# Internet Routes and Measure of Round Trip Times

Lab 4

*50.005 Computer System Engineering*

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



**Natalie Agus**
INFORMATION SYSTEMS TECHNOLOGY AND DESIGN

# 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.**

**These would inevitably increase the delay, and in turn, the minimum round-trip time for the packets to complete the transmission process.**

**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.

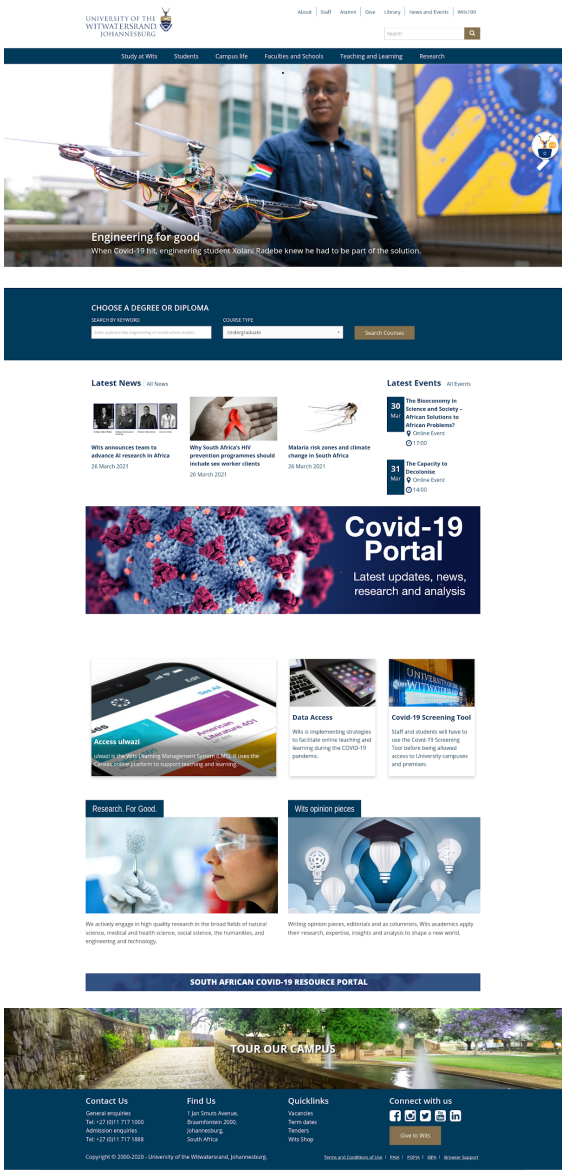
**Your answer:**

**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.**




**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.**
- **The network might be dropping packets due to network congestion.**

# 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 com- mand 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.**

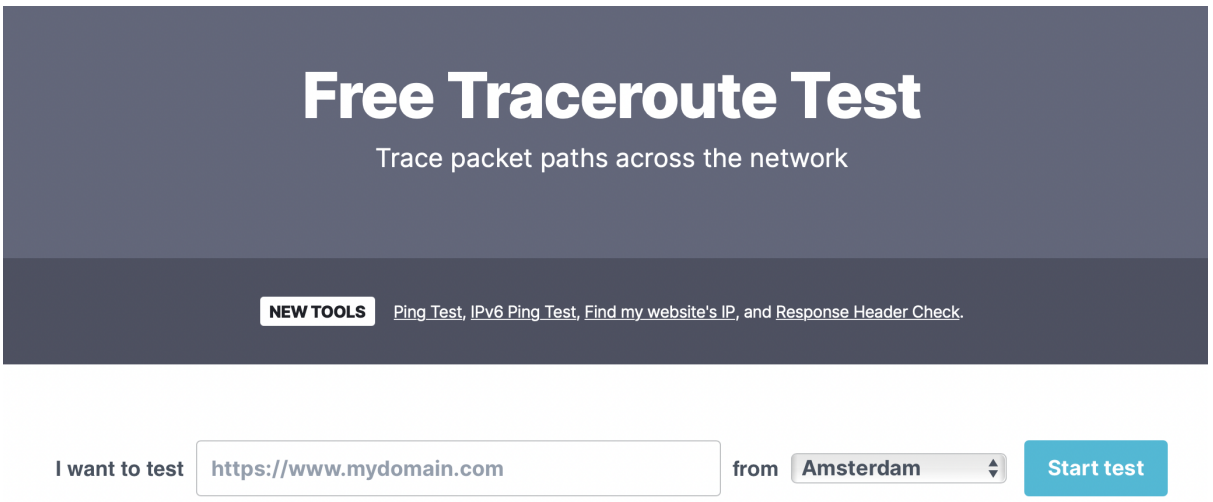
3. **The sender's `traceroute` process will then measure the amount of time taken from the packet was sent until the packet is received back at the sender from router i at each probe. This amount of time is considered the round-trip time (RTT), which depends on network infrastructure, internodal distance,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

