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**Lab 2: Basic Network Utilities**



This lab introduces some basic network monitoring/analysis tools. There are a few exercises along the way. You should write up answers to the ***ping*** and ***traceroute*** exercises and turn them in next lab. (You should try out each tool, whether it is needed for an exercise or not!).

Prerequisite: Basic understanding of command line utilities of Linux Operating system.

**Some Basic command line Networking utilities**

Start with a few of the most basic command line tools. These commands are available on Unix, including Linux (and the first two, at least, are also for Windows). Some parameters or options might differ on different operating systems. Remember that you can use man <command> to get information about a command and its options.

**ping** — The command ping <host> sends a series of packets and expects to receieve a response to eachpacket. When a return packet is received, ping reports the round trip time (the time between sending the packet and receiving the response). Some routers and firewalls block ping requests, so you might get no reponse at all. Ping can be used to check whether a computer is up and running, to measure network delay time, and to check for dropped packets indicating network congestion. Note that <host> can be either a domain name or an IP address. By default, ping will send a packet every second indefinitely; stop it with Control-C

Network latency, specifically round trip time (RTT), can be measured using ping, which sends ICMP packets. The syntax for the command in Linux or Mac OS is:

ping [-c <count>] [-s <packetsize>] <hostname>

The syntax in Windows is:

ping [-n <count>] [-l <packetsize>] <hostname>

The default number of ICMP packets to send is either infinite (in Linux and Mac OS) or 4 (in Windows). The default packet size is either 64 bytes (in Linux) or 32 bytes (in Windows). You can specify either a hostname (e.g., spit.ac.in) or an IP address.

To save the output from ping to a file, include a greater than symbol and a file name at the end of the command. For example:

ping -c 10 google.com > ping\_c10\_s64\_google.log

**Experiments with Ping**

1. Ping the any hosts 10 times (i.e., packet count is 10) with a packet size of 64 bytes, 100 bytes, 500 bytes, 1000 bytes, 1400 bytes

**Questions About Latency**

Now look at the results you gathered and answer the following questions about latency. Store your answers in a file named ping.txt.

1. Does the average RTT vary between different hosts? What aspects of latency (transmit, propagation, and queueing delay) might impact this and why?
2. Does the average RTT vary with different packet sizes? What aspects of latency (transmit, propagation, and queueing delay) might impact this and why?

**Exercise 1**: Experiment with ping to find the round trip times to a variety of destinations. Write up any interesting observations, including in particular how the round trip time compares to the physical distance. Here are few places from who to get replies: www.uw.edu, www.cornell.edu, berkeley.edu, www.uchicago.edu, www.ox.ac.uk (England), www.u-tokyo.ac.jp (Japan).

**nslookup** — The command nslookup <host> will do a DNS query to find and report the IP address (oraddresses) for a domain name or the domain name corresponding to an IP address. To do this, it contacts a "DNS server." Default DNS servers are part of a computer's network configuration. (For a static IP address in Linux, they are configured in the file /etc/network/interfaces that you encountered in the last lab.) You can specify a different DNS server to be used by nslokup by adding the server name or IP address to the command: nslookup <host> <server>

**ifconfig** — You used ifconfig in the previous lab. When used with no parameters, ifconfig reports someinformation about the computer's network interfaces. This usually includes lo which stands for localhost; it can be used for communication between programs running on the same computer. Linux often has an interface named eth0, which is the first ethernet card. The information is different on Mac OS and Linux, but includes the IP or "inet" address and ethernet or "hardware" address for an ethernet card. On Linux, you get the number of packets received (RX) and sent (TX), as well as the number of bytes transmitted and received. (A better place to monitor network bytes on our Linux computers is in the GUI program System Monitor, if it is installed!!!.)

**netstat** — The netstat command gives information about network connections. I often use netstat -t -nwhich lists currently open TCP connections (that's the "-t" option) by IP address rather than domain name (that's the "-n" option). Add the option "-l" (lower case ell) to list listening sockets, that is sockets that have been opened by server programs to wait for connection requests from clients: netstat -t -n -l. (On Mac, use netstat -p tcp to list tcp connections, and add "-a" to include listening sockets in the list.)

**telnet** — Telnet is an old program for remote login. It's not used so much for that any more, since it hasno security features. But basically, all it does is open a connection to a server and allow server and client to send lines of plain text to each other. It can be used to check that it's possible to connect to a server and, if the server communicates in plain text, even to interact with the server by hand. Since the Web uses a plain text protocol, you can use telnet to connect to a web client and play the part of the web browser. I will suggest that you to do this with your own web server when you write it, but you might want to try it now. When you use telnet in this way, you need to specify both the host and the port number to which you want to connect: telent <host> <port>. For example, to connect to the web server on www.spit.ac.in: telnet spit.ac.in 80

**traceroute** — Traceroute is discussed in man utility. The command traceroute <host> will show routers encountered by packets on their way from your computer to a specified <host>. For each n = 1, 2, 3,..., traceroute sends a packet with "time-to-live" (ttl) equal to n. Every time a router forwards a packet, it decreases the ttl of the packet by one. If the ttl drops to zero, the router discards the packet and sends an error message back to the sender of the packet. (Again, as with ping, the packets might be blocked or might not even be sent, so that the error messages will never be received.) The sender gets the identity of the router from the source of the error message. Traceroute will send packets until n reaches some set upper bound or until a packet actually gets through to the destination. It actually does this three times for each n. In this way, it identifies routers that are one step, two steps, three steps, ... away from the source computer. A packet for which no response is received is indicated in the output as a \*.

