50.005 Computer System Engineering

NS Lab 1: Internet Routes and Measurement of Round Trip Times

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Overview

In this lab exercise, you will learn how to use `ping` and `traceroute` to measure round trip times and find network routes.

Learning objectives

At the end of this lab exercise, you should be able to:

- Understand how the `ping` and `traceroute` utilities work.
- Use the `ping` utility to measure network round trip times.
- Use the `traceroute` utility to find network routes.
- Observe and understand the effects of varying packet sizes on delays experienced.

Preparation

You will need `ping` and `traceroute` to be installed on your Ubuntu virtual machine. Most Ubuntu installations should already include `ping` by default. You can install `traceroute` by running "`sudo apt-get install traceroute`" from the command line.

Part 1: Measurement of round trip times using ping

The `ping` utility is one of the most widely-used network utilities. It enables you to measure the time that it takes for a packet to travel through the Internet to a remote host and back.

The `ping` utility works by sending a short message, known as an *echo-request*, to a remote host using the Internet Control Message Protocol (ICMP). When a host that supports ICMP receives an echo-request message, it replies by sending an echo-response message back to the originating host.

In the first part of this lab exercise, you will use the `ping` utility to send echo requests to a number of different hosts. In many of the exercises, you will be referring to hosts using their DNS names rather than their IP addresses. For more information about `ping`, you can look up its manual page by running "`man ping`" from the command line.

Round trip times

Use `ping` to send 10 packets to each of the following hosts. Each packet should have a size of 56 bytes, and there should be an interval of 5 seconds between each packet sent.

```
www.csail.mit.edu
www.berkeley.edu
www.usyd.edu.au
www.kyoto-u.ac.jp
```

Note: The size of each packet is 56 bytes by default, but you may observe that the actual size of the packet is larger than 56 bytes. You can look up the manual for `ping` to understand why such a discrepancy exists.

Question 1 (10pt): For each host, record the percentage of packets sent that resulted in a successful response. Record also the minimum, average, and maximum round trip times for the packets that resulted in a response.

Website	**Successful Percentage %**	**Min RTT**	**Average RTT**	**Max RTT**
www.csail.mit.edu	100	5.196	12.707	70.237
www.berkeley.edu	100	210.583	333.268	609.873
www.usyd.edu.au	100	97.984	99.109	101.816
www.kyoto-u.ac.jp	100	77.445	80.892	90.901

Question 2 (10pt): Describe and explain the differences in the minimum round trip time to each of these hosts.

The round trip time depends on the respective nodal delays, which is affected by 4 factors: processing delay, queueing delay, transmission delay and propagation delay. Since the routing to and from each of the different destinations are different, this will result in different routers and links traversed, which will lead to different distances and different number of hops. As a result, the propagation delay is most likely the biggest factor that accounts for the differences in the (minimum) round trip time.

Additionally, MIT could be a content provider network that only carries traffic to and from its own servers, thus accounting for the much shorter (minimum) round trip times as compared to the rest.

Question 3 (10pt): Repeat the exercise using packet sizes of 56, 512 and 1024 bytes. Record the minimum, average, and maximum round trip times for each of the packet sizes. Why are the minimum round-trip times to the same hosts different when using 56, 512, and 1024–byte packets?

Website	**Data byte packets**	**Successful Percentage %**	**Min RTT**	**Average RTT**	**Max RTT**
www.csail.mit.edu	**56**	100	5.553	12.763	44.420
	512	100	4.692	6.649	11.228
	1024	100	4.890	7.190	11.851
www.berkeley.edu	**56**	90	212.676	332.299	549.066
	512	80	212.475	299.195	524.735
	1024	90	211.480	281.865	556.941
www.usyd.edu.au	**56**	100	98.580	110.604	188.833
	512	100	98.828	101.267	106.630
	1024	100	98.427	98.950	99.604

www.kyoto-u.ac.jp	**56**	100	77.660	78.465	80.682
	512	100	77.948	79.109	79.984
	1024	100	78.328	81.654	98.977

When the packet size is different, this will affect the transmission delay aspect of the total nodal delay. Generally, the greater the packet length/size, the higher the transmission delay, and hence the RTT should be greater. However, the increase in transmission delay should be small as compared to the fluctuation in propagation delay. Therefore, the effect of packet size on RTT is not very significant (and obvious) in the table values.

Unanswered pings

Use ping to send 100 packets to the following host. Each packet should have a size of 56 bytes, and there should be an interval of 5 seconds between each packet sent.

