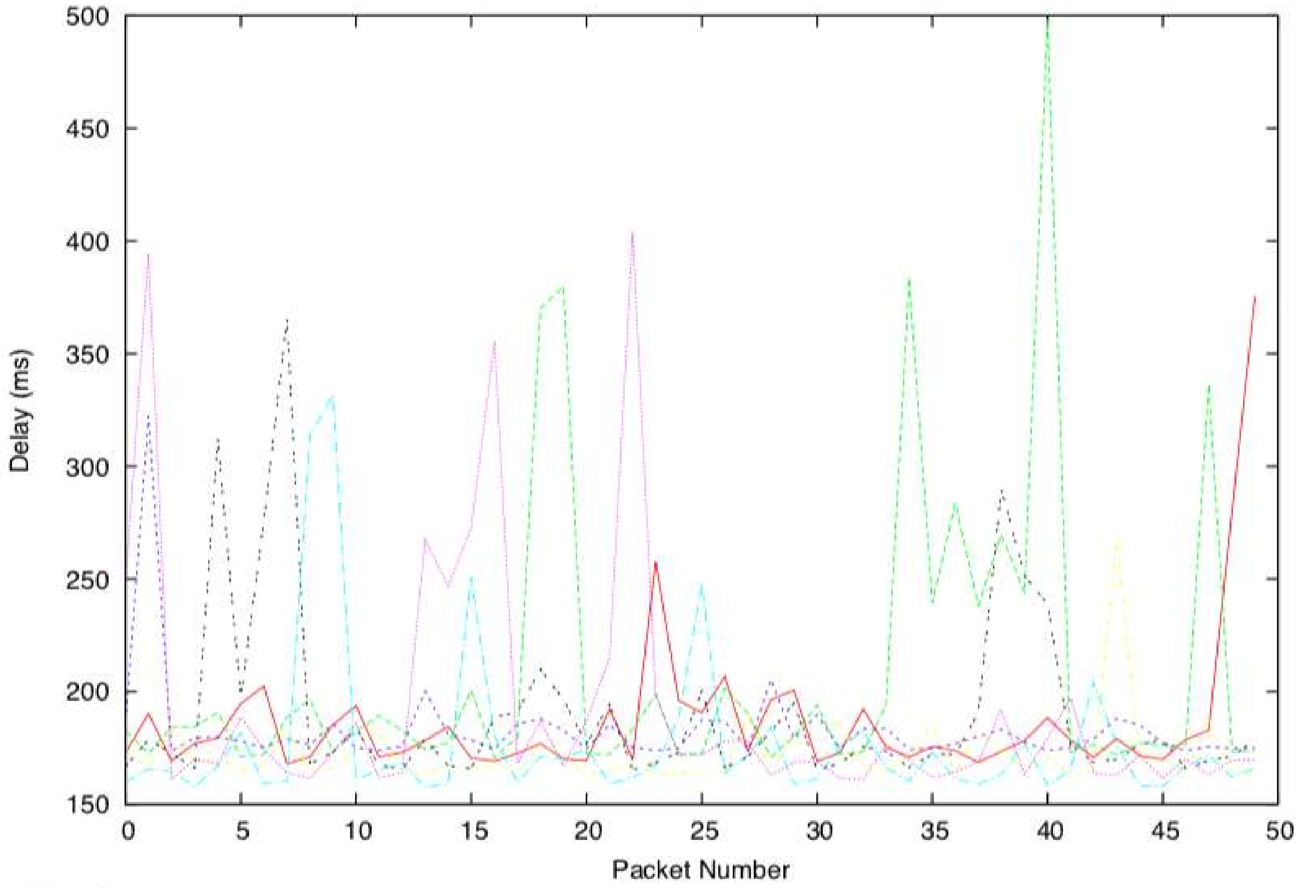
Question 2.

