

Internet Routes and Measure of Round Trip Times

Lab 4
50.005 Computer System Engineering

Due: 01 Apr 08:30 AM (Week 10)

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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 OS. Most **Ubuntu** / **MacOS** installations should already include ping by default. You can install traceroute by running “`sudo apt-get install traceroute`” from the command line.

Submission

- **The total points for this lab are 35.**
- Export this handout and fill in your answers in the blanks denoted in **blue**.
- Export as pdf and **ZIP** it (not RAR, or any other compression algorithm).
- **Upload** to @csesubmitbot Telegram bot using the command `/submitlab4`
- **CHECK** your submission by using the command `/checksubmission`

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 [4pt]: 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.

Your answer:

Website	Successful Percentage (%)	Min RTT (ms)	Average RTT (ms)	Max RTT (ms)
www.csail.mit.edu	100	3.523	4.994	9.912
www.berkeley.edu	100	215.585	220.052	229.233
www.usyd.edu.au	100	95.343	147.794	210.238
www.kyoto-u.ac.jp	100	3.753	7.262	16.620

Question 2 [4pt]: Describe and explain the differences in the minimum round-trip time to each of these hosts.

Your answer:

The differences might be caused by a multitude of factors, some of which would include:

- The number of nodes/hops between the client endpoint and the host server endpoint.
- The geographical/physical distance between the client endpoint and the host server endpoint.
- The amount and level of traffic during which the measurements were taken (congestions and bottlenecks might happen).
- The load balancing capabilities of each server and the number of global CDN servers that they utilize worldwide.
- The amount of time it takes for the server to respond to the ICMP echo request.
- The nature and type of the signal transmission medium and the nodes.

Question 3 [4pt]: 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?

Your answer:

Website	Packet Size (bytes)	Successful Percentage %	Min RTT (ms)	Average RTT (ms)	Max RTT (ms)
www.csail.mit.edu	56	100	3.282	4.856	7.522
	512	100	3.771	8.459	20.301
	1024	0	-	-	-
www.berkeley.edu	56	100	215.353	222.384	234.477
	512	100	212.165	215.098	227.054
	1024	0	-	-	-
www.usyd.edu.au	56	100	95.534	169.459	206.934
	512	100	95.061	157.525	200.003
	1024	0	-	-	-
www.kyoto-u.ac.jp	56	100	4.160	7.887	16.669
	512	100	4.078	7.220	14.447
	1024	0	-	-	-

The differences in the minimum RTT values might be due to network-related factors such as the physical distance and the number of nodes/hops. While the minimum RTT values seem to be slightly longer for larger packet sizes, they are not affected that significantly by the packet size. In some cases, larger packet sizes might even reduce the minimum RTT values since the routers might implement a TCP/IP optimization method to buffer together smaller packets before they are actually sent. The only significant effect that packet size has on the minimum RTT values would be when the packet size is 1024 bytes (including the ICMP header data), whereby all the ping request packets are lost, and no responses are received from all of the specified hosts. This might be due to a configuration that enables packet drop for any packet larger than 1024 bytes in the zone protection profile assigned to either the source zone of the originating ping or the host zone receiving the ping. This setting might not be changeable or configurable by the normal user since it might have been set by the ISP or the corresponding network host provider that the

current user is subscribed to so as to prevent any malicious DDoS-related attacks such as pings of death and ping floods.

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 [8pt]: Record the **percentage** of the packets sent that resulted in a **successful response** for each host. What are some possible **reasons** why you may not have received a response? (Be sure to check the host in a web browser).

You can provide screenshots to your answer.

Your answer:

Successful response percentage: 0%.

```
jamestiotio@JRT-PC:~$ ping -c 100 -s 56 -i 5 -v www.wits.ac.za
ping: socket: Permission denied, attempting raw socket...
ping: socket: Permission denied, attempting raw socket...
PING ccms.wits.ac.za (146.141.13.50) 56(84) bytes of data.

--- ccms.wits.ac.za ping statistics ---
100 packets transmitted, 0 received, 100% packet loss, time 506851ms
```

However, the host is up and running and the website can be accessed via a web browser.