`www.wits.ac.za`

Question 4 (10pt): Record the percentage of the packets sent that resulted in a successful response. What are some possible reasons why you may not have received a response? (Be sure to check the host in a web browser.)

Percentage of packets set: 0%. The web server may have set up a firewall to block anything other than the port traffic for the services offered (including ICMP packets). It could be possible that the server does not exist, or that the computer could not establish a connection to the host server as well. However, keying the URL into a web browser allows the page to load, meaning that the host is alive and connection can be established. Therefore, the first reason (firewall) is more likely to be true.

Part 2: Understanding Internet routes using traceroute

The `traceroute` utility is another useful network utility. It enables you to trace the route taken by a packet from your machine to a remote host.

Here is an example of the output produced when `traceroute` is used to trace the route taken by a packet to `www.mit.edu`.

```
traceroute to www.mit.edu (118.215.81.86), 30 hops max, 60 byte pack-
ets
 1  192.168.9.2 (192.168.9.2)  0.221 ms  0.193 ms  0.107 ms
 2  10.12.0.1 (10.12.0.1)  3.363 ms  2.555 ms  3.253 ms
 3  172.16.1.106 (172.16.1.106)  3.072 ms  3.416 ms  3.418 ms
 4  172.16.1.210 (172.16.1.210)  4.977 ms  4.712 ms  4.921 ms
 5  192.168.22.27 (192.168.22.27)  4.806 ms  6.521 ms  6.451 ms
 6  103.24.77.1 (103.24.77.1)  7.172 ms  3.590 ms  3.187 ms
 7  201.210-193-8.qala.com.sg (210.193.8.201)  4.312 ms  9.056 ms
7.870 ms
 8  137.203-211-158.unknown.qala.com.sg (203.211.158.137) 8.904 ms
6.690 ms  6.555 ms
 9  213.203-211-158.unknown.qala.com.sg (203.211.158.213) 7.710 ms
5.423 ms  5.193 ms
10  203.116.10.125 (203.116.10.125)  6.783 ms  6.705 ms  6.440 ms
```

Each line in the output begins with a host on the route from your computer to `www.mit.edu`, followed by the round-trip times for 3 packets sent to that host. For more information about `traceroute`, you can look up its manual page by running "`man traceroute`" from the command line.

Basics

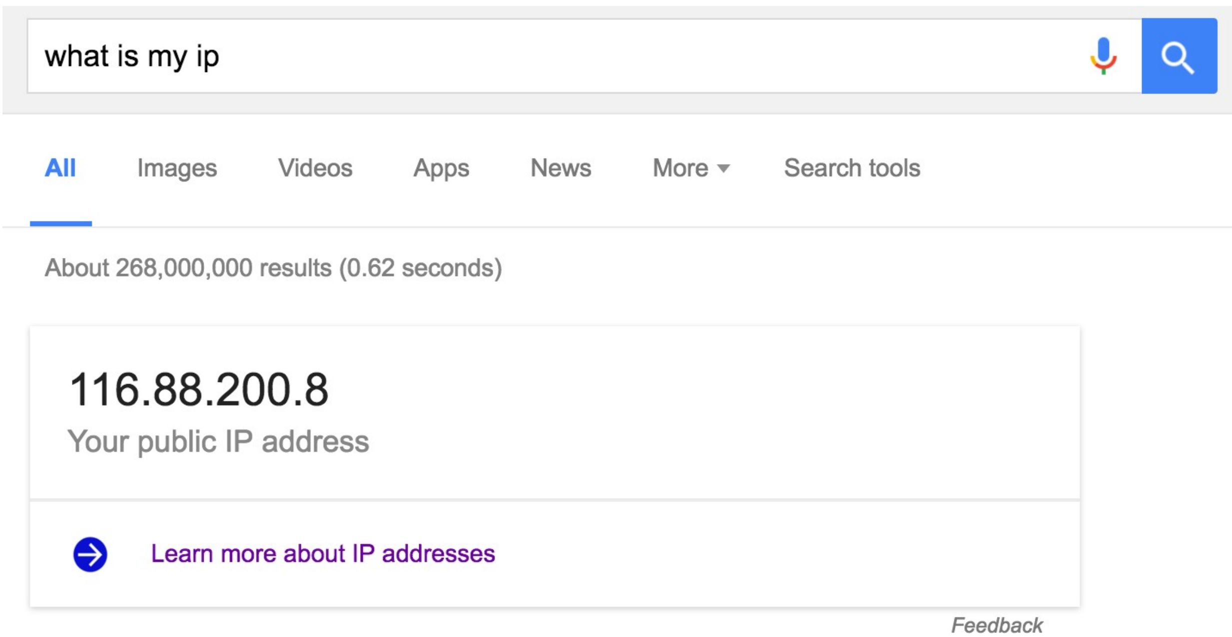
Question 5 (10pt): Explain how `traceroute` discovers a path to a remote host. (*Hint:* The `traceroute` manual will be helpful for answering this question.)