Each of the following plots (destination_delay.pdf) depicts the delay of consecutive packets of same size (every line), for different packet sizes (six different lines):

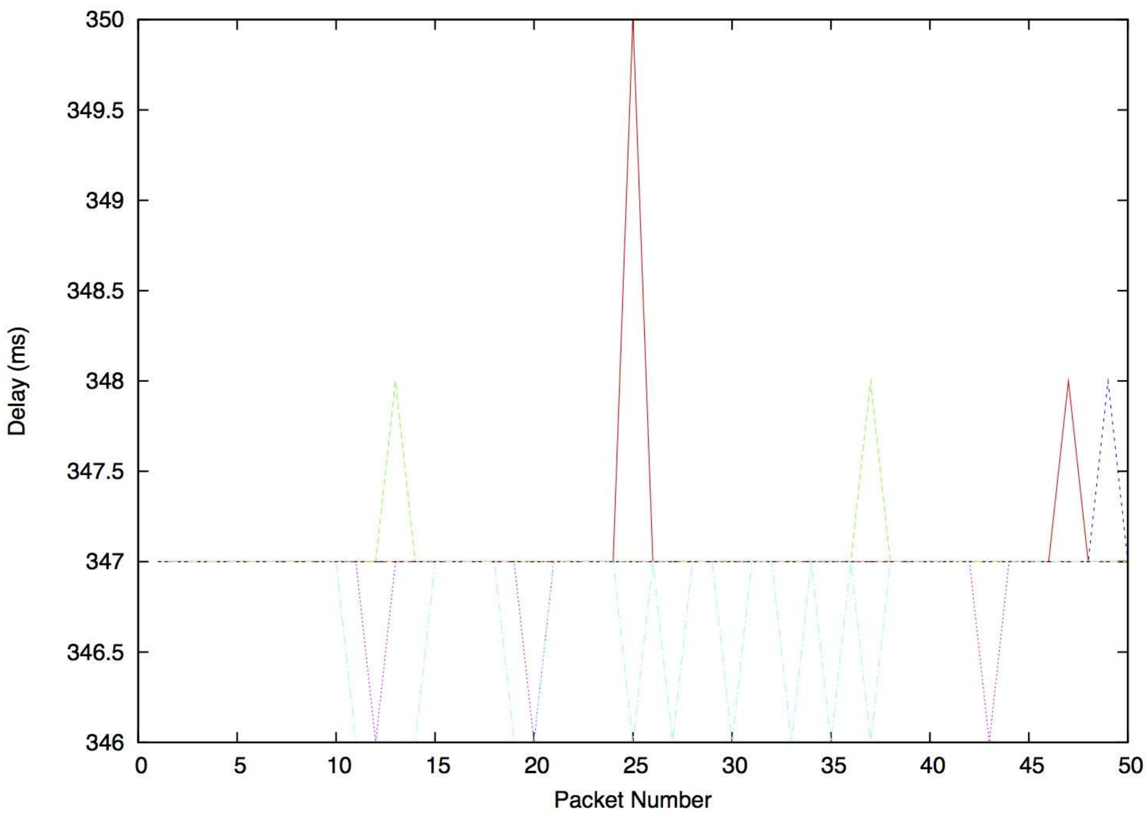
www.uq.edu.au (http://www.uq.edu.au/) (notice the variations here - some packets experience very large delays)



www.dlsu.edu.ph (http://www.dlsu.edu.ph/) (notice the large variations here - some packets experience very large delays)



