50.005 Computer System Engineering

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

Name:
ID:

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	2.174	2.548	3.929
www.berkeley.edu	100	193.2	193.5	194.0
www.usyd.edu.au	100	93.15	93.34	93.53
www.kyoto-u.ac.jp	100	68.78	68.20	69.44

min RTT is affected by delay, and most importantly propagation delay. propagation delay is highly dependent on the speed and length of the link.
assuming the speed is similar, the length is the main factor for min RTT time. the time generally increases with increasing geographical distance (japan, US). interestingly, mit has the lowest min RTT, despite being in the US. there could be existence of cache/CDN for mit's server nearer to Singapore

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

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	2.174	2.548	3.929
	512	100	2.219	2.391	2.551
	1024	100	2.254	3.105	6.908
www.berkeley.edu	56	100	193.2	193.5	194.0
	512	100	193.3	193.6	193.8
	1024	100	193.3	193.4	193.9
www.usyd.edu.au	56	100	93.15	93.34	93.53
	512	100	93.26	93.55	94.65
	1024	100	93.31	93.53	94.65
www.kyoto-u.ac.jp	56	100	68.78	68.20	69.44
	512	100	67.87	68.21	70.02
	1024	100	67.96	68.30	68.77

min RTT increases very slightly with larger packet size due to more data being need to be sent over and back

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.)

0%. the host probably drops all ICMP ECHO requests

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

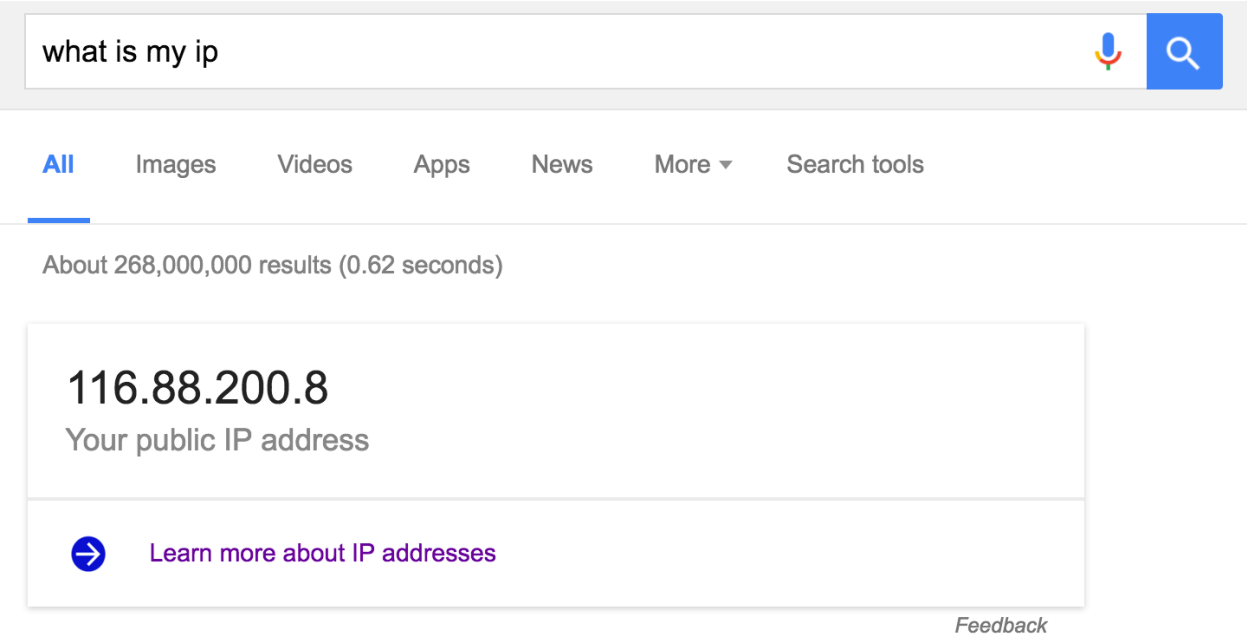
Question 5 (10pt): Explain how `traceroute` discovers a path to a remote host. (*Hint:* The `traceroute` manual will be helpful for answering this question.)