## Route asymmetries

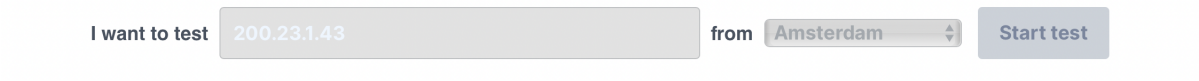
In this exercise, you will run traceroute in two opposite directions. First, you will run traceroute on a remote host to see the route taken to your network. You will also run traceroute from your computer to see the route taken to that host.

**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.




| 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.snjsca04.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 | - | - | - | | |

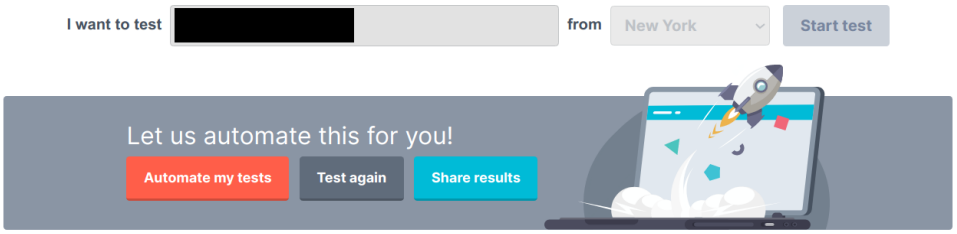
**Step 4:** On your computer, run `traceroute` using the IP address recorded in the previous step as the remote destination.