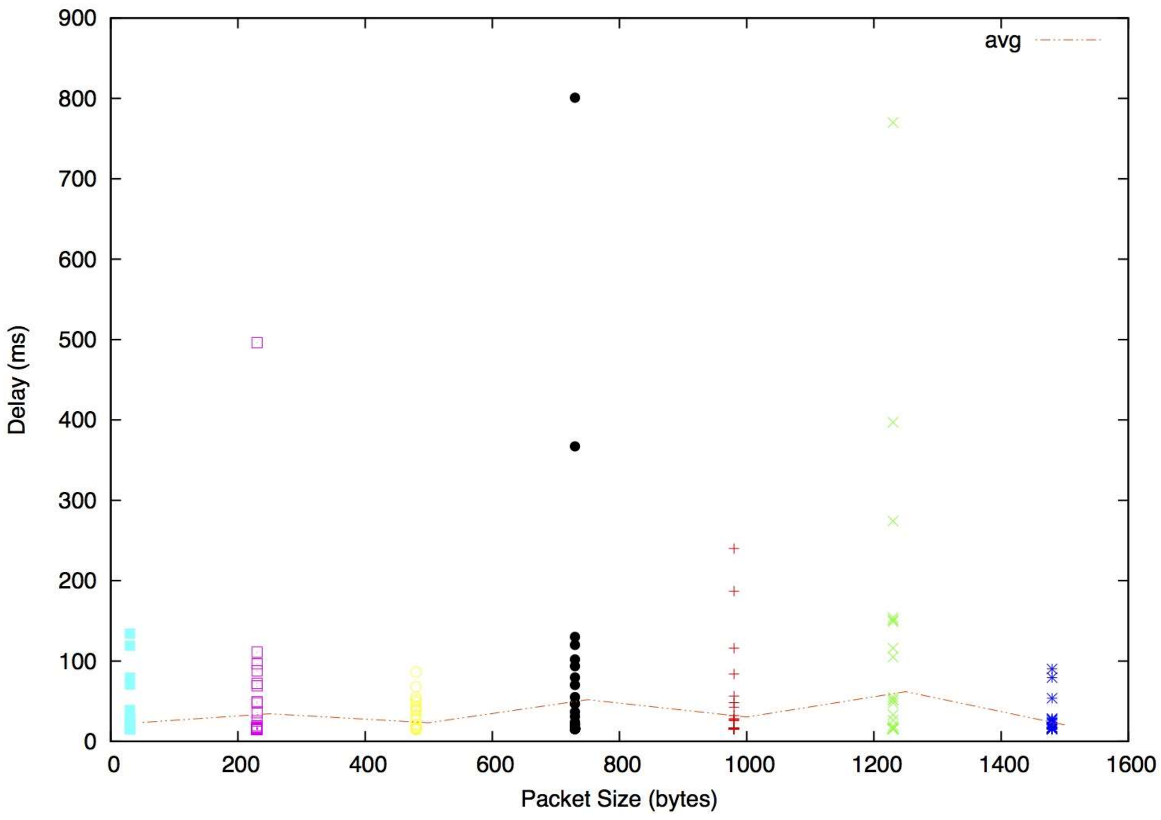
www.tu-berlin.de (http://www.tu-berlin.de/)



We can see from these plots that 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, and it does not necessarily depend on the physical distance or even the number of hops.