traceroute sends out packets with n TTL. when a host in the route receives the packet and the packet's TTL = 0, the host sends back ICMP TTL Exceeded to the sender, hence the sender is able to discover the host

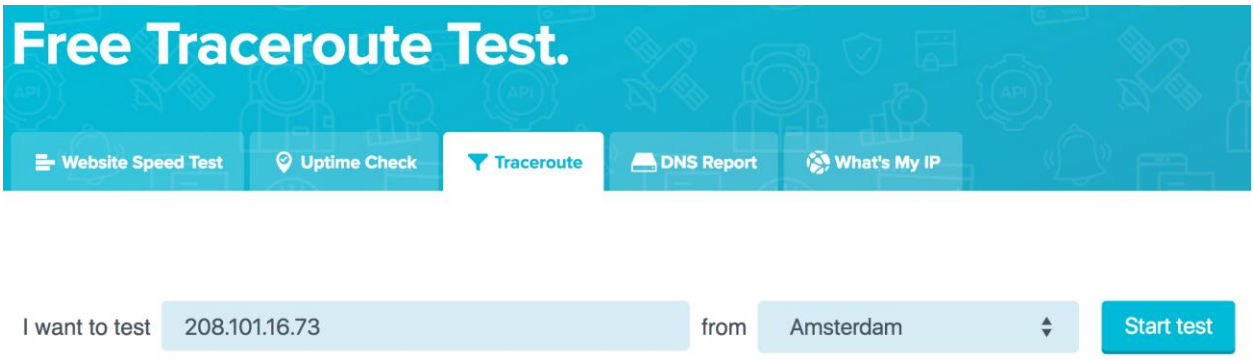
Route asymmetries

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.

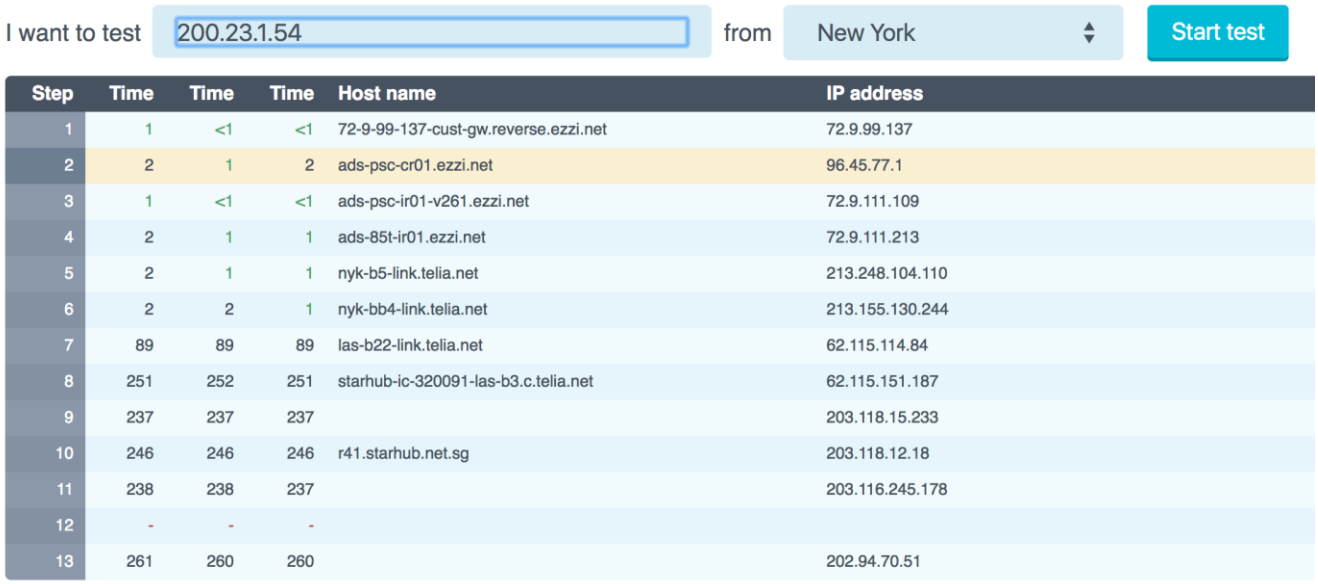
Step 1: Find out your computer's public IP address. (*Hint:* You can use a website like http://www.whatismypublicip.com/, or search for "*what is my ip*" using Google's search engine.)



