CS 252: Lab 2

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Contents

(i) `ifconfig`

Network Interface Information:

- Team Member: Krushnakant Bhattad
  - Type: `wifi`
  - IPv4: `192.168.43.1`
  - IPv6: `fe80::d85a:33ff:fef0:2d33`
  - MAC: `40:5b:d8:9b:c0:4d`
  - MTU: `1500`
  - Transmit Queue Length: `1000`
- Team Member: Devansh Jain
  - Type: `wifi`
  - IPv4: `192.168.29.249`
  - IPv6: `fe80::113d:1e1c:c608:4f93`
  - MAC: `dc:71:96:3c:31:ba`
  - MTU: `1500`
  - Transmit Queue Length: `1000`
- Team Member: Harshit Varma
  - Type: `Ethernet`[1]
  - IPv4: `172.23.207.194`
  - IPv6: `fe80::215:5dff:febd:ce13`
  - MAC: `00:15:5d:bd:ce:13`
  - MTU: `1500`
  - Transmit Queue Length: `1000`

Number of bits used for:

- IPv4: `32`
- IPv6: `128`
- MAC: `48`

MTU stands for **Maximum Transmission Unit**, which defines the size of the largest protocol data unit (PDU) that can be communicated in a single network layer (layer-3) transaction. It is specified in terms of **bytes** or octets of the largest PDU that the layer can pass onwards. [2]

Units for Transmit Length Queue: **packets**

[1] WSL vEthernet adapter: WSL-2 has a virtualized ethernet adapter with its own unique addresses
[2] Source: Wikipedia

(ii) `traceroute <dest host IP or name>`

Team Member: Harshit Varma
Destination: `www.google.com`

Source: Local machine
Number of hops: `8`
Average RTT: `7.33`
Destination IP: `172.17.112.70` (Mumbai) [1]

Source: Tokyo (Japan, Asia)
Number of hops: `5`
Average RTT: `<1`
Destination IP: `172.217.25.100` (Mountain View, California)

Source: Sydney (Australia)
Number of hops: `10`
Average RTT: `1`
Destination IP: `142.250.66.196` (Sydney)

Source: Oslo (Norway, Europe)
Number of hops: `11`
Average RTT: `9.33`
Destination IP: `142.250.74.36` (Mountain View, California)

Source: Buenos Aires (Argentina, South America)
Number of hops: `9`
Average RTT: `6.67`
Destination IP: `172.217.172.228` (Buenos Aires)

Source: Los Angeles (USA, North America)
Number of hops: `6`
Average RTT: `1`
Destination IP: `216.58.193.196` (Mountain View, California)

The destination IP addresses changes when the source changes, even if the domain name is the same.

In fact, it even changes with time keeping the source and the destination fixed.
For example, when `traceroute` was run again from the local machine, $\approx$ 10 mins later, the destination IP address changed from `216.58.203.36` to `142.250.76.164` (also Mumbai) and then after $\approx$ 5 mins, it reverted back to `216.58.203.36`, and then it changed to `216.58.200.196` (Zhengzhou, China), approximately 2 mins later.

This is because when a client attempts to connect to Google, several DNS servers resolve `www.google.com` into multiple IP addresses via **Round Robin policy**. This acts as the first level of load balancing and directs the client to different Google cluster, which has thousands of server. [2]

[1] `https://ipinfo.io/` was used for getting location from IP address, equivalently, the `whois` command can also be used
[2] Reference: `https://en.wikipedia.org/wiki/Google_data_centers`

Team Member: Devansh Jain
Destination: `www.cnn.com`

Source: Local machine (Gujarat, India)
Number of hops: `12`
Average RTT: `77.5`
Destination IP: `151.101.65.67` (San Francisco, California) [1]

Source: Jakarta (Indonesia, Asia)
Number of hops: `6`
Average RTT: `13`
Destination IP: `151.101.9.67` (San Francisco, California)