Traceroute is installed on the computers. If was not installed in your virtual server last week, but you can install it with the command sudo apt-get install traceroute

The path taken through a network can be measured using traceroute. The syntax for the command in Linux is:

traceroute <hostname>

The syntax in Windows is:

tracert <hostname>

You can specify either a hostname (e.g., cs.iitb.ac.in) or an IP address (e.g., 128.105.2.6).

**1.2.1 Experiments with Traceroute**

From **your machine** traceroute to the following hosts:

1. ee.iitb.ac.in
2. mscs.mu.edu
3. www.cs.grinnell.edu
4. csail.mit.edu
5. cs.stanford.edu
6. cs.manchester.ac.uk

Store the output of each traceroute command in a separate file named traceroute\_HOSTNAME.log, replacing HOSTNAME with the hostname for end-host you pinged

(e.g., traceroute\_ee.iitb.ac.in.log).

**Exercise 2:** (Very short.) Use traceroute to trace the route from your computer to math.hws.edu and towww.hws.edu. Explain the difference in the results.

**Exercise 3:** Two packets sent from the same source to the same destination do not necessarily follow thesame path through the net. Experiment with some sources that are fairly far away. Can you find cases where packets sent to the same destination follow different paths? How likely does it seem to be? What about when the packets are sent at very different times? Save some of the outputs from traceroute. (You can copy them from the Terminal window by highlighting and right-clicking, then paste into a text editor.) Come back sometime next week, try the same destinations again, and compare the results with the results from today. Report your observations.

**Questions About Paths**

Now look at the results you gathered and answer the following questions about the paths taken by your packets. Store your answers in a file named traceroute.txt.

1. Is any part of the path common for all hosts you tracerouted?
2. Is there a relationship between the number of nodes that show up in the traceroute and the location of the host? If so, what is this relationship?
3. Is there a relationship between the number of nodes that show up in the traceroute and latency of the host (from your ping results above)? Does the same relationship hold for all hosts?

**Whois** — The *whois* command can give detailed information about domain names and IP addresses. If it is not installed on the computers then install it with command sudo apt-get install whois in. *Whois* can tell you what organization owns or is responsible for the name or address and where to contact them. It often includes a list of domain name servers for the organization.

When using *whois* to look up a domain name, use the simple two-part network name, not an individual computer name (for example, *whois spit.ac.in*).

**Exercise 4:** (Short.) Use*whois*to investigate a well-known web site such as google.com oramazon.com, and write a couple of sentences about what you find out.

**Exercise 5:** (Should be short.) Because of NAT, the domain name*spit.ac.in*has a different IP addressoutside of SPIT than it does on campus. Using information in this lab and working on a home computer, find the outside IP address for spit.ac.in. Explain how you did it.

Geolocation — A geolocation service tries to tell, approximately, where a given IP address is located physically. They can't be completely accurate—but they probably get at least the country right most of the time.

This geolocation program is not installed on our computers, but you can access one on the command line using the *curl* command, which can send HTTP requests and display the response. The following command uses *curl* to contact a public web service that will look up an IP address for you: curl ipinfo.io/<IP-address>. For a specific example:

curl ipinfo.io/129.64.99.200

(As you can see, you get back more than just the location.)

**Exercise 6:** Find a few IP addresses that are connected to the web server on spit.ac.in right now,and determine where those IP addresses are located. (I'm expecting that there will be several; if not, try again in a few minutes or sometime later.) Find one that is far from Geneva, NY. Explain how you did it.

**Ex 1**:

**Washington University Webpage (**[**www.uw.edu**](http://www.uw.edu)**)**

\*Example PING output for [Washington University](http://www.uw.edu)

PING www.washington.edu (128.95.155.135) 64(92) bytes of data.

72 bytes from www2.cac.washington.edu (128.95.155.135): icmp\_seq=1 ttl=49 time=306 ms

72 bytes from www2.cac.washington.edu (128.95.155.135): icmp\_seq=2 ttl=49 time=328 ms

72 bytes from www2.cac.washington.edu (128.95.155.135): icmp\_seq=3 ttl=49 time=249 ms

72 bytes from www2.cac.washington.edu (128.95.155.135): icmp\_seq=4 ttl=49 time=272 ms

72 bytes from www2.cac.washington.edu (128.95.155.135): icmp\_seq=5 ttl=49 time=294 ms

72 bytes from www2.cac.washington.edu (128.95.155.135): icmp\_seq=6 ttl=49 time=316 ms

72 bytes from www2.cac.washington.edu (128.95.155.135): icmp\_seq=7 ttl=49 time=339 ms

72 bytes from www2.cac.washington.edu (128.95.155.135): icmp\_seq=8 ttl=49 time=260 ms

72 bytes from www2.cac.washington.edu (128.95.155.135): icmp\_seq=9 ttl=49 time=282 ms

72 bytes from www2.cac.washington.edu (128.95.155.135): icmp\_seq=10 ttl=49 time=305 ms

--- www.washington.edu ping statistics ---

10 packets transmitted, 10 received, 0% packet loss, time 9012ms

rtt min/avg/max/mdev = 248.644/295.067/339.142/27.918 ms

PING www.washington.edu (128.95.155.134) 100(128) bytes of data.