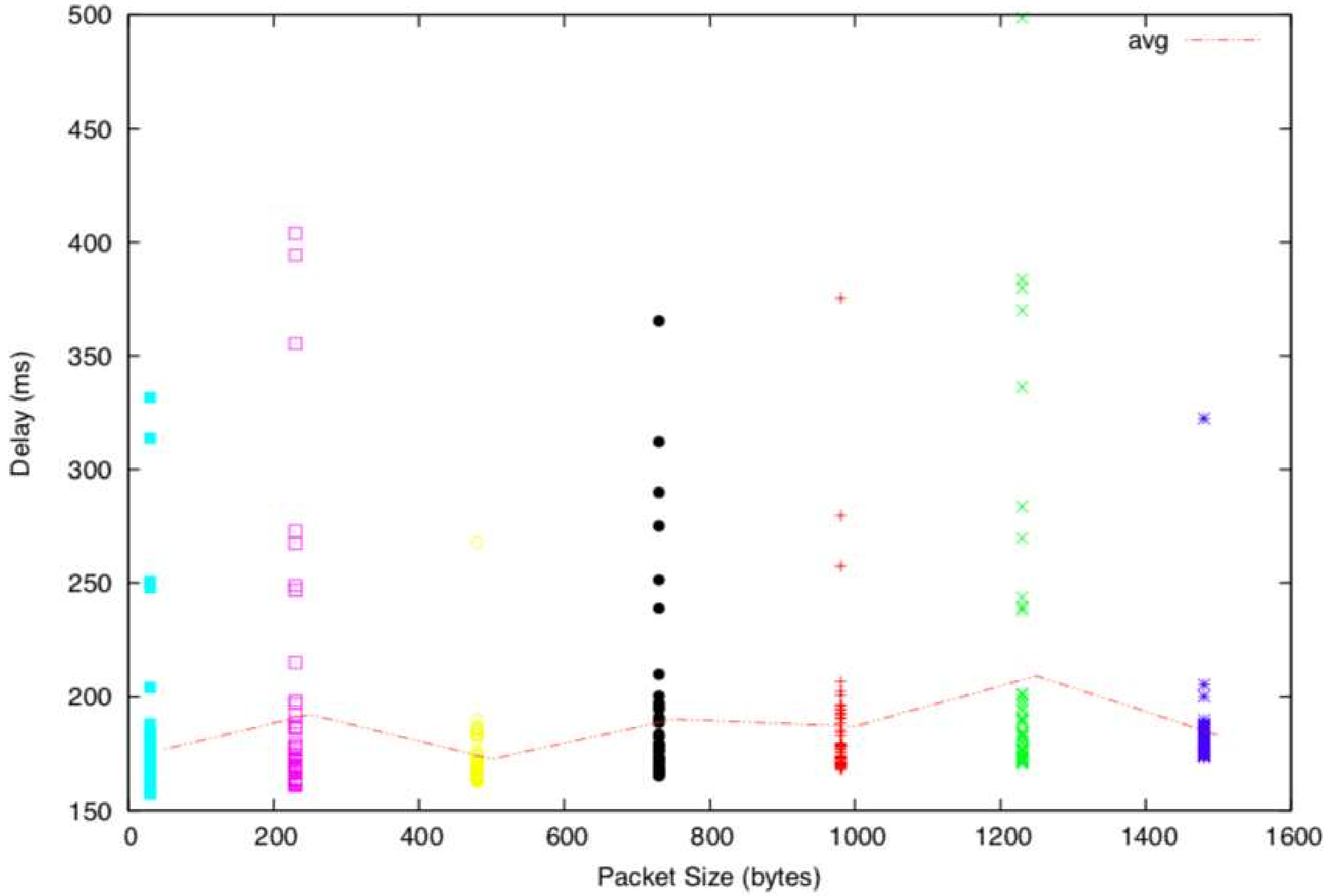
The following plots (destination_scatter.pdf) depict the various measurements of delay as a scatter plot for different packet sizes. The average delay for each packet size is also depicted.

www.uq.edu.au (http://www.uq.edu.au/)