Traceroute tracks the route packets taken from an IP network on their way to the remote host. It utilizes the IP protocol's time to live (TTL) field and attempts to elicit an ICMP TIME_EXCEEDED response from each gateway along the path to the host.
The traceroute program starts by sending 3 packets (probes) that will reach router i (reached after i hops) on the path towards the destination, and router i will return the packets to the sender. The number i starts from 1 and is increased by 1 each time the packets are returned, and i is bound by an upper limit (e.g. 64 hops max).The round trip time (to router i and back) is then measured and reflected for each packet. This continues until the destination is reached or the maximum number of hops is reached.

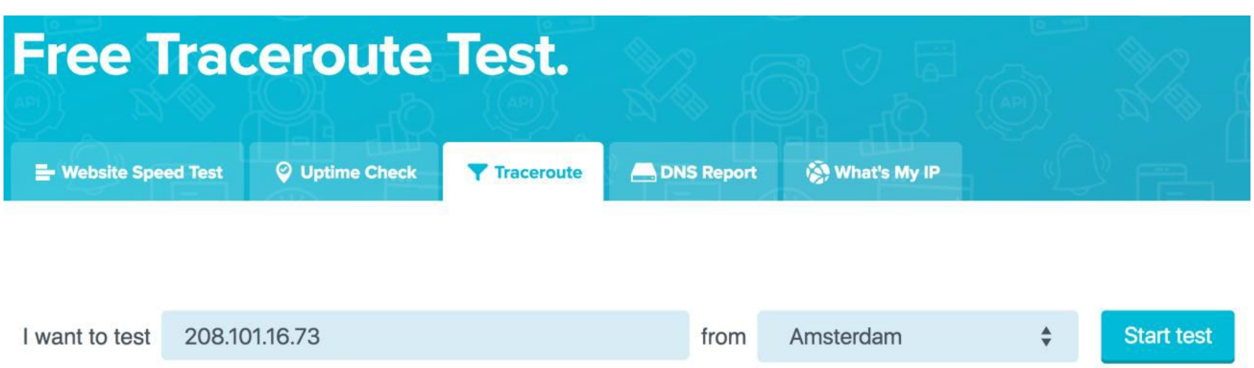
Route asymmetries

In this exercise, you will run `traceroute` in two opposite directions. First, you will run `traceroute` on a remote host to see the route taken to your network. You will also run `traceroute` from your computer to see the route taken to that host.

Step 1: Find out your computer's public IP address. (*Hint:* You can use a website like http://www.whatismypublicip.com/, or search for "*what is my ip*" using Google's search engine.)



Step 2: Visit https://www.uptrends.com/tools/traceroute in your web browser. Enter your computer's public IP address, select the "from Location" and click "Start Test" to start a `traceroute` to your computer. Follow the steps shown below for at least three locations namely: New York, Amsterdam, Tokyo.



Step 3: After `traceroute` finishes running, you should be able to view the route taken from `specified location` to your network. Record the IP address of the first hop, which will be used in the next step.

I want to test 200.23.1.54 from New York Start test

Step	Time	Time	Time	Host name	IP address
1	1	<1	<1	72-9-99-137-cust-gw.reverse.ezzi.net	72.9.99.137
2	2	1	2	ads-psc-cr01.ezzi.net	96.45.77.1
3	1	<1	<1	ads-psc-ir01-v261.ezzi.net	72.9.111.109
4	2	1	1	ads-85t-ir01.ezzi.net	72.9.111.213
5	2	1	1	nyk-b5-link.telia.net	213.248.104.110
6	2	2	1	nyk-bb4-link.telia.net	213.155.130.244
7	89	89	89	las-b22-link.telia.net	62.115.114.84
8	251	252	251	starhub-ic-320091-las-b3.c.telia.net	62.115.151.187
9	237	237	237		203.118.15.233
10	246	246	246	r41.starhub.net.sg	203.118.12.18
11	238	238	237		203.116.245.178
12	-	-	-		
13	261	260	260		202.94.70.51

Step 4: On your computer, run `traceroute` using the IP address recorded in the previous step as the remote destination.

```
$ traceroute <ip address from step 3>
```

Question 6 (10pt): Record the output of `traceroute` when run in both directions above.