Source: Auckland (New Zealand)
Number of hops: `5`
Average RTT: `1`
Destination IP: `151.101.165.67` (San Francisco, California)

Source: Amsterdam (Netherlands, Europe)
Number of hops: `7`
Average RTT: `2`
Destination IP: `151.101.1.67` (San Francisco, California)

Source: Buenos Aires (Argentina, South America)
Number of hops: `11`
Average RTT: `152`
Destination IP: `151.101.5.67` (San Francisco, California)

Source: Los Angeles (USA, North America)
Number of hops: `5`
Average RTT: `1.33`
Destination IP: `151.101.25.67` (San Francisco, California)

All the destination IP are located in San Francisco, irrespective of the source.
CNN is headquartered in US and one possible explanation of the above observation is that CNN uses a cluster of servers located at the same location (facility) for service.

[1] `https://ping.eu/ns-whois/` was used for getting location from IP address, equivalently, the `whois` command can also be used

Team Member: Krushnakant Bhattad [1]
Destination: `www.iitd.ac.in`

Source: Local machine (Maharashtra, India)
Number of hops: `17`
Average RTT: `42 ms`
Destination IP: `103.27.9.24` (New Delhi) [2]

Source: Frankfurt (Germany, Europe)
Number of hops: `19`
Average RTT: `190 ms`
Destination IP: `103.27.9.24` (New Delhi)

Source: New York (USA, North America)
Number of hops: `17`
Average RTT: `213 ms`
Destination IP: `103.27.9.24` (New Delhi)

Source: Singapore (Republic of Singapore, South East Asia)
Number of hops: `15`
Average RTT: `74 ms`
Destination IP: `103.27.9.24` (New Delhi)

Source: Sydney (Australia)
Number of hops: `23`
Average RTT: `281 ms`
Destination IP: `103.27.9.24` (New Delhi)

Source: São Paulo (Brazil, South America)
Number of hops: `19`
Average RTT: `356 ms`
Destination IP: `103.27.9.24` (New Delhi)

All the destination IP Addresses are same for the same url `www.iitd.ac.in`, irrespective of the source. Also, for, say `www.cse.iitd.ac.in`, the IP address responding is always `103.27.9.152`, irrespective of source. Location for all servers was New Delhi, probably some Computer-Center in the institute.
This points towards a possibility that IIT-Delhi has designated a certain server for responding to a specific url, like, the server with IP `103.27.9.24` will respond to requests for `www.iitd.ac.in`; while the server with IP `103.27.9.152` will respond to requests for `www.cse.iitd.ac.in`.

[1] For this experiment, `https://tools.keycdn.com/traceroute` was used for all external sources except Sao Paulo, instead of uptrends, since uptrends wasn't working as expected.

[2] `https://ping.eu/ns-whois/` was used for getting information from IP address, to confirm location

Destination: `iitb.ac.in`

When we tried performing `traceroute` for `www.iitb.ac.in` [and other iitb urls], it reveals the destination IP address (located in Powai) but the traceroute never reaches that.
The last IP address detected (for all sources), was `115.110.234.170`, identified with Tata Communications Limited. After this, we only received `* * *` as the output.
This is most probably becuase the IITB network system is blanketed with a VPN.

After connecting to the IITB-VPN, the traceroute instantly reaches the private IP for `iitb.ac.in` in a single hop.
Interestingly, (when on IITB-VPN) the route to most other addresses (including `www.google.com`) passes through `vpn4profsoumen.iitb.ac.in`

(iii) ping <dest host>

Team Member: Harshit Varma

Server: www.nasa.gov
Expected Location: USA, North America
Average RTT using local machine: 8.433 ms (15 transmitted, 15 received)
Average RTT using ping.eu: 27.153 ms (4 transmitted, 4 received)

Server: www.gov.uk
Expected Location: UK, Europe
Average RTT using local machine: 9.561 ms (15 transmitted, 15 received)
Average RTT using ping.eu: 32.261 ms (4 transmitted, 4 received)