The screenshot shows the official website of the University of the Witwatersrand Johannesburg. At the top, there's a navigation bar with links for 'About', 'Staff', 'Alumni', 'Give', 'Library', 'News and Events', and 'Wits 100'. A search bar is also present. Below the header, there's a large banner featuring a student holding a quadcopter drone, with the text 'Engineering for good' and a caption about a student named Xolani Radube. The main content area includes sections for 'CHOOSE A DEGREE OR DIPLOMA' (with a search bar), 'Latest News' (with several news items), 'Latest Events' (with three event cards), and a prominent 'Covid-19 Portal' section. This portal has sub-sections for 'Access uWits' (showing a mobile device interface), 'Data Access' (mentioning online teaching), 'Covid-19 Screening Tool' (describing how staff and students can use it), 'Research For Good' (showing a scientist), and 'Wits opinion pieces' (showing a graduation cap and lightbulbs). At the bottom, there's a 'SOUTH AFRICAN COVID-19 RESOURCE PORTAL' section with a 'TOUR OUR CAMPUS' image and various contact and quicklink options.

Thus, these are the possible reasons:

- Firewall was set up on the host to block pings and prevent any responses to ICMP echo requests to be returned. The specified port, socket, or service for a ping to be received properly might be closed and blocked by the firewall.
- The host server might be in the middle of processing the response for the ping requests, but it takes longer than 500 seconds to respond to even the first ping request.

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 packets
```

```
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.

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

Your answer:

1. At each step i , the traceroute attempts to transmit 3 packets that will reach router i (i.e., the router after i hops) on the path towards the destination host. These packets will be sent to a likely unusable port in the destination. The value of i is initially unknown and it is iteratively increased until either a set maximum value is reached, or the destination is reached. The increase of the value of i corresponds with the increase of the packets' time-to-live (TTL) value and each router in the path will decrease this TTL value by 1.
2. Each router/gateway will respond to the sender by replying with a ICMP TTL Time Exceeded response packet. The router that sets the packets' TTL values to 0 will send back the ICMP TTL Exceeded packet since it is not the destination router. If the packet reaches the destination host, it

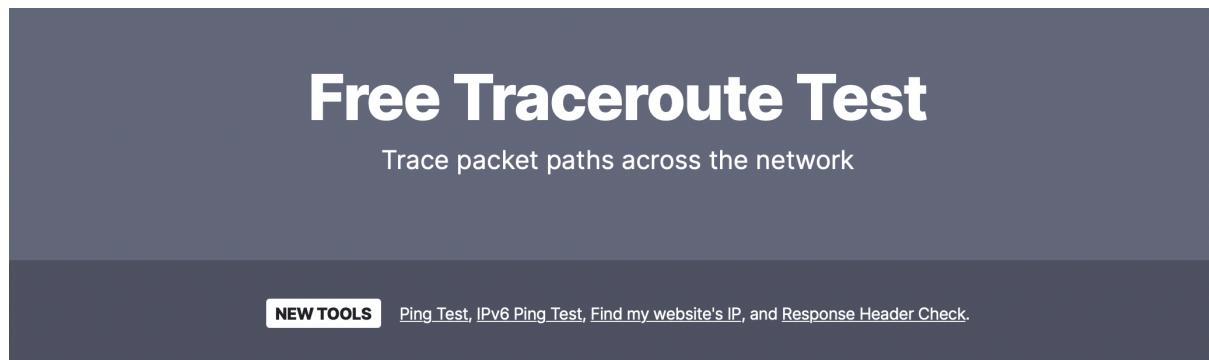
- will send back an ICMP Port Unreachable message to indicate the end of the path.
3. The sender's traceroute process will then measure the amount of time taken from the packet was sent until the packet is received back at the sender from router i at each probe. This amount of time is considered the round-trip time (RTT), which depends on network infrastructure, internodal distance, network conditions and packet size.

Route asymmetries

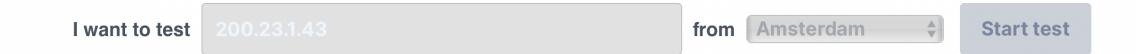
In this exercise, you will run traceroute in two opposite directions. First, you will run traceroute on a remote host to see the route taken to your network. You will also run traceroute from your computer to see the route taken to that host.