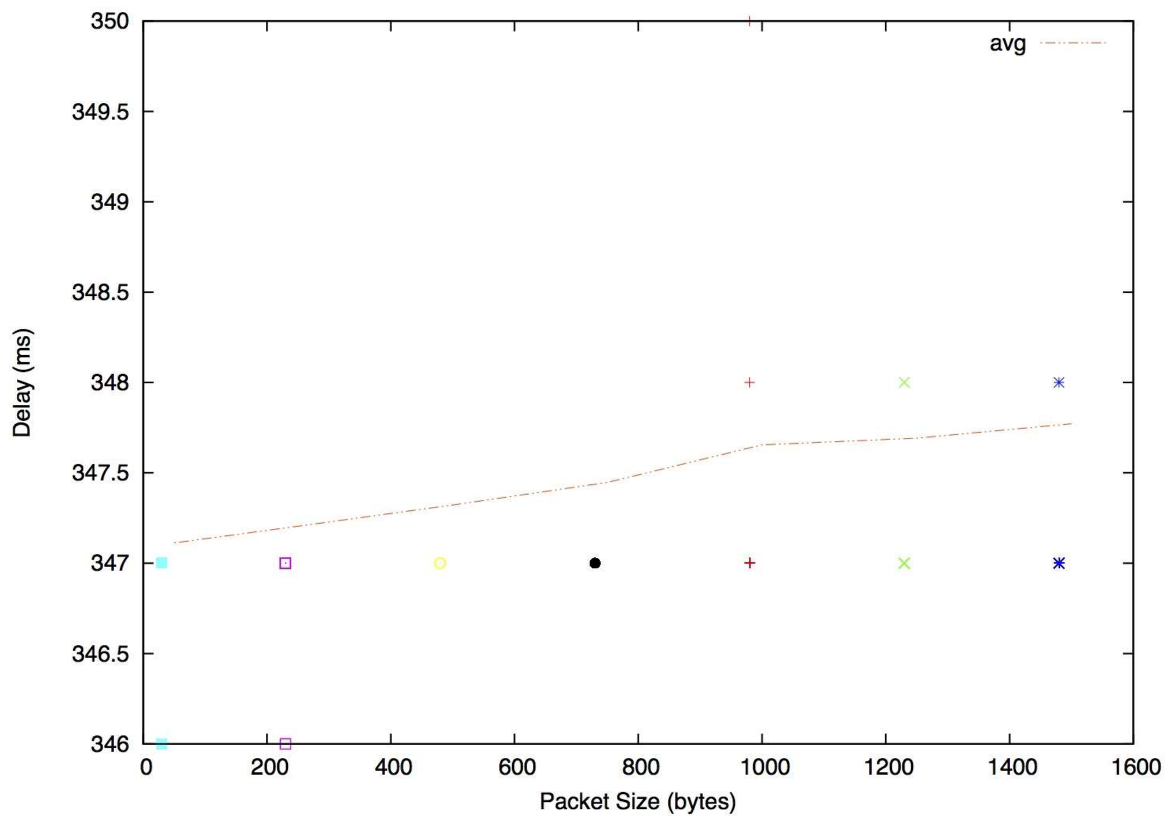


(http://www.uq.edu.au/)

www.dlsu.edu.ph (http://www.dlsu.edu.ph/) (the high variability is evident for this destination)



www.tu-berlin.de (http://www.tu-berlin.de/) (the delay values I got for this destination were remarkably stable, I am keen to find out the experience of others).



For Berlin destination, the average delay varies very little when the packet sizes is changed (347.1 to 347.7). For Manila and Brisbane, the average delay trend line increases slightly with the size of the packets. For larger packets the transmission delay is greater which should result in the increase in overall delay. However, this trend is not so obvious for our experiments. The average delay does not seem to vary much for different packet sizes. Generally, this may happen for the following reasons:
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 for "all" experiments, and therefore, the queueing delay (rather than the transmission delay) makes up a significant part of the total delay. High congestion for "all" experiments is rather unlikely to be seen since there is enough time passed between the experiments and the network conditions change each time, but we have added this explanation here for completeness.

Note that the first reason above may not be relevant for Brisbane but one could attribute the weak trend of the Berlin data (i.e. very marginal increase in delay as packet size increase) to this effect. The delay experienced by some of the ping packets sent to Brisbane and Manila are extremely high. These outliers may have distorted any inherent trend in the data.

Question 3.

The website is not hosted in Switzerland. This can be confirmed from ping and traceroute. It is hosted in a CDN node (www.epfl.ch.cdn.cloudflare.net (http://www.epfl.ch.cdn.cloudflare.net/)) which is only 7-8 hops away from UNSW with RTT of about 36ms.

Question 4.

The propagation delay does not depend on the packet size. It's related to the link and, in general, does not vary (except if the link varies: cable, satellite, etc.)

The queuing delay only depends on the congestion in the network. It will increase with the amount of traffic on the network (the more traffic there is, the more our packets will wait to be processed at a router).

The transmission delay is almost proportional to the packet size; for a fixed packet size, it is constant.

The processing delay can depend on the packet size, but to a much smaller degree than transmission delay; for a fixed packet size, it is reasonably constant.

Resource created 3 months ago (Monday 08 February 2021, 02:31:50 PM), last modified 2 months ago (Wednesday 17 March 2021, 09:44:35 AM).

Comments

(/COMP3331/21T1/forums/search?forum_choice=resource/57925)

(/COMP3331/21T1/forums/resource/57925)

Add a comment

There are no comments yet.