108 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=1 ttl=49 time=306 ms

108 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=2 ttl=49 time=331 ms

108 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=3 ttl=49 time=355 ms

108 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=4 ttl=49 time=276 ms

108 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=5 ttl=49 time=301 ms

108 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=6 ttl=49 time=325 ms

108 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=7 ttl=49 time=348 ms

108 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=8 ttl=49 time=269 ms

108 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=9 ttl=49 time=293 ms

108 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=10 ttl=49 time=317 ms

--- www.washington.edu ping statistics ---

10 packets transmitted, 10 received, 0% packet loss, time 9001ms

rtt min/avg/max/mdev = 268.826/312.047/354.955/27.011 ms

PING www.washington.edu (128.95.155.134) 500(528) bytes of data.

508 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=1 ttl=49 time=320 ms

508 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=2 ttl=49 time=342 ms

508 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=3 ttl=49 time=263 ms

508 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=4 ttl=49 time=285 ms

508 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=5 ttl=49 time=308 ms

508 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=6 ttl=49 time=331 ms

508 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=7 ttl=49 time=242 ms

508 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=8 ttl=49 time=274 ms

508 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=9 ttl=49 time=240 ms

508 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=10 ttl=49 time=320 ms

--- www.washington.edu ping statistics ---

10 packets transmitted, 10 received, 0% packet loss, time 9011ms

rtt min/avg/max/mdev = 239.539/292.376/341.950/35.049 ms

PING www.washington.edu (128.95.155.134) 1000(1028) bytes of data.

1008 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=1 ttl=49 time=241 ms

1008 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=2 ttl=49 time=240 ms

1008 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=3 ttl=49 time=308 ms

1008 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=4 ttl=49 time=240 ms

1008 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=5 ttl=49 time=241 ms

1008 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=6 ttl=49 time=263 ms

1008 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=7 ttl=49 time=297 ms

1008 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=8 ttl=49 time=313 ms

1008 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=9 ttl=49 time=452 ms

1008 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=10 ttl=49 time=267 ms

--- www.washington.edu ping statistics ---

10 packets transmitted, 10 received, 0% packet loss, time 9006ms

rtt min/avg/max/mdev = 239.932/286.231/451.854/61.718 ms

PING www.washington.edu (128.95.155.134) 1400(1428) bytes of data.

1408 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=1 ttl=49 time=408 ms

1408 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=2 ttl=49 time=325 ms

1408 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=3 ttl=49 time=348 ms

1408 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=4 ttl=49 time=374 ms

1408 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=5 ttl=49 time=292 ms

1408 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=6 ttl=49 time=315 ms

1408 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=7 ttl=49 time=338 ms

1408 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=8 ttl=49 time=258 ms

1408 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=9 ttl=49 time=280 ms

1408 bytes from www1.cac.washington.edu (128.95.155.134): icmp\_seq=10 ttl=49 time=303 ms

--- www.washington.edu ping statistics ---

10 packets transmitted, 10 received, 0% packet loss, time 9010ms

rtt min/avg/max/mdev = 257.516/324.086/408.491/42.766 ms

\*Washington University physical distance : **18,666.6** km (roughly)

* Round trip time for **64** bytes

min = 248.644 ms

avg = **295.067** ms

max = 339.142 ms

* Round trip time for **100** bytes

min = 268.826 ms

avg = **312.047** ms

max = 354.955 ms

* Round trip time for **500** bytes

min = 239.539 ms

avg = **292.376** ms

max = 341.950 ms

* Round trip time for **1000** bytes

min = 239.932 ms

avg = **286.231** ms

max = 451.854 ms

* Round trip time for **4000** bytes

min = 257.516 ms

avg = **324.086** ms

max = 408.491 ms

Similar results are seen when pinging other websites. They generally have the **same** average round trip time irrespective of **packet size**. There is **no clear trend.**

**Berkeley University, California** ([berkeley.edu](http://berkeley.edu))

\*Berkeley website uses AWS server in West US ([www-production-1113102805.us-west-2.elb.amazonaws.com](http://www-production-1113102805.us-west-2.elb.amazonaws.com)).

But it is still a similar distance away from India i.e **18,666.6**km(roughly)

* Average round trip time for 64 byte packet: **285.658** ms
* Average round trip time for 100 byte packet: **293.094** ms
* Average round trip time for 500 byte packet: **314.845** ms
* Average round trip time for 1000 byte packet: **309.332** ms
* Average round trip time for 4000 byte packet: **289.739** ms

**Oxford University, Australia**([www.ox.ac.uk](http://www.ox.ac.uk))

\*This webpage is hosted in Australia as opposed to USA. We observed similar Round trip time in both above cases, but in this case we see a drastic **reduction** in Round trip time as compared to the former websites.

Oxford University distance: **7000**km

* Average round trip time for 64 byte packet: **40.506** ms
* Average round trip time for 100 byte packet: **51.796** ms
* Average round trip time for 500 byte packet: **40.751** ms
* Average round trip time for 1000 byte packet: **49.616** ms
* Average round trip time for 4000 byte packet: **53.816** ms

Hence, we conclude that the Round Trip Time varies with the physical distance that it has to travel, and the size of packets sent doesn't influence the Round Trip Time. The other webpages were pinged but didn’t give any response/were blocked via firewall.