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.



The screenshot shows a traceroute interface with the following fields:

- I want to test: 200.23.1.43
- from: Amsterdam
- Start test

Below the interface is a table showing the traceroute results:

Hop	Time	Time	Time	Host name	IP address
1	<1	<1	<1	gateway.as64425.com	5.182.210.1
2	-	-	-		
3	1	1	1		212.119.24.97
4	2	1	1	ae-10.r25.amstnl02.nl.bb.gin.ntt.net	129.250.2.90
5	12	12	12	ae-6.r20.parsfr04.fr.bb.gin.ntt.net	129.250.4.138
6	14	15	17	ae-2.r21.parsfr04.fr.bb.gin.ntt.net	129.250.3.46
7	90	87	86	ae-13.r24.asbnva02.us.bb.gin.ntt.net	129.250.6.6
8	149	149	149	ae-2.r24.snjasca04.us.bb.gin.ntt.net	129.250.6.237
9	-	-	-		
10	149	149	149	ae-2.r00.mlpsca01.us.bb.gin.ntt.net	129.250.4.101
11	148	148	148		129.250.24.196
12	155	155	155		129.250.130.254
13	148	148	148		198.107.143.162
14	-	-	-		

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 [5pt]: Record the output of traceroute when run in both directions above. **Paste it as screenshots here or at the end of this document.**

Mobile Personal Data Network:

- **New York:**
 - **From:**

I want to test [redacted] from New York Start test

Hop	Time	Time	Time	Host name	IP address
1	<1	<1	<1		45.58.112.1
2	2	2	2		50.208.232.129
3	1	1	1		96.110.33.245
4	2	2	2		96.110.35.86
5	7	7	7		96.110.36.117
6	8	7	7		96.110.34.153
7	7	7	7		96.110.32.114
8	19	19	19		96.110.32.1
9	20	20	19		96.110.34.197
10	20	19	19		96.110.34.166
11	20	20	47		96.110.39.169
12	20	20	20		96.110.34.233
13	20	19	19		96.110.34.250
14	33	33	33		96.110.32.218
15	32	32	32		96.110.46.101
16	33	32	32		96.110.46.106
17	61	60	60		96.110.37.190
18	61	61	61		96.110.45.173
19	60	60	60		96.110.44.102
20	60	60	60		203.208.169.61
21	60	60	60		203.208.171.117
22	228	227	227		203.208.182.77
23	230	229	230		203.208.182.253
24	229	228	228		203.208.192.190
25	237	237	237		202.166.120.202