Server: www.gov.au
Expected Location: Australia
Average RTT using local machine: 24.009 ms (15 transmitted, 15 received)
Average RTT using ping.eu: 7.797 ms (4 transmitted, 4 received)

Server: www.statehouse.gov.ng
Expected Location: Nigeria, Africa
Average RTT using local machine: 269.625 ms (34 transmitted, 16 received)
Average RTT using ping.eu: 151.545 ms (4 transmitted, 4 received)

Server: www.gob.cl
Expected Location: Chile, South America
Average RTT using local machine: 17.144 ms (15 transmitted, 15 received)
Average RTT using ping.eu: 4.753 ms (4 transmitted, 4 received)

Server: www.jnto.go.jp
Expected Location: Japan, Asia
Average RTT using local machine: 24.113 ms (15 transmitted, 15 received)
Average RTT using ping.eu: 26.369 ms (4 transmitted, 4 received)

Server: comnap.aq[1]
Expected Location: Antarctica [2]
Average RTT using local machine: 189.067 ms (15 transmitted, 15 received)
Average RTT using ping.eu: 295.686 ms (4 transmitted, 4 received)

[1] Tried to ping www.ats.aq, www.soki.aq, www.soos.aq but no packets were returned
[2] A traceroute reveals that the actual location is Christchurch, New Zealand

Team Member: Devansh Jain

Server: `www.canada.ca`
Expected Location: `Canada, North America`
Average RTT using local machine: `13.441 ms` (20 transmitted, 20 received)
Average RTT using `ping.eu`: `35.974 ms` (4 transmitted, 4 received)

Server: `www.spth.gob.es`
Expected Location: `Spain, Europe`
Average RTT using local machine: `182.319 ms` (20 transmitted, 20 received)
Average RTT using `ping.eu`: `12.891 ms` (4 transmitted, 4 received)

Server: `www.australia.gov.au`
Expected Location: `Australia`
Average RTT using local machine: `24.133 ms` (20 transmitted, 20 received)
Average RTT using `ping.eu`: `27.464 ms` (4 transmitted, 4 received)

Server: `www.gov.za`
Expected Location: `South Africa, Africa`
Average RTT using local machine: `360.516 ms` (20 transmitted, 20 received)
Average RTT using `ping.eu`: `185.209 ms` (4 transmitted, 4 received)

Server: `www.argentina.gob.ar`
Expected Location: `Argentina, South America`
Average RTT using local machine: `178.347 ms` (20 transmitted, 20 received)
Average RTT using `ping.eu`: `5.219 ms` (4 transmitted, 4 received)

Server: `www.nepal.gov.np`
Expected Location: `Nepal, Asia`
Average RTT using local machine: `301.342 ms` (20 transmitted, 20 received)
Average RTT using `ping.eu`: `163.905 ms` (4 transmitted, 4 received)

Server: `www.comnap.aq`[1]
Expected Location: `Antarctica` [2]
Average RTT using local machine: `252.765 ms` (20 transmitted, 20 received)
Average RTT using `ping.eu`: `294.773 ms` (4 transmitted, 4 received)

[1] Tried to ping `www.ats.aq, www.soki.aq, www.soos.aq` but no packets were returned
[2] A `traceroute` reveals that the actual location is Christchurch, New Zealand

Team Member: Krushnakant Bhattad

Server: `www.gob.mx`
Expected Location: `Mexico, North America`
Average RTT using local machine: `38.448 ms` (20 transmitted, 20 received)
Average RTT using `ping.eu`: `30.273 ms` (4 transmitted, 4 received)

Server: `www.admin.ch`
Expected Location: `Switzerland, Europe`
Average RTT using local machine: `255.733 ms` (20 transmitted, 20 received)
Average RTT using `ping.eu`: `27.594 ms` (4 transmitted, 4 received)

Server: `www.govt.nz`
Expected Location: `New Zealand`
Average RTT using local machine: `26.581 ms` (20 transmitted, 20 received)
Average RTT using `ping.eu`: `192.383 ms` (4 transmitted, 4 received)