**Ex 2**:

**traceroute math.hws.edu**

traceroute to math.hws.edu (64.89.144.237), 30 hops max, 60 byte packets

1 **\_gateway** (192.168.43.1) 8.073 ms 7.636 ms 9.969 ms

2 192.168.0.1 (192.168.0.1) 13.749 ms 16.701 ms 19.020 ms

3 nsg-static-122.167.76.182-**airtel**.com (182.76.167.122) 24.354 ms 41.534 ms 50.127 ms

4 10.237.0.205 (10.237.0.205) 52.492 ms \* \*

5 182.74.195.161 (182.74.195.161) 43.511 ms 45.478 ms 47.496 ms

6 182.79.255.9 (182.79.255.9) 289.265 ms 182.79.239.78 (182.79.239.78) 236.587 ms 182.79.211.194 (182.79.211.194) 231.148 ms

7 ae58.edge1.**LosAngeles6**.Level3.net (4.26.0.17) 227.885 ms xe-9-1-0.edge1.LosAngeles6.Level3.net (4.26.0.61) 228.929 ms ae58.edge1.LosAngeles6.Level3.net (4.26.0.17) 229.827 ms

8 \* \* \*

9 \* \* \*

10 roc1-ar5-xe-0-0-0-0.us.**twtelecom**.net (35.248.1.158) 288.757 ms 290.979 ms 360.215 ms

11 66-195-65-170.static.**ctl**.one (66.195.65.170) 360.140 ms 408.000 ms 407.923 ms

12 **nat.hws.edu** (64.89.144.100) 407.737 ms 407.771 ms \*

13 \* \* \*

14 \* \* \*

15 \* \* \*

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27 \* \* \*

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29 \* \* \*

30 \* \* \*

**traceroute www.hws.edu**

traceroute to www.hws.edu (64.89.145.159), 30 hops max, 60 byte packets

1 **\_gateway** (192.168.43.1) 3.805 ms 4.394 ms 4.360 ms

2 192.168.0.1 (192.168.0.1) 6.808 ms 8.412 ms 9.375 ms

3 nsg-static-122.167.76.182-**airtel**.com (182.76.167.122) 9.332 ms 9.284 ms 9.235 ms

4 \* \* \*

5 182.74.195.161 (182.74.195.161) 19.480 ms 19.466 ms 19.753 ms

6 182.79.239.78 (182.79.239.78) 238.537 ms 182.79.211.194 (182.79.211.194) 226.767 ms 182.79.201.106 (182.79.201.106) 229.856 ms

7 ae58.edge1.**LosAngeles6**.Level3.net (4.26.0.17) 229.735 ms xe-9-1-0.edge1.LosAngeles6.Level3.net (4.26.0.61) 229.763 ms ae58.edge1.LosAngeles6.Level3.net (4.26.0.17) 235.125 ms

8 ae-2-52.ear3.**LosAngeles1**.Level3.net (4.69.207.49) 222.579 ms 225.831 ms 224.634 ms

9 \* \* \*

10 roc1-ar5-xe-0-0-0-0.us.**twtelecom**.net (35.248.1.158) 294.884 ms \* \*

11 \* 66-195-65-170.static.**ctl**.one (66.195.65.170) 409.801 ms 409.664 ms

12  **nat.hws.edu** (64.89.144.100) 409.463 ms 409.477 ms 409.433 ms

13 \* \* \*

14 \* \* \*

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29 \* \* \*

30 \* \* \*

* Both pages are different, but fetched from the same server, as indicated by the same IP address.
* The first website route goes to a bogon server, whereas second site route doesn’t

{

"ip": "10.237.0.205",

"bogon": true

}

* The IP address of one server in the middle changes, but the location and organisation is the same for both “BHARTI Airtel Ltd.”. So, it’s probably routed to different IP’s in the same Network Service Provider’s Server.

math.hws.edu

{

"ip": "182.79.255.9",

"city": "Gurgaon",

"region": "Haryana",

"country": "IN",

"loc": "28.4601,77.0263",

"org": "AS9498 BHARTI Airtel Ltd.",

"postal": "122004",

"timezone": "Asia/Kolkata",

"readme": "https://ipinfo.io/missingauth"

}

www.hws.edu

{

"ip": "182.79.239.78",

"city": "Gurgaon",

"region": "Haryana",

"country": "IN",

"loc": "28.4601,77.0263",

"org": "AS9498 BHARTI Airtel Ltd.",

"postal": "122004",

"timezone": "Asia/Kolkata",

"readme": "<https://ipinfo.io/missingauth>"

}

* The IP address of one server in the middle belonging to L.A. changes, but the location and organisation is the same “LosAngeles1.Level3.net” . So, it’s probably routed to one more IP’s in the same Network Service Provider’s Server.

**Ex 3**:

* As part of this experiment, we tracerouted [**google**](http://www.google.com) multiple times, **afternoon** and **evening**, and after a gap of **4 days**, starting Tuesday.
* We observed that the path taken is slightly different, but the number of nodes is the same i.e 8. And the path taken is not dependent on time of the day.
* We also observe that it connects to Google LLC Bombay, so we tried with the institutes pinged above to get some traceroute results from IP’s far away.