- To:

```
jamestiotio@JRT-PC:~$ traceroute 45.58.112.1
traceroute to 45.58.112.1 (45.58.112.1), 30 hops max, 60 byte packets
 1  _gateway (172.26.10.1)  0.830 ms  0.951 ms  1.000 ms
 2  192.168.233.32 (192.168.233.32)  191.021 ms  190.650 ms  190.472 ms
 3  18.252.23.97 (18.252.23.97)  112.139 ms  111.999 ms  10.252.23.101 (10.252.23.101)  140.226 ms
 4  18.252.12.54 (18.252.12.54)  139.739 ms  139.543 ms  18.252.12.98 (18.252.12.98)  139.194 ms
 5  208.100.126.24 (208.100.126.24)  139.739 ms  139.543 ms  139.973 ms  139.973 ms
 6  282.160.124.81 (282.160.124.81)  138.770 ms  126.120 ms  282.160.124.81  138.918 ms
 7  * 192.166.166.97 (282.166.166.97)  126.156 ms  28.024 ms  27.949 ms
 8  203.208.191.197 (203.208.191.197)  32.971 ms  203.208.145.233 (203.208.145.233)  32.738 ms  203.208.191.113 (203.208.191.113)  32.810 ms
 9  283.288.182.249 (203.208.182.249)  32.845 ms  32.769 ms  49.247 ms
10  283.288.172.226 (203.208.172.226)  211.416 ms  te-0-8-0-2-7-7-pe02.529bryant.ca.ibone.comcast.net (75.149.231.241)  223.631 ms  223.573 ms
11  283.288.158.178 (203.208.158.178)  207.949 ms  be-3102-cs01.sunnyvale.ca.ibone.comcast.net (96.110.41.209)  225.315 ms  203.208.158.178 (203.208.158.178)  207.5
20 ms
12  te-0-8-0-2-7-pe02.529bryant.ca.ibone.comcast.net (75.149.231.241)  223.518 ms  193.361 ms  203.208.172.234 (203.208.172.234)  190.815 ms
13  be-3402-cr13.042.sunnyvale.ca.ibone.comcast.net (96.110.41.221)  198.572 ms  be-302-cr12.champa.co.ibone.comcast.net (96.110.39.21)  232.677 ms  te-0-8-0-2-7-pe02.5
29bryant.ca.ibone.comcast.net (75.149.231.241)  199.848 ms
14  be-1411-cr11.sunnyvale.ca.ibone.comcast.net (96.110.46.38)  199.337 ms  be-1112-cs01.champa.co.ibone.comcast.net (96.110.37.299)  231.244 ms  be-1412-cs04.champ
a.co.ibone.comcast.net (96.110.37.221)  246.636 ms
15  be-1111-cr11.sunnyvale.ca.ibone.comcast.net (96.110.46.2)  213.302 ms  be-1211-cr11.sunnyvale.ca.ibone.comcast.net (96.110.46.14)  207.706 ms  be-1213-cr13.cham
pa.co.ibone.comcast.net (96.110.37.230)  240.878 ms
16  be-302-cr12.champa.co.ibone.comcast.net (96.110.39.21)  232.500 ms  be-304-cr12.champa.co.ibone.comcast.net (96.110.39.29)  224.090 ms  be-303-cr12.champa.co.ib
one.comcast.net (96.110.39.25)  243.165 ms
17  be-1212-cs02.champa.co.ibone.comcast.net (96.110.37.213)  229.445 ms  be-1114-cs01.1601milehigh.co.ibone.comcast.net (96.110.39.113)  242.959 ms  be-1113-cr13.c
hampa.co.ibone.comcast.net (96.110.37.226)  243.023 ms
18  be-1211-cr11.1601milehigh.co.ibone.comcast.net (96.110.39.70)  251.309 ms  be-303-cr13.1601milehigh.co.ibone.comcast.net (96.110.36.202)  243.156 ms  be-303-cr1
4.1601milehigh.co.ibone.comcast.net (96.110.39.10)  248.271 ms
19  be-303-cr13.1601milehigh.co.ibone.comcast.net (96.110.36.202)  242.965 ms  be-1314-cs03.1601milehigh.co.ibone.comcast.net (96.110.39.121)  245.112 ms  be-1114-c
s03.1601milehigh.co.ibone.comcast.net (96.110.39.123)  243.101 ms
20  be-1114-cs04.1601milehigh.co.ibone.comcast.net (96.110.39.125)  243.036 ms  be-1211-cs02.350ecermak.il.ibone.comcast.net (96.110.35.5)  264.469 ms  be-1111-cr11.1601m
ilehigh.co.ibone.comcast.net (96.110.39.66)  242.982 ms
21  be-1122-cr12.350ecermak.il.ibone.comcast.net (96.110.35.18)  266.055 ms  be-1111-cr11.1601milehigh.co.ibone.comcast.net (96.110.39.66)  225.602 ms  be-1112-cr12.35
0ecermak.il.ibone.comcast.net (96.110.35.18)  251.286 ms
22  be-1111-cs01.350ecermak.il.ibone.comcast.net (96.110.35.31)  251.166 ms  * be-302-cr11.newyork.ny.ibone.comcast.net (96.110.38.79)  289.553 ms
23  be-1111-cs01.350ecermak.il.ibone.comcast.net (96.110.35.31)  256.246 ms  be-1211-cs02.350ecermak.il.ibone.comcast.net (96.110.35.5)  256.194 ms  be-1112-cr12.350
ecermak.il.ibone.comcast.net (96.110.35.18)  256.289 ms
24  be-1212-cr12.350ecermak.il.ibone.comcast.net (96.110.35.22)  243.291 ms  be-1312-cr12.350ecermak.il.ibone.comcast.net (96.110.35.26)  243.146 ms  243.064 ms
25  be-301-cr11.newark.nj.ibone.comcast.net (96.110.36.145)  243.248 ms  be-1211-cs02.newyork.ny.ibone.comcast.net (96.110.35.117)  303.358 ms  303.399 ms
26  be-1311-cs03.newyork.ny.ibone.comcast.net (96.110.35.121)  303.483 ms  303.444 ms  be-1111-cs01.newyork.ny.ibone.comcast.net (96.110.35.113)  303.511 ms
27  be-1212-cr12.newyork.ny.ibone.comcast.net (96.110.35.134)  268.684 ms  be-2111-pe11.newark.nj.ibone.comcast.net (96.110.33.242)  274.510 ms  be-302-cr11.newark.
nj.ibone.comcast.net (96.110.36.149)  288.262 ms
28  50.208.232.130 (50.208.232.130)  279.585 ms  272.679 ms  be-302-cr11.newark.nj.ibone.comcast.net (96.110.36.149)  279.596 ms
29  * be-1211-cs02.newark.nj.ibone.comcast.net (96.110.35.69)  273.255 ms  be-2311-pe11.newark.nj.ibone.comcast.net (96.110.33.250)  294.581 ms
30  * 50.208.232.130 (50.208.232.130)  271.518 ms
```