Server: `www.pm.gov.tn` [1]
Expected Location: `Tunisia, Africa`
Average RTT using local machine: `253.009 ms` (20 transmitted, 20 received)
Average RTT using `ping.eu`: `46.893 ms` (4 transmitted, 4 received)

Server: `www.ttconnect.gov.tt`
Expected Location: `Trinidad and Tobago, South America`
Average RTT using local machine: `393.735 ms` (20 transmitted, 20 received)
Average RTT using `ping.eu`: `159.213 ms` (4 transmitted, 4 received)

Server: `www.gco.gov.qa`
Expected Location: `Qatar, Asia`
Average RTT using local machine: `22.229 ms` (20 transmitted, 20 received)
Average RTT using `ping.eu`: `5.193 ms` (4 transmitted, 4 received)

Server: `www.acap.aq`
Expected Location: `Antarctica`[2]
Average RTT using local machine: `212.604 ms` (20 transmitted, 20 received)
Average RTT using `ping.eu`: `248.566 ms` (4 transmitted, 4 received)

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[1] Tried to ping `www.grnnet.gov.na` (Namibia), `www.presidence.gov.mg` (Madagascar), `www.president.go.ke` (Kenya), etc. but no packets were returned

[2] A `traceroute` reveals that the actual location is Sydney, Australia

Inferences:

Dependence on Geographical Proximity:

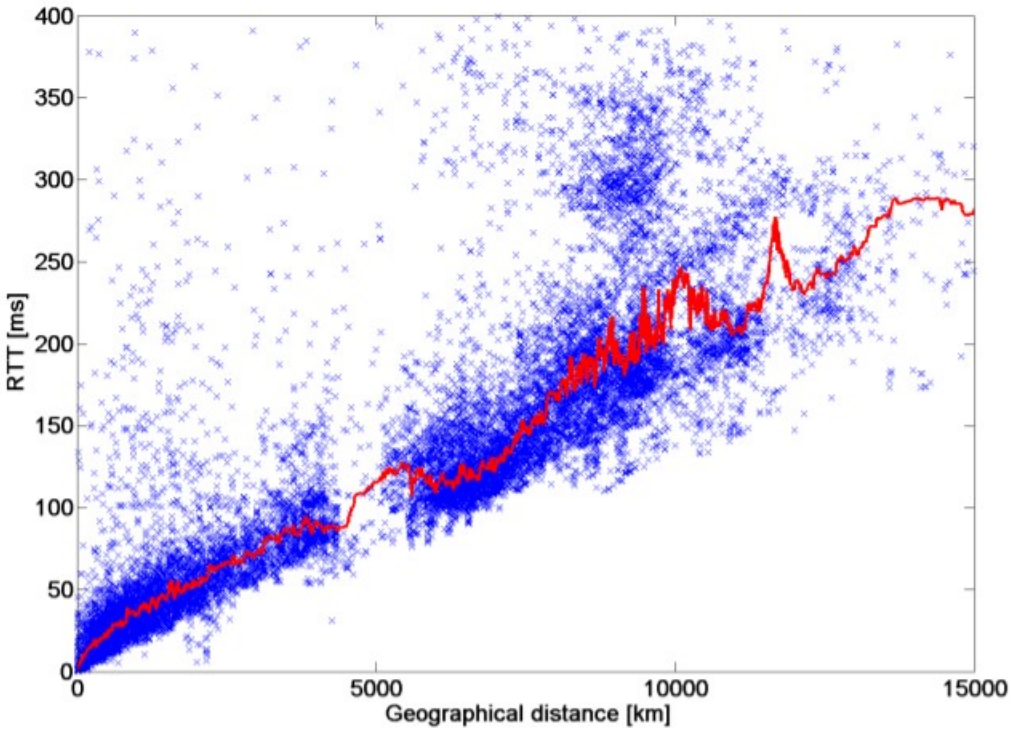

Figure 1: Source: O. Krajsa and L. Fojtova, "RTT measurement and its dependence on the real geographical distance"

We observe that the RTT does somewhat increase with increase in the geographical distance.
The time delay caused by the number of routers the signal has to travel through, server response time, the network traffic, etc. also affects the RTT. [1]
A much more extensive analysis was performed by O. Krajsa and L. Fojtova [2] who claimed that the dependence of RTT on the geographical distance can be for some cases considered as a linear function.