New York

Step	Time	Time	Time	Host name	IP address
1	1	<1	1	72-9-99-137-cust-gw.reverse.ezzi.net	72.9.99.137
2	2	2	2	ads-psc-cr01.ezzi.net	96.45.77.1
3	1	<1	1	ads-psc-ir01-v261.ezzi.net	72.9.111.109
4	1	1	1	ads-psc-ir02-te2-1.ezzi.net	72.9.111.206
5	1	1	1		38.32.124.49
6	2	1	2	te0-3-1-12.rcr51.ewr06.atlas.cogentco.com	154.24.13.241
7	3	2	2	be3791.rcr21.ewr02.atlas.cogentco.com	154.24.61.177
8	3	3	2	be2236.ccr41.jfk02.atlas.cogentco.com	154.54.45.5
9	3	3	3	be3495.ccr31.jfk10.atlas.cogentco.com	66.28.4.182
10	3	3	3	ae-13.r01.nycmny17.us.bb.gin.ntt.net	129.250.8.145
11	4	6	3	ae-13.r20.nwrknj03.us.bb.gin.ntt.net	129.250.4.40
12	61	2906	61	ae-5.r22.sttlwa01.us.bb.gin.ntt.net	129.250.6.177
13	63	62	62	ae-0.r23.sttlwa01.us.bb.gin.ntt.net	129.250.6.30
14	165	163	163	ae-16.r24.osakjp02.jp.bb.gin.ntt.net	129.250.3.61
15	166	166	165	ae-0.r25.osakjp02.jp.bb.gin.ntt.net	129.250.2.151
16	225	225	225	ae-0.r20.sngpsi07.sg.bb.gin.ntt.net	129.250.2.66
17	226	225	225	ae-1.r01.sngpsi07.sg.bb.gin.ntt.net	129.250.3.100
18	224	224	224		116.51.18.138
19	223	231	223		203.118.6.202
20	224	224	225		183.90.44.46
21	224	223	223		183.90.44.110
22	225	225	226		182.19.177.226

```
C:\Users\Poay Hiang>tracert 72.9.99.137

Tracing route to 72-9-99-137-cust-gw.reverse.ezzi.net [72.9.99.137]
over a maximum of 30 hops:

  1     5 ms     2 ms     1 ms  192.168.1.1
  2     5 ms    25 ms     3 ms  183.90.59.1
  3     4 ms     4 ms     4 ms  183.90.44.109
  4     3 ms     3 ms     3 ms  183.90.44.45
  5     4 ms     4 ms     4 ms  203.118.3.65
  6     8 ms     4 ms     4 ms  203.118.7.86
  7     4 ms     4 ms     4 ms  snge-b2-link.telia.net [62.115.167.48]
  8     5 ms     5 ms     5 ms  snge-b1-link.telia.net [62.115.135.204]
  9   167 ms   168 ms   167 ms  sjo-b21-link.telia.net [62.115.114.40]
 10     *        *        *     Request timed out.
 11   236 ms   235 ms   236 ms  nyk-b5-link.telia.net [62.115.115.1]
 12   236 ms   236 ms   236 ms  coretech-ic-322321-nyk-b5.c.telia.net [213.248.104.111]
 13   227 ms   237 ms   227 ms  ads-85t-ir02.ezzi.net [72.9.111.118]
 14   243 ms   228 ms   228 ms  ads-psc-ir02-vl2548-te2-2.ezzi.net [72.9.111.182]
 15   235 ms   235 ms   236 ms  ads-psc-cr02.ezzi.net [72.9.111.106]
 16   229 ms   228 ms   228 ms  72-9-99-137-cust-gw.reverse.ezzi.net [72.9.99.137]

Trace complete.
```