- Amsterdam:

- From:

I want to test from Amsterdam

Let us automate this for you!

Hop	Time	Time	Time	Host name	IP address
1	<1	<1	<1		5.182.210.1
2	1	<1	1		87.245.246.38
3	186	205	186		87.245.232.11
4	*	*	*	Request timed out	
5	200	204	200		203.208.183.250
6	197	197	197		203.208.182.253
7	198	198	200		203.208.175.34
8	231	198	198		202.166.120.202
9	198	198	198		202.166.124.37
10	198	198	198		202.166.124.82
11	198	198	198		202.166.126.25
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	

- To:

```
jamestiotto@JRT-PC:~$ traceroute 5.182.210.1
traceroute to 5.182.210.1 (5.182.210.1), 30 hops max, 60 byte packets
1 _gateway (172.20.10.1) 1.367 ms 1.340 ms 1.374 ms
2 192.168.233.32 (192.168.233.32) 165.375 ms 165.415 ms 165.463 ms
3 10.252.23.101 (10.252.23.101) 110.595 ms 10.252.23.97 (10.252.23.97) 110.430 ms 127.274 ms
4 10.252.12.54 (10.252.12.54) 126.937 ms 10.252.12.50 (10.252.12.50) 126.966 ms 126.950 ms
5 202.166.126.24 (202.166.126.24) 126.898 ms 126.886 ms 126.849 ms
6 202.166.124.81 (202.166.124.81) 126.893 ms 119.747 ms 119.822 ms
7 ae6-0.tp-er03.singnet.com.sg (202.166.126.97) 119.630 ms 33.367 ms 26.024 ms
8 203.208.145.233 (203.208.145.233) 35.941 ms 203.208.191.197 (203.208.191.197) 35.751 ms 203.208.191.113 (203.208.191.113) 35.749 ms
9 203.208.166.202 (203.208.166.202) 199.471 ms 204.451 ms 204.387 ms
10 Linux-224.retn.net (195.66.224.193) 249.412 ms 249.361 ms 249.423 ms
11 ae0-2.RT.IR9.AWS.NL.retn.net (87.245.232.123) 249.202 ms 249.202 ms 240.126 ms
12 * * *
13 * * *
14 * * *
15 * * *
16 * * *
17 * * *
18 * * *
19 * * *
20 * * *
21 * * *
22 * * *
23 * * *
24 * * *
25 * * *
26 * * *
27 * * *
28 * * *
29 * * *
30 * * *
```

● Tokyo:

- From:

Hop	Time	Time	Time	Host name	IP address
1	<1	<1	<1		31.204.145.131
2	68	67	68		109.200.218.223
3	67	67	69		109.200.218.4
4	79	79	79		213.179.200.9
5	77	77	77		203.208.152.2
6	179	178	178		203.208.158.41
7	168	169	168		203.208.175.34
8	179	178	179		202.166.120.202
9	170	172	170		202.166.124.37
10	184	184	184		202.166.124.82
11	171	171	171		202.166.126.25
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	