\*Tuesday 18/08/20 Afternoon

traceroute to www.google.com (216.58.199.132), 30 hops max, 60 byte packets

1 \_gateway (192.168.0.1) 5.518 ms 5.455 ms 5.406 ms

2 nsg-static-122.167.76.182-airtel.com (182.76.167.122) 5.358 ms 5.306 ms 5.256 ms

3 10.237.0.205 (10.237.0.205) 13.415 ms \* \*

4 124.40.245.250 (124.40.245.250) 15.177 ms 15.325 ms 15.280 ms

5 209.85.149.210 (209.85.149.210) 32.838 ms 32.860 ms 32.814 ms

6 108.170.248.193 (108.170.248.193) 33.062 ms 108.170.248.209 (108.170.248.209) 32.373 ms 33.030 ms

7 72.14.239.235 (72.14.239.235) 30.523 ms 30.862 ms 30.773 ms

8 bom07s01-in-f4.1e100.net (216.58.199.132) 31.243 ms 31.137 ms 31.072 ms

\*Tuesday 18/08/20 Evening

traceroute to www.google.com (172.217.174.228), 30 hops max, 60 byte packets

1 \_gateway (192.168.43.1) 2.678 ms 7.264 ms 7.554 ms

2 192.168.0.1 (192.168.0.1) 9.967 ms 11.747 ms 12.299 ms

3 nsg-static-122.167.76.182-airtel.com (182.76.167.122) 13.211 ms 13.578 ms 13.974 ms

4 \* \* \*

5 124.40.245.250 (124.40.245.250) 22.923 ms 23.276 ms 23.676 ms

6 209.85.149.210 (209.85.149.210) 44.491 ms 34.201 ms 33.858 ms

7 108.170.248.161 (108.170.248.161) 32.676 ms 108.170.248.177 (108.170.248.177) 34.814 ms 108.170.248.161 (108.170.248.161) 33.171 ms

8 142.250.60.135 (142.250.60.135) 36.740 ms 37.483 ms 38.417 ms

9 bom12s03-in-f4.1e100.net (172.217.174.228) 33.705 ms 36.148 ms 38.870 ms

\*Saturday 22/08/20 Afternoon

Tracing route to www.google.com [142.250.67.164]

over a maximum of 30 hops:

1 1 ms 1 ms 2 ms 192.168.0.1

2 5 ms 8 ms 5 ms nsg-static-122.167.76.182-airtel.com [182.76.167.122]

3 17 ms 15 ms 13 ms 10.237.0.205

4 12 ms 12 ms 12 ms 124.40.245.250

5 30 ms 29 ms 29 ms 209.85.149.210

6 29 ms 29 ms 30 ms 108.170.248.177

7 29 ms 29 ms 29 ms 142.250.227.75

8 29 ms 33 ms 31 ms bom12s07-in-f4.1e100.net [142.250.67.164]

\*Saturday 22/08/20 Evening

Tracing route to www.google.com [142.250.67.228]

over a maximum of 30 hops:

1 2 ms 1 ms 2 ms 192.168.0.1

2 2 ms 2 ms 2 ms nsg-static-122.167.76.182-airtel.com [182.76.167.122]

3 13 ms 12 ms 12 ms 10.237.0.205

4 13 ms 13 ms 14 ms 124.40.245.250

5 32 ms 30 ms 29 ms 209.85.149.210

6 30 ms 30 ms 32 ms 108.170.248.209

7 31 ms 29 ms 29 ms 216.239.58.19

8 32 ms 29 ms 29 ms bom07s24-in-f4.1e100.net [142.250.67.228]

* **Washington University** ([www.uw.edu](http://www.uw.edu)) and **Oxford University** ([www.ox.ac.uk](http://www.ox.ac.uk)) were also tested on Saturday(22/08/2020) and the next Monday(24/08/2020), since they are both farther from India.

**Saturday 22/08/2020**

(Washington University)

traceroute to **www.uw.edu** (128.95.155.135), 30 hops max, 60 byte packets

1 \_gateway (192.168.0.1) 2.029 ms 2.658 ms 2.628 ms

2 nsg-static-122.167.76.182-airtel.com (182.76.167.122) 2.899 ms 2.859 ms 2.825 ms

**3**  \* \* \*

4 182.74.195.161 (182.74.195.161) 14.713 ms 15.859 ms 15.740 ms

5 182.79.224.145 (182.79.224.145) 55.716 ms 116.119.49.240 (116.119.49.240) 55.069 ms 182.79.146.196 (182.79.146.196) 56.498 ms

6 63-218-107-193.static.pccwglobal.net (63.218.107.193) 51.900 ms \* \*

7 TenGE0-3-0-1.br03.sea01.pccwbtn.net (63.223.47.49) 343.882 ms TenGE0-3-0-5.br03.sea01.pccwbtn.net (63.223.47.65) 343.854 ms TenGE0-3-0-1.br03.sea01.pccwbtn.net (63.223.47.49) 343.809 ms

8 TenGE0-3-0-5.br03.sea01.pccwbtn.net (63.223.47.65) 343.730 ms TenGE0-3-0-1.br03.sea01.pccwbtn.net (63.223.47.49) 343.723 ms TenGE0-3-0-5.br03.sea01.pccwbtn.net (63.223.47.65) 343.660 ms

9 pnwgp-six1.pnw-gigapop.net (206.81.80.84) 344.062 ms 343.195 ms 343.971 ms

10 ae20--4010.icar-sttl1-3.infra.pnw-gigapop.net (209.124.188.134) 343.929 ms 343.852 ms 230.462 ms

**11** et-7-0-0--4010.uwcr-atg-1.infra.washington.edu (209.124.188.135) 305.938 ms 305.878 ms 358.652 ms

(Oxford University)

Tracing route to **www.washington.edu** [128.95.155.198]

over a maximum of 30 hops:

1 2 ms 1 ms 1 ms 192.168.0.1

2 2 ms 2 ms 3 ms nsg-static-122.167.76.182-airtel.com [182.76.167.122]