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.



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.

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 number of hops taken is very different for New York:
from New York to my IP: 22 hops
from my IP to New York: 13 hops

not able to reach Amsterdam at all, after 43 hops

from Tokyo to my IP: it was able to reach at 5, 20,21,23 hops
some hops do not reach any host, and have no responses

the routers used are not the same in both directions
there are too many routers available for the path, highly unlikely to end up with the same router for both directions.

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	4	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	1	1	<1	ads-psc-ir02-vl32-te2-2.ezzi.net	72.9.111.186
5	2	1	1		38.32.124.49
6	1	1	1	te0-3-1-12.rcr51.ewr06.atlas.cogentco.com	154.24.13.241
7	2	2	2	be3791.rcr21.ewr02.atlas.cogentco.com	154.24.61.177
8	3	3	3	be2236.ccr41.jfk02.atlas.cogentco.com	154.54.45.5
9	3	2	3	be3495.ccr31.jfk10.atlas.cogentco.com	66.28.4.182
10	4	3	3	ae-13.r01.nycmny17.us.bb.gin.ntt.net	129.250.8.145
11	2802	4	3	ae-13.r20.nwrknj03.us.bb.gin.ntt.net	129.250.4.40
12	-	-	-		
13	74	61	68	ae-0.r23.sttlwa01.us.bb.gin.ntt.net	129.250.6.30
14	170	169	169	ae-16.r24.osakjp02.jp.bb.gin.ntt.net	129.250.3.61
15	172	171	172	ae-0.r25.osakjp02.jp.bb.gin.ntt.net	129.250.2.151
16	231	230	230	ae-0.r20.sngpsi07.sg.bb.gin.ntt.net	129.250.2.66
17	236	235	235	ae-1.r00.sngpsi07.sg.bb.gin.ntt.net	129.250.3.82
18	239	234	234	ae-0.a01.sngpsi07.sg.bb.gin.ntt.net	129.250.2.122
19	229	228	229		116.51.31.34
20	230	229	230	103-6-148-14.myrepublic.com.sg	103.6.148.14
21	230	230	230	103-6-148-38.myrepublic.com.sg	103.6.148.38
22	231	232	231	87-128-140-158.myrepublic.com.sg	158.140.128.87

```
 traceroute 72.9.99.137
traceroute to 72.9.99.137 (72.9.99.137), 64 hops max, 52 byte packets
 1  router.asus.com (192.168.11.254)  0.557 ms  0.274 ms  0.230 ms
 2  * * *
 3  103-6-148-37.myrepublic.com.sg (103.6.148.37)  1.829 ms  1.940 ms  1.908 ms
 4  103-6-148-13.myrepublic.com.sg (103.6.148.13)  1.864 ms  1.776 ms  2.071 ms
 5  snge-b1-link.telia.net (213.248.72.21)  2.314 ms  1.958 ms  2.297 ms
 6  sjo-b21-link.telia.net (62.115.114.40)  164.361 ms  164.516 ms  164.836 ms
 7  * * nyk-bb2-link.telia.net (62.115.119.228)  234.666 ms
 8  nyk-b5-link.telia.net (80.91.254.14)  234.978 ms  234.494 ms  237.895 ms
 9  coretech-ic-322321-nyk-b5.c.telia.net (213.248.104.111)  233.292 ms  233.422 ms  233.531 ms
10  ads-85t-ir02.ezzi.net (72.9.111.118)  231.981 ms  232.515 ms  231.517 ms
11  ads-psc-ir02-vl2548-te2-2.ezzi.net (72.9.111.182)  225.207 ms  225.407 ms  226.200 ms
12  ads-psc-cr02.ezzi.net (72.9.111.106)  232.201 ms  232.484 ms  232.978 ms
13  72-9-99-137-cust-gw.reverse.ezzi.net (72.9.99.137)  232.093 ms  231.827 ms  232.578 ms
```