- To:

```
jamestiotio@JRT-PC:~$ traceroute 31.204.145.131
traceroute to 31.204.145.131 (31.204.145.131), 30 hops max, 60 byte packets
 1  _gateway (172.28.10.1)  0.788 ms  0.708 ms  0.752 ms
 2  192.168.233.32 (192.168.233.32)  42.776 ms  42.814 ms  42.898 ms
 3  10.252.12.54 (10.252.12.54)  32.096 ms  10.252.12.54 (10.252.12.54)  33.023 ms  33.239 ms
 4  10.252.12.54 (10.252.12.54)  33.093 ms  10.252.12.54 (10.252.12.54)  33.143 ms  33.174 ms
 5  202.166.126.24 (202.166.126.24)  34.202 ms  36.407 ms  34.133 ms
 6  202.166.126.81 (202.166.126.81)  34.194 ms  23.532 ms  27.052 ms
 7  ae6-0_tp-er03.singnet.com.sg (202.166.126.97)  27.075 ms  20.977 ms  20.946 ms
 8  203.208.191.197 (203.208.191.197)  20.963 ms  203.208.191.113 (203.208.191.113)  21.064 ms  28.961 ms
 9  203.208.182.249 (203.208.182.249)  29.837 ms  29.894 ms  29.158 ms
10  *  203.208.183.133 (203.208.183.133)  27.110 ms
11  203.208.158.178 (203.208.158.178)  288.858 ms  288.746 ms  ix-xe-0-1-2-0.tcore2.pdi-paloalto.as6453.net (66.198.144.41)  222.589 ms
12  203.208.172.234 (203.208.172.234)  194.682 ms  191.396 ms  196.771 ms
13  ix-xe-0-1-2-0.tcore2.pdi-paloalto.as6453.net (66.198.144.41)  230.075 ms  if-ae-7-2.tcore2.svi-santaclara.as6453.net (209.58.86.73)  346.868 ms  ix-xe-0-1-2-0.t
core2.pdi-paloalto.as6453.net (66.198.144.41)  213.391 ms
14  ix-xe-0-1-2-0.tcore2.pdi-paloalto.as6453.net (66.198.144.41)  213.336 ms  if-ae-2-2.tcore1.pdi-paloalto.as6453.net (66.198.127.1)  346.795 ms  ix-xe-0-1-2-0.tco
re2.pdi-paloalto.as6453.net (66.198.144.41)  215.881 ms
15  if-ae-1-2-0.tcore2.kuching.as6453.net (128.29.211.93)  329.838 ms  if-ae-2-2.tcore1.pdi-paloalto.as6453.net (66.198.127.1)  346.513 ms  if-ae-7-2.tcore2.svi-sant
actrala.as6453.net (209.58.86.73)  346.368 ms  322.777 ms  322.678 ms
16  if-ae-7-2.tcore2.svi-santaclara.as6453.net (209.58.86.73)  346.368 ms  322.777 ms  322.678 ms
17  hosted-by.13d.net (31.204.145.131)  230.983 ms  194.542 ms  if-ae-0-2.tcore1.svi-santaclara.as6453.net (63.243.251.1)  307.984 ms
```

SUTD_LAB:

- New York:
 - From:



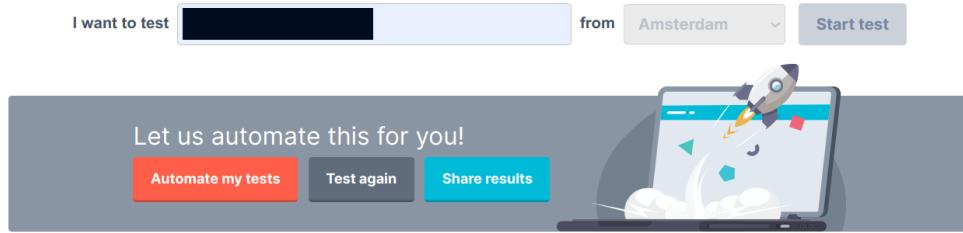
Hop	Time	Time	Time	Host name	IP address
1	1	<1	<1		45.58.112.1
2	2	2	1		50.208.232.129
3	1	1	1		96.110.33.245
4	2	1	1		96.110.35.70
5	2	1	1		96.110.36.146
6	2	2	2		96.110.35.137
7	1	1	1		96.110.38.234
8	1	1	1		75.149.231.198
9	289	287	288		213.144.176.11
10	293	292	294		93.186.133.63
11	*	*	*	Request timed out	
12	274	271	274		61.16.67.185
13	289	287	289		61.16.67.186
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	