`$ 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:**

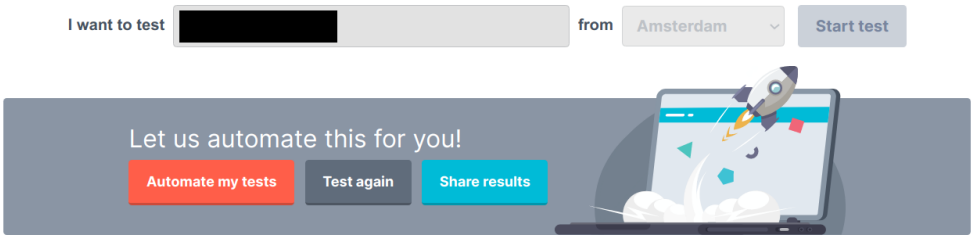



| Hop | Time | Time | Time | Host name | IP address |
|---|---|---|---|---|---|
| 1 | <1 | <1 | <1 | | 45.58.112.1 |
| 2 | 2 | 2 | 2 | | 50.208.232.129 |
| 3 | 1 | 1 | 1 | | 96.110.33.245 |
| 4 | 2 | 2 | 2 | | 96.110.35.86 |
| 5 | 7 | 7 | 7 | | 96.110.36.117 |
| 6 | 8 | 7 | 7 | | 96.110.34.153 |
| 7 | 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 (172.20.10.1)  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  10.252.23.97 (10.252.23.97)  112.139 ms  111.993 ms 10.252.23.101 (10.252.23.101)  140.226 ms
 4  10.252.12.54 (10.252.12.54)  139.739 ms  139.542 ms 10.252.12.50 (10.252.12.50)  139.194 ms
 5  202.166.126.24 (202.166.126.24)  139.185 ms  138.973 ms  138.779 ms
 6  202.166.124.81 (202.166.124.81)  138.772 ms  126.122 ms  126.010 ms
 7  ae6-0.tp-er03.singnet.com.sg (202.166.126.97)  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  203.208.182.249 (203.208.182.249)  32.845 ms  32.769 ms  49.247 ms
10  203.208.172.226 (203.208.172.226)  211.416 ms te-0-8-0-2-7-pe02.529bryant.ca.ibone.comcast.net (75.149.231.241)  223.631 ms  223.573 ms
11  203.208.158.178 (203.208.158.178)  207.449 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-cs04.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)  190.848 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 (96.110.37.209)  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)  248.274 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
s01.1601milehigh.co.ibone.comcast.net (96.110.39.113)  243.163 ms
20  be-1414-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
.1601milehigh.co.ibone.comcast.net (96.110.39.66)  242.982 ms
21  be-1112-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
.350ecermak.il.ibone.comcast.net (96.110.35.18)  251.286 ms
22  be-1111-cs01.350ecermak.il.ibone.comcast.net (96.110.35.1)  251.146 ms * be-302-cr11.newyork.ny.ibone.comcast.net (96.110.38.70)  289.553 ms
23  be-1111-cs01.350ecermak.il.ibone.comcast.net (96.110.35.1)  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)  256.280 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)  280.262 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:**

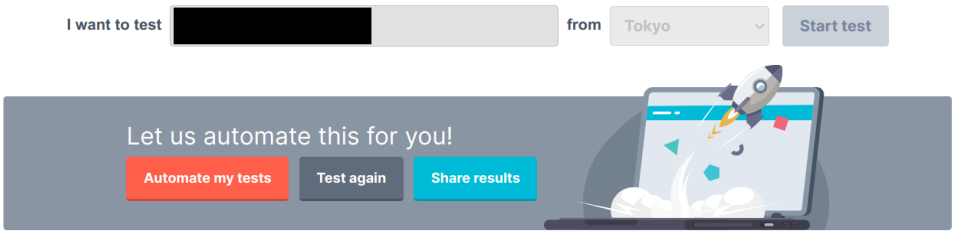



| Hop | Time | Time | Time | Host name | IP address |
|---|---|---|---|---|---|
| 1 | <1 | <1 | <1 | | 5.182.210.1 |
| 2 | 1 | <1 | 1 | | 87.245.246.38 |
| 3 | 186 | 205 | 186 | | 87.245.232.11 |
| 4 | * | * | * | Request timed out | |
| 5 | 200 | 204 | 200 | | 203.208.183.250 |
| 6 | 197 | 197 | 197 | | 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:**

```
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 (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)  119.830 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  linx-224.retn.net (195.66.224.193)  249.412 ms  249.361 ms  249.423 ms
11  ae0-2.RT.IR9.AMS.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:**



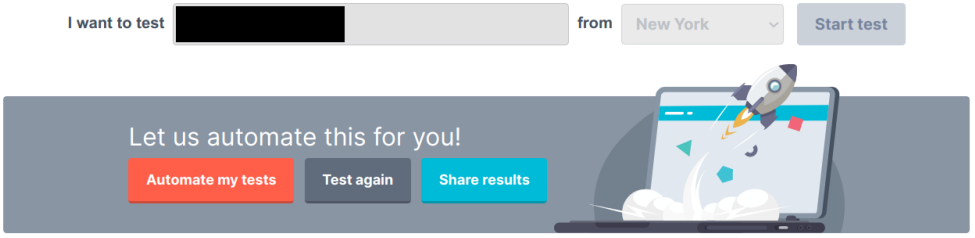

| Hop | Time | Time | Time | Host name | IP address |
|---|---|---|---|---|---|
| 1 | <1 | <1 | <1 | | 31.204.145.131 |
| 2 | 68 | 67 | 68 | | 109.200.218.223 |
| 3 | 67 | 67 | 69 | | 109.200.218.4 |
| 4 | 79 | 79 | 79 | | 213.179.200.9 |
| 5 | 77 | 77 | 77 | | 203.208.152.2 |
| 6 | 179 | 178 | 178 | | 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 (172.20.10.1)  0.708 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  10.252.23.101 (10.252.23.101)  32.996 ms 10.252.23.97 (10.252.23.97)  33.023 ms  33.239 ms
 4  10.252.12.54 (10.252.12.54)  33.093 ms 10.252.12.50 (10.252.12.50)  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  202.166.124.81 (202.166.124.81)  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)  208.850 ms  208.746 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)  194.602 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.sv1-santaclara.as6453.net (209.58.86.73)  346.868 ms ix-xe-0-1-2-0.tcore2.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.tcore2.pdi-paloalto.as6453.net (66.198.144.41)  215.881 ms
15  if-et-1-2.hcore2.kv8-chiba.as6453.net (120.29.211.3)  329.838 ms if-ae-2-2.tcore1.pdi-paloalto.as6453.net (66.198.127.1)  346.513 ms if-ae-7-2.tcore2.sv1-santaclara.as6453.net (209.58.86.73)  346.428 ms
16  if-ae-7-2.tcore2.sv1-santaclara.as6453.net (209.58.86.73)  346.368 ms  322.777 ms  322.678 ms
17  hosted-by.i3d.net (31.204.145.131)  230.983 ms  194.542 ms if-ae-0-2.tcore1.sv1-santaclara.as6453.net (63.243.251.1)  307.984 ms
```