Amsterdam

Step	Time	Time	Time	Host name	IP address
1	<1	<1	<1	gateway.as64425.com	5.182.210.1
2	13	<1	<1		185.173.233.9
3	1	1	1		81.20.67.49
4	1	1	3	ae-18.r25.amstnl02.nl.bb.gin.ntt.net	129.250.2.108
5	7	8	9	ae-17.r21.frnkge13.de.bb.gin.ntt.net	129.250.3.76
6	9	8	8	ae-0.r20.frnkge13.de.bb.gin.ntt.net	129.250.6.1
7	167	166	167	ae-8.r20.sngpsi07.sg.bb.gin.ntt.net	129.250.7.8
8	167	167	167	ae-1.r00.sngpsi07.sg.bb.gin.ntt.net	129.250.3.82
9	167	179	167	ae-1.a00.sngpsi03.sg.bb.gin.ntt.net	129.250.7.75
10	158	158	158		116.51.31.46
11	155	155	155	103-6-148-38.myrepublic.com.sg	103.6.148.38
12	157	156	157	87-128-140-158.myrepublic.com.sg	158.140.128.87

```
 traceroute 5.182.210.1
traceroute to 5.182.210.1 (5.182.210.1), 64 hops max, 52 byte packets
 1  router.asus.com (192.168.11.254)  0.701 ms  0.249 ms  0.221 ms
 2  * * *
 3  103-6-148-37.myrepublic.com.sg (103.6.148.37)  2.022 ms  1.661 ms  1.731 ms
 4  * * *
 5  100ge11-1.core1.mrs1.he.net (184.105.65.14)  137.768 ms  140.258 ms  137.969 ms
 6  100ge4-2.core1.par2.he.net (184.105.222.21)  156.691 ms  169.307 ms  154.089 ms
 7  100ge10-1.core1.ams1.he.net (184.105.81.110)  157.063 ms  154.751 ms  157.143 ms
 8  fiberxpress-bv.100gigabitethernet4-1.core1.ams1.he.net (184.104.200.22)  170.249 ms  158.544 ms  160.919 ms
 9  * * *
10  * * *
11  * * *
12  * * *
13  * * *
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39  * * *
40  * * *
41  * * *
42  * * *
43  * * *
```

Tokyo

Step	Time	Time	Time	Host name	IP address
1	50	1	<1	hosted-by.i3d.net	31.204.145.130
2	67	66	66	132132.tyo.equinix.com	203.190.230.179
3	67	67	67	103-6-148-22.myrepublic.com.sg	103.6.148.22
4	2777	2999	67	103-6-148-38.myrepublic.com.sg	103.6.148.38
5	68	68	68	87-128-140-158.myrepublic.com.sg	158.140.128.87
6	-	-	-		
7	-	-	-		
8	-	-	-		
9	-	-	-		
10	-	-	-		
11	-	-	-		
12	-	-	-		
13	-	-	-		
14	-	-	-		
15	-	-	-		
16	-	-	-		
17	-	-	-		
18	-	-	-		
19	-	-	-		
20	2777	2999	362	87-128-140-158.myrepublic.com.sg	158.140.128.87
21	79	2707	362	87-128-140-158.myrepublic.com.sg	158.140.128.87
22	-	-	-		
23	2777	2999	362	87-128-140-158.myrepublic.com.sg	158.140.128.87

```
 traceroute 31.204.145.130
traceroute to 31.204.145.130 (31.204.145.130), 64 hops max, 52 byte packets
 1  router.asus.com (192.168.11.254)  0.578 ms  0.280 ms  0.219 ms
 2  * * *
 3  103-6-148-37.myrepublic.com.sg (103.6.148.37)  1.979 ms  1.705 ms  1.750 ms
 4  103-6-148-13.myrepublic.com.sg (103.6.148.13)  1.879 ms  1.884 ms  1.982 ms
 5  hosted-by.i3d.net (31.204.145.130)  68.903 ms  69.338 ms  72.681 ms
```