- To:

```
jamestiotio@JRT-PC:~$ traceroute 45.58.112.1
traceroute to 45.58.112.1 (45.58.112.1), 30 hops max, 60 byte packets
 1 _gateway (10.21.140.1)  4.412 ms  5.920 ms  5.891 ms
 2 172.16.1.106 (172.16.1.106)  4.225 ms  5.834 ms  5.809 ms
 3 172.16.1.210 (172.16.1.210)  5.779 ms  5.750 ms  5.719 ms
 4 103.24.77.1 (103.24.77.1)  5.988 ms  202.94.70.1 (202.94.70.1)  5.652 ms  103.24.77.1 (103.24.77.1)  5.925 ms
 5 * 203.116.245.177 (203.116.245.177)  6.170 ms  6.141 ms
 6 * *
 7 unknown.telstraglobal.net (210.176.138.173)  5.380 ms * *
 8 202.84.219.178 (202.84.219.178)  20.214 ms  7.290 ms  20.169 ms
 9 202.84.219.178 (202.84.219.178)  22.621 ms * *
10 * 202.84.225.238 (202.84.225.238)  6.000 ms *
11 et-0-0-0-1.cr4-sin1.ip4.gtt.net (183.182.80.169)  5.951 ms * *
12 * ae1.cr2-nyc4.ip4.gtt.net (213.200.112.170)  234.132 ms *
13 * *
14 * *
15 * *
16 * *
17 * *
18 * *
19 * *
20 * *
21 * *
22 * *
23 * *
24 * *
25 * *
26 * *
27 * *
28 * *
29 * *
30 * *
```

• Amsterdam:

- From:



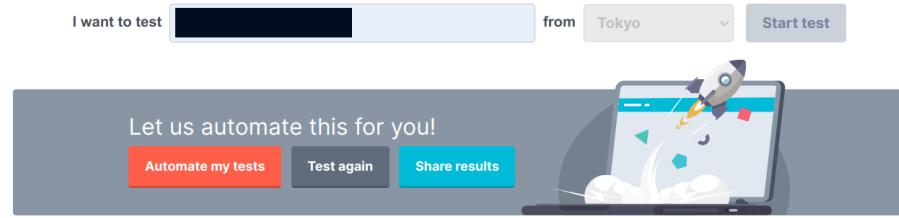
Hop	Time	Time	Time	Host name	IP address
1	1	<1	13		5.182.210.1
2	2	22	38		87.245.246.38
3	6	6	6		87.245.234.112
4	*	*	*	Request timed out	
5	177	168	168		203.118.3.66
6	169	169	169		203.116.239.174
7	*	*	*	Request timed out	
8	170	170	170		61.16.67.185
9	170	170	170		61.16.67.186
10	*	*	*	Request timed 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	

- To:

```
jamestiotio@JRT-PC:~$ traceroute 5.182.210.1
traceroute to 5.182.210.1 (5.182.210.1), 30 hops max, 60 byte packets
 1  _gateway (10.21.140.1)  6.825 ms *
 2  172.16.1.106 (172.16.1.106)  6.636 ms  7.540 ms  7.510 ms
 3  172.16.1.210 (172.16.1.210)  7.481 ms  7.452 ms  7.426 ms
 4  103.24.77.1 (103.24.77.1)  7.968 ms  7.418 ms  7.853 ms
 5  * *
 6  * * 203.118.6.201 (203.118.6.201)  7.600 ms
 7  203.118.4.136 (203.118.4.136)  5.260 ms *
 8  203.116.239.173 (203.116.239.173)  7.318 ms 9002.sgw.equinix.com (27.111.229.103)  5.105 ms 203.116.239.173 (203.116.239.173)  7.243 ms
 9  203.118.6.197 (203.118.6.197)  9.008 ms *
10  203.118.5.98 (203.118.5.98)  7.218 ms  8.235 ms  9.824 ms
11  * 9002.sgw.equinix.com (27.111.229.103)  8.075 ms *
12  * ae0-2.RT.IR9.AMS.NL.retn.net (87.245.232.123)  172.757 ms *
13  * *
14  * *
15  * *
16  * *
17  * *
18  * *
19  * *
20  * *
21  * *
22  * *
23  * *
24  * *
25  * *
26  * *
27  * *
28  * *
29  * *
30  * *
```