3 13 ms 13 ms 13 ms 10.237.0.205

4 13 ms 13 ms 14 ms 182.74.195.161

5 53 ms 54 ms 53 ms 182.79.146.194

6 \* 52 ms 53 ms 63-218-107-193.static.pccwglobal.net [63.218.107.193]

7 250 ms 262 ms 249 ms TenGE0-3-0-5.br03.sea01.pccwbtn.net [63.223.47.65]

8 248 ms 248 ms 248 ms TenGE0-3-0-5.br03.sea01.pccwbtn.net [63.223.47.65]

9 258 ms 256 ms 256 ms pnwgp-six1.pnw-gigapop.net [206.81.80.84]

10 256 ms 256 ms 257 ms et-7-0-0--4000.uwcr-ads-1.infra.washington.edu [209.124.188.133]

11 \* \* \* Request timed out.

12 252 ms 256 ms 252 ms ae3--836.uwar-uwtc-1.infra.washington.edu [128.95.155.195]

13 251 ms 250 ms 250 ms www4.cac.washington.edu [128.95.155.198]

**Monday 22/08/2020**

(Washington University)

traceroute to **www.uw.edu** (128.95.155.197), 30 hops max, 60 byte packets

1 \_gateway (192.168.43.1) 3.160 ms 4.096 ms 4.463 ms

2 192.168.0.1 (192.168.0.1) 9.087 ms 19.424 ms 20.376 ms

3 nsg-static-122.167.76.182-airtel.com (182.76.167.122) 29.895 ms \* \*

4 \* \* \*

5 182.74.195.161 (182.74.195.161) 42.495 ms \* \*

6 182.79.224.145 (182.79.224.145) 74.737 ms 182.79.134.149 (182.79.134.149) 66.956 ms 182.79.237.18 (182.79.237.18) 77.549 ms

7 63-218-107-193.static.pccwglobal.net (63.218.107.193) 74.903 ms \* 74.883 ms

8 TenGE0-3-0-1.br03.sea01.pccwbtn.net (63.223.47.49) 245.481 ms 245.468 ms TenGE0-3-0-5.br03.sea01.pccwbtn.net (63.223.47.65) 247.237 ms

9 TenGE0-3-0-5.br03.sea01.pccwbtn.net (63.223.47.65) 245.413 ms 245.389 ms 247.165 ms

10 pnwgp-six1.pnw-gigapop.net (206.81.80.84) 257.620 ms 257.633 ms 304.345 ms

11 ae20--4010.icar-sttl1-3.infra.pnw-gigapop.net (209.124.188.134) 240.915 ms 246.252 ms 252.564 ms

**12**  et-7-0-0--4010.uwcr-atg-1.infra.washington.edu (209.124.188.135) 253.704 ms 257.081 ms 250.064 ms

(Oxford University)

Tracing route to **www.washington.edu** [128.95.155.135]

over a maximum of 30 hops:

1 2 ms 1 ms 4 ms 192.168.0.1

2 6 ms 2 ms 2 ms nsg-static-122.167.76.182-airtel.com [182.76.167.122]

3 14 ms 12 ms 13 ms 10.237.0.205

4 14 ms 19 ms 23 ms 182.74.195.161

5 51 ms 53 ms 51 ms 182.79.146.194

6 50 ms 49 ms \* 63-218-107-193.static.pccwglobal.net [63.218.107.193]

7 242 ms 240 ms 240 ms TenGE0-3-0-5.br03.sea01.pccwbtn.net [63.223.47.65]

8 246 ms 242 ms 240 ms TenGE0-3-0-5.br03.sea01.pccwbtn.net [63.223.47.65]

9 247 ms 247 ms 251 ms pnwgp-six1.pnw-gigapop.net [206.81.80.84]

10 249 ms 247 ms 246 ms et-7-0-0--4000.uwcr-ads-1.infra.washington.edu [209.124.188.133]

11 \* \* \* Request timed out.

12 250 ms 246 ms 247 ms ae4--583.uwar-ads-1.infra.washington.edu [128.95.155.131]

13 248 ms 249 ms 247 ms www2.cac.washington.edu [128.95.155.135]

* We observe here that even if the servers are remote, the traceroute shows that it follows the similar path, even if it’s taken on different days of the week and encounters same/similar nodes.
* The ping time/latency shows no clear pattern with the number of nodes visited, for closeby connections, the latency is close to 30ms. And for farther connections, after reaching close to 6-7 nodes, we see it averages around 250ms, for farther connections.

**Ex 4**:

* **Whois**
* We get information about the registrar WHOIS server (whois.markmonitor.com), it’s complaint cell details
* We also get Domain Name Registry expiry date(2028-09-14T04:00:00Z),list of domain status and domain names, and so on.

Domain Name: GOOGLE.COM

Registry Domain ID: 2138514\_DOMAIN\_COM-VRSN

Registrar WHOIS Server: whois.markmonitor.com

Registrar URL: http://www.markmonitor.com

Updated Date: 2019-09-09T15:39:04Z

Creation Date: 1997-09-15T04:00:00Z

Registry Expiry Date: 2028-09-14T04:00:00Z

Registrar: MarkMonitor Inc.