## SUTD_LAB:

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



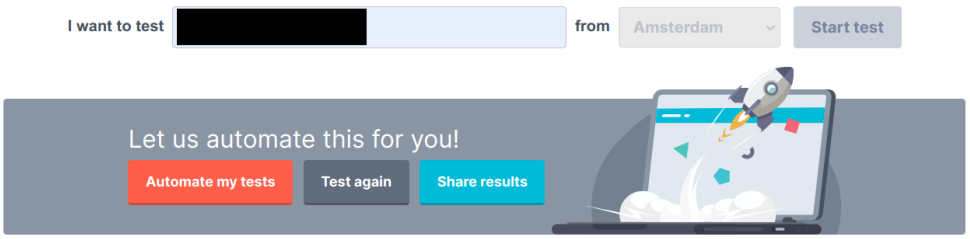

| Hop | Time | Time | Time | Host name | IP address |
|---|---|---|---|---|---|
| 1 | 1 | <1 | <1 | | 45.58.112.1 |
| 2 | 2 | 2 | 1 | | 50.208.232.129 |
| 3 | 1 | 1 | 1 | | 96.110.33.245 |
| 4 | 2 | 1 | 1 | | 96.110.35.70 |
| 5 | 2 | 1 | 1 | | 96.110.36.146 |
| 6 | 2 | 2 | 2 | | 96.110.35.137 |
| 7 | 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:**

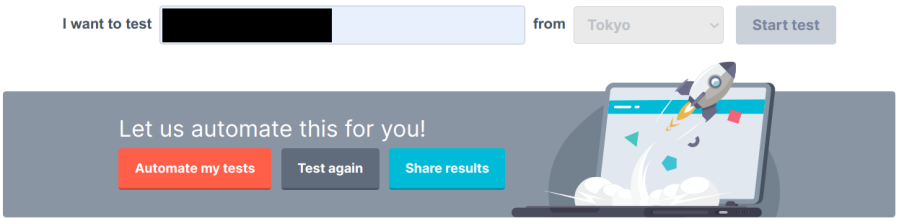



| Hop | Time | Time | Time | Host name | IP address |
|---|---|---|---|---|---|
| 1 | 1 | <1 | 13 | | 5.182.210.1 |
| 2 | 2 | 22 | 38 | | 87.245.246.38 |
| 3 | 6 | 6 | 6 | | 87.245.234.112 |
| 4 | * | * | * | Request timed out | |
| 5 | 177 | 168 | 168 | | 203.118.3.66 |
| 6 | 169 | 169 | 169 | | 203.116.239.174 |
| 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)  7.908 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.**