● Tokyo:

- From:



Hop	Time	Time	Time	Host name	IP address
1	<1	<1	<1		31.204.145.130
2	<1	<1	<1		109.200.218.1
3	67	67	67		109.200.218.223
4	*	*	*	Request timed out	
5	76	76	76		10.100.11.227
6	77	77	77		61.16.67.185
7	77	77	77		61.16.67.186
8	*	*	*	Request timed out	
9	*	*	*	Request timed out	
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	

- To:

```
jamestiotio@JRT-PC:~$ traceroute 31.204.145.130
traceroute to 31.204.145.130 (31.204.145.130), 30 hops max, 60 byte packets
 1 _gateway (10.21.140.1) 4.791 ms 4.735 ms 4.725 ms
 2 172.16.1.106 (172.16.1.106) 4.702 ms 4.691 ms 4.682 ms
 3 172.16.1.210 (172.16.1.210) 4.671 ms 4.658 ms 4.648 ms
 4 202.94.70.1 (202.94.70.1) 5.371 ms 5.362 ms 103.24.77.1 (103.24.77.1) 5.352 ms
 5 203.116.245.177 (203.116.245.177) 5.889 ms * 5.868 ms
 6 203.118.3.75 (203.118.3.75) 5.315 ms *
 7 ix-be-15.ecore1.svw-singapore.as6453.net (180.87.106.0) 5.482 ms 5.472 ms *
 8 203.116.239.173 (203.116.239.173) 8.469 ms * 8.449 ms
 9 * 203.118.3.75 (203.118.3.75) 7.974 ms *
10 ix-be-15.ecore1.svw-singapore.as6453.net (180.87.106.0) 7.911 ms * *
11 * * *
12 if-ae-44-2.tcore2.tv2-tokyo.as6453.net (180.87.181.191) 102.093 ms 102.083 ms *
13 * 180.87.181.147 (180.87.181.147) 85.148 ms 85.138 ms
14 * * *
15 * * *
16 * * *
17 * * *
18 * * *
19 * * *
20 * * *
21 * * *
22 * * *
23 * * *
24 * * *
25 * * *
26 * * *
27 * * *
28 * * *
29 * * *
30 * * *
```

Question 7 [5pt]: 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?

Your answer:

The traceroutes were done by using a personal mobile data network and the SUTD_LAB network since the SUTD_Wifi's internal network seems to block incoming (but not outgoing) traceroute ICMP (and perhaps UDP as well) requests from certain hosts. In particular, the Amsterdam and Tokyo host servers seem to also block incoming traceroute ICMP (and maybe UDP) requests. These timed out requests for the Amsterdam and Tokyo cases might be caused by firewalls blocking traceroute ICMP (and maybe UDP) requests. The New York traceroute requests seem to go past beyond 25/30 hops and thus it did not finish/reach either endpoint within the specified limit of number of hops. Extending or increasing the maximum number of hops by using the -m flag will result in a series of timeouts near the ending part anyway.

The routes that are being traversed in one direction are not the same (i.e., asymmetric) as the routes being traversed in the opposite direction.

Different routers are traversed in both directions. This is because the routing table will automatically resolve the best most optimized path of routers at that specific point in time between the two endpoints, which is highly dependent on the global Internet traffic distribution between all the routers/nodes at that point in time. In fact, an identical, symmetric, or similar to-and-fro route would be suspicious since it might indicate that someone is directly attempting to control, monitor, modify and tamper with the network route.