Amsterdam

Step	Time	Time	Time	Host name	IP address
1	7	<1	<1	gateway.as64425.com	5.182.210.1
2	1	1	1	ae2-226.RT.IR9.AMS.NL.retn.net	87.245.246.38
3	3	1	1	ae18-2.RT.TC2.AMS.NL.retn.net	87.245.232.122
4	-	-	-		
5	10	11	11	i-91.ulhc-core01.telstraglobal.net	202.84.178.37
6	161	161	160	i-15003.sgpl-core02.telstraglobal.net	202.84.136.17
7	159	159	193	i-92.sgpl01.telstraglobal.net	202.84.224.194
8	160	159	160	unknown.telstraglobal.net	210.176.138.174
9	157	157	177		203.118.3.67
10	157	157	158		183.90.44.46
11	160	160	161		183.90.44.110
12	191	191	191		182.19.177.226

```
C:\Users\Poay Hiang>tracert 5.182.210.1

Tracing route to gateway.as64425.com [5.182.210.1]
over a maximum of 30 hops:

  1     2 ms     1 ms     1 ms  192.168.1.1
  2     4 ms     3 ms     4 ms  183.90.59.1
  3     4 ms     4 ms     4 ms  183.90.44.101
  4     6 ms     4 ms     4 ms  183.90.44.229
  5    38 ms    39 ms    37 ms  v1144.core1.hkg1.he.net [74.82.46.81]
  6    55 ms    46 ms    50 ms  100ge2-1.core1.sin1.he.net [184.105.222.102]
  7   179 ms   196 ms   175 ms  100ge11-1.core1.mrs1.he.net [184.105.65.14]
  8   194 ms   201 ms     *     100ge4-2.core1.par2.he.net [184.105.222.21]
  9   202 ms   201 ms   198 ms  100ge10-1.core1.ams1.he.net [184.105.81.110]
 10     *        *        *     Request timed out.
 11   194 ms   194 ms   194 ms  gateway.as64425.com [5.182.210.1]

Trace complete.
```

Tokyo

Step	Time	Time	Time	Host name	IP address
1	<1	<1	<1	hosted-by.i3d.net	31.204.145.130
2	1	<1	1	ce-0-18-0-0.r01.tokyjp08.jp.bb.gin.ntt.net	61.120.146.13
3	1	2	2	ae-19.r31.tokyjp05.jp.bb.gin.ntt.net	129.250.6.132
4	68	68	68	ae-4.r21.sngpsi07.sg.bb.gin.ntt.net	129.250.2.242
5	71	71	71	ae-2.r01.sngpsi07.sg.bb.gin.ntt.net	129.250.3.130
6	68	68	68		116.51.18.138
7	69	92	89		203.118.6.202
8	76	76	76		183.90.44.46
9	68	68	68		183.90.44.110
10	77	78	78		182.19.177.226

```
C:\Users\Poay Hiang>tracert 31.204.145.130

Tracing route to hosted-by.i3d.net [31.204.145.130]
over a maximum of 30 hops:

  1     2 ms     4 ms     3 ms  192.168.1.1
  2     5 ms     4 ms     3 ms  183.90.59.1
  3     5 ms     5 ms     4 ms  183.90.44.101
  4     4 ms     4 ms     3 ms  183.90.44.229
  5     5 ms     4 ms     4 ms  203.117.36.53
  6     6 ms     6 ms     5 ms  203.117.36.42
  7     *        *        *     Request timed out.
  8    83 ms    83 ms    83 ms  if-ae-28-2.tcore2.tv2-tokyo.as6453.net [180.87.181.75]
  9    83 ms    83 ms    83 ms  180.87.181.70
 10     *        *        *     Request timed out.
 11     *        *        *     Request timed out.
 12     *        *        *     Request timed out.
 13     *        *        *     Request timed out.
 14     *        *        *     Request timed out.
 15     *        *        *     Request timed out.
 16     *        *        *     Request timed out.
 17     *        *        *     Request timed out.
 18     *        *        *     Request timed out.
 19     *        *        *     Request timed out.
 20     *        *        *     Request timed out.
 21     *        *        *     Request timed out.
 22     *        *        *     Request timed out.
 23     *        *        *     Request timed out.
 24     *        *        *     Request timed out.
 25     *        *        *     Request timed out.
 26     *        *        *     Request timed out.
 27     *        *        *     Request timed out.
 28     *        *        *     Request timed out.
 29     *        *        *     Request timed out.
 30     *        *        *     Request timed out.

Trace complete.
```

Question 7 (10pt): Describe anything unusual you might observe about the output. Are the same routers traversed in both directions? If no, why might this be the case?

The unusual thing about the observations is that when tracing from my IP address to Tokyo, the request timed-out. This may be because its IP address (31.204.145.130) blocks incoming ICMP packets.
Different routers are travelled in each direction. This is because from the source, the most suitable routers are picked for the subsequent hop. However, since the source is different for both directions and the router is chosen from the pool of i number of hops from the source, the resulting sequence of routers traversed will be different.