Registrar IANA ID: 292

Registrar Abuse Contact Email: abusecomplaints@markmonitor.com

Registrar Abuse Contact Phone: +1.2083895740

Domain Status: clientDeleteProhibited https://icann.org/epp#clientDeleteProhibited

Domain Status: clientTransferProhibited https://icann.org/epp#clientTransferProhibited

Domain Status: clientUpdateProhibited https://icann.org/epp#clientUpdateProhibited

Domain Status: serverDeleteProhibited https://icann.org/epp#serverDeleteProhibited

Domain Status: serverTransferProhibited https://icann.org/epp#serverTransferProhibited

Domain Status: serverUpdateProhibited https://icann.org/epp#serverUpdateProhibited

Name Server: NS1.GOOGLE.COM

Name Server: NS2.GOOGLE.COM

Name Server: NS3.GOOGLE.COM

Name Server: NS4.GOOGLE.COM

DNSSEC: unsigned

URL of the ICANN Whois Inaccuracy Complaint Form: https://www.icann.org/wicf/

>>> Last update of whois database: 2020-08-17T17:09:11Z <<<

For more information on Whois status codes, please visit https://icann.org/epp

NOTICE: The expiration date displayed in this record is the date the

registrar's sponsorship of the domain name registration in the registry is

currently set to expire. This date does not necessarily reflect the expiration

date of the domain name registrant's agreement with the sponsoring

registrar. Users may consult the sponsoring registrar's Whois database to

view the registrar's reported date of expiration for this registration.

TERMS OF USE: You are not authorized to access or query our Whois

database through the use of electronic processes that are high-volume and

automated except as reasonably necessary to register domain names or

modify existing registrations; the Data in VeriSign Global Registry

Services' ("VeriSign") Whois database is provided by VeriSign for

information purposes only, and to assist persons in obtaining information

about or related to a domain name registration record. VeriSign does not

guarantee its accuracy. By submitting a Whois query, you agree to abide

by the following terms of use: You agree that you may use this Data only

for lawful purposes and that under no circumstances will you use this Data

to: (1) allow, enable, or otherwise support the transmission of mass

unsolicited, commercial advertising or solicitations via e-mail, telephone,

or facsimile; or (2) enable high volume, automated, electronic processes

that apply to VeriSign (or its computer systems). The compilation,

repackaging, dissemination or other use of this Data is expressly

prohibited without the prior written consent of VeriSign. You agree not to

use electronic processes that are automated and high-volume to access or

query the Whois database except as reasonably necessary to register

domain names or modify existing registrations. VeriSign reserves the right

to restrict your access to the Whois database in its sole discretion to ensure

operational stability. VeriSign may restrict or terminate your access to the

Whois database for failure to abide by these terms of use. VeriSign

reserves the right to modify these terms at any time.

The Registry database contains ONLY .COM, .NET, .EDU domains and

Registrars.

Domain Name: google.com

Registry Domain ID: 2138514\_DOMAIN\_COM-VRSN

Registrar WHOIS Server: whois.markmonitor.com

Registrar URL: http://www.markmonitor.com

Updated Date: 2019-09-09T08:39:04-0700

Creation Date: 1997-09-15T00:00:00-0700

Registrar Registration Expiration Date: 2028-09-13T00:00:00-0700

Registrar: MarkMonitor, Inc.

Registrar IANA ID: 292

Registrar Abuse Contact Email: abusecomplaints@markmonitor.com

Registrar Abuse Contact Phone: +1.2083895770

Domain Status: clientUpdateProhibited (https://www.icann.org/epp#clientUpdateProhibited)

Domain Status: clientTransferProhibited (https://www.icann.org/epp#clientTransferProhibited)

Domain Status: clientDeleteProhibited (https://www.icann.org/epp#clientDeleteProhibited)

Domain Status: serverUpdateProhibited (https://www.icann.org/epp#serverUpdateProhibited)

Domain Status: serverTransferProhibited (https://www.icann.org/epp#serverTransferProhibited)

Domain Status: serverDeleteProhibited (https://www.icann.org/epp#serverDeleteProhibited)

Registrant Organization: Google LLC

Registrant State/Province: CA

Registrant Country: US

Registrant Email: Select Request Email Form at https://domains.markmonitor.com/whois/google.com

Admin Organization: Google LLC

Admin State/Province: CA

Admin Country: US

Admin Email: Select Request Email Form at https://domains.markmonitor.com/whois/google.com

Tech Organization: Google LLC

Tech State/Province: CA

Tech Country: US

Tech Email: Select Request Email Form at https://domains.markmonitor.com/whois/google.com

Name Server: ns1.google.com

Name Server: ns2.google.com

Name Server: ns3.google.com

Name Server: ns4.google.com

DNSSEC: unsigned

URL of the ICANN WHOIS Data Problem Reporting System: http://wdprs.internic.net/

>>> Last update of WHOIS database: 2020-08-17T10:03:20-0700 <<<

For more information on WHOIS status codes, please visit:

https://www.icann.org/resources/pages/epp-status-codes

If you wish to contact this domain’s Registrant, Administrative, or Technical

contact, and such email address is not visible above, you may do so via our web

form, pursuant to ICANN’s Temporary Specification. To verify that you are not a

robot, please enter your email address to receive a link to a page that

facilitates email communication with the relevant contact(s).

Web-based WHOIS:

https://domains.markmonitor.com/whois

If you have a legitimate interest in viewing the non-public WHOIS details, send

your request and the reasons for your request to whoisrequest@markmonitor.com

and specify the domain name in the subject line. We will review that request and

may ask for supporting documentation and explanation.

The data in MarkMonitor’s WHOIS database is provided for information purposes,

and to assist persons in obtaining information about or related to a domain

name’s registration record. While MarkMonitor believes the data to be accurate,

the data is provided "as is" with no guarantee or warranties regarding its

accuracy.

By submitting a WHOIS query, you agree that you will use this data only for

lawful purposes and that, under no circumstances will you use this data to:

(1) allow, enable, or otherwise support the transmission by email, telephone,

or facsimile of mass, unsolicited, commercial advertising, or spam; or

(2) enable high volume, automated, or electronic processes that send queries,

data, or email to MarkMonitor (or its systems) or the domain name contacts (or

its systems).

MarkMonitor reserves the right to modify these terms at any time.

By submitting this query, you agree to abide by this policy.

MarkMonitor Domain Management(TM)

Protecting companies and consumers in a digital world.

Visit MarkMonitor at https://www.markmonitor.com

Contact us at +1.8007459229

In Europe, at +44.02032062220

**Ex 5**:

* traceroute spit.ac.in

nslookup spit.ac.in

Server: 127.0.0.53

Address: 127.0.0.53#53

Non-authoritative answer:

Name: spit.ac.in

Address: 43.252.193.19

* curl ipinfo.io/43.252.193.19

{

"ip": "43.252.193.19",

"city": "Mumbai",

"region": "Maharashtra",

"country": "IN",

"loc": "19.0728,72.8826",

"org": "AS17625 BlazeNet's Network",

"postal": "400070",

"timezone": "Asia/Kolkata",

"readme": "https://ipinfo.io/missingauth"

}

**Ex 6**:

**netstat -t -n**

Active Internet connections (w/o servers)

Proto Recv-Q Send-Q Local Address Foreign Address State

tcp 0 0 192.168.43.218:55782 69.173.159.48:443 ESTABLISHED

tcp 0 0 192.168.43.218:51466 216.58.199.163:443 ESTABLISHED

tcp 0 0 192.168.43.218:41468 74.125.200.125:443 ESTABLISHED

tcp 0 1 192.168.43.218:43030 103.231.98.193:443 FIN\_WAIT1

tcp 0 0 192.168.43.218:36780 216.58.199.174:443 ESTABLISHED

tcp 0 0 192.168.43.218:60854 13.107.6.171:443 ESTABLISHED

tcp 0 0 192.168.43.218:38406 52.11.231.199:443 ESTABLISHED

tcp 0 0 192.168.43.218:57350 216.58.203.35:443 ESTABLISHED

tcp 0 0 192.168.43.218:39502 74.125.24.188:5228 ESTABLISHED

tcp 0 0 192.168.43.218:39722 34.213.232.243:443 ESTABLISHED

tcp 0 0 192.168.43.218:44642 142.250.67.228:443 ESTABLISHED

tcp 0 0 192.168.43.218:44616 209.58.162.201:443 ESTABLISHED

tcp 0 0 192.168.43.218:43122 172.217.166.35:443 ESTABLISHED

tcp 0 0 192.168.43.218:53900 74.125.200.189:443 ESTABLISHED

tcp 0 0 192.168.43.218:35090 35.190.63.234:443 ESTABLISHED

tcp 0 0 192.168.43.218:34036 52.32.142.97:443 ESTABLISHED

tcp 1 1 192.168.43.218:33732 35.213.34.3:443 LAST\_ACK

tcp 0 0 192.168.43.218:56616 184.25.161.247:443 ESTABLISHED

tcp 0 0 192.168.43.218:43234 107.178.247.57:443 ESTABLISHED

tcp 0 0 192.168.43.218:44962 54.244.7.118:443 ESTABLISHED

▶ curl ipinfo.io/69.173.159.48

{

"ip": "69.173.159.48",

"city": "Central",

"region": "Central and Western",

"country": "HK",

"loc": "22.2830,114.1585",

"org": "AS26667 The Rubicon Project, Inc.",

"timezone": "Asia/Hong\_Kong",

"readme": "https://ipinfo.io/missingauth"

}

▶ curl ipinfo.io/216.58.199.163

{

"ip": "216.58.199.163",

"hostname": "bom05s08-in-f163.1e100.net",

"city": "Mumbai",

"region": "Maharashtra",

"country": "IN",

"loc": "19.0728,72.8826",

"org": "AS15169 Google LLC",

"postal": "400070",

"timezone": "Asia/Kolkata",

"readme": "https://ipinfo.io/missingauth"

}

▶ curl ipinfo.io/103.231.98.193

{

"ip": "103.231.98.193",

"city": "Singapore",

"region": "Singapore",

"country": "SG",

"loc": "1.2897,103.8501",

"org": "AS62713 PubMatic, Inc.",

"postal": "048508",

"timezone": "Asia/Singapore",

"readme": "https://ipinfo.io/missingauth"

}

▶ curl ipinfo.io/52.32.142.97

{

"ip": "52.32.142.97",

"hostname": "ec2-52-32-142-97.us-west-2.compute.amazonaws.com",

"city": "Portland",

"region": "Oregon",

"country": "US",

"loc": "45.5235,-122.6762",

"org": "AS16509 Amazon.com, Inc.",

"postal": "97258",

"timezone": "America/Los\_Angeles",

"readme": "https://ipinfo.io/missingauth"

}

**Conclusion:**

* We used the different network utilities to perform the experiment.
* We used ping and found that there is no relation of packet size with latency, and that the latency varies with the physical location of the IP address.
* We experimented with traceroute to find that the latency doesn’t correlate with the number of nodes visited.
* We also used whois and ipinfo.io to find more information about DNS/geolocation respectively.