Dependence on the Country

We also observe that less developed countries (like Trinidad and Tobago, Tunisia, Nepal, etc) have much higher RTTs than the developed ones.
For a contrasting example, the RTT to Nepal was about `301.342 ms` while the RTT to Australia (which is much further geographically) was only `24.133 ms`

[1] Reference: `https://www.cloudflare.com/en-gb/learning/cdn/glossary/round-trip-time-rtt/`

[2] O. Krajsa and L. Fojtova, "RTT measurement and its dependence on the real geographical distance", 2011 34th International Conference on Telecommunications and Signal Processing (TSP), Budapest, 2011, pp. 231-234, doi: 10.1109/TSP.2011.6043737.

(iv) `Iperf`

Terminology:

The "Sender" is the client, the value mentioned is the upload speed from the client to the `iperf` server. The "Receiver" is `iperf` server, the value mentioned is the download speed on `iperf` server for the client.[1]

Observations:

Team Member: Harshit Varma

Server: `iperf.scottlinux.com` (California, USA)
TCP Bandwidth:
Sender: `28.9 Mbits/sec`
Reciever: `27.8 Mbits/sec`
For UDP:
The observed throughput becomes much less than the specified UDP rate at `128 Mbits/sec`

Server: `ping.online.net` (île-de-france, France)
TCP Bandwidth:
Sender: `27.6 Mbits/sec`
Reciever: `25.8 Mbits/secc`
For UDP:
The observed throughput becomes much less than the specified UDP rate at `256 Mbits/sec`

Team Member: Devansh Jain

Server: `ping6.online.net` (île-de-france, France)
TCP Bandwidth:
Sender: `3.19 Mbits/sec`
Reciever: `2.70 Mbits/sec`
For UDP:
The observed throughput becomes much less than the specified UDP rate at `256 Mbits/sec`

Server: `speedtest.serverius.net` (Netherlands)
TCP Bandwidth:
Sender: `2.6 Mbits/sec`
Reciever: `2.2 Mbits/secc`
For UDP:
The observed throughput becomes much less than the specified UDP rate at `128 Mbits/sec`

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[1] Reference: `https://github.com/esnet/iperf/issues/480#issuecomment-307205313`

Team Member: Krushnakant Bhattad

Server: `bouygues.testdebit.info` (Colombes, France)
TCP Bandwidth:
Sender: `8.00 Mbits/sec`
Receiver: `5.60 Mbits/sec`
For UDP:
The observed throughput becomes much less than the specified UDP rate at `128 Mbits/sec`

Server: `iperf.volia.net` (Kremenchug, Ukraine)
TCP Bandwidth:
Sender: `7.77 Mbits/sec`
Receiver: `5.60 Mbits/sec`
For UDP:
The observed throughput becomes much less than the specified UDP rate at `128 Mbits/sec`

Errors

We were often getting the following errors while running `iperf`/`iperf3`:

- `iperf3: error - the server is busy running a test. try again later`
  Changing the port number using `-p` flag sometimes seemed to resolve this issue.
  Sometimes, running `iperf` instead of `iperf3` resolved this issue.
- `connect failed: No route to host`
  This was observed while using `iperf`, couldn't find any fix for this, the same server worked using `iperf3` though
- `iperf3: error - unable to connect to server: Connection refused`
  Got this error when trying to use different ports

Conclusions:

In both the cases for all team members, it was a common observation that the UDP rates are higher than the TCP ones.
Expected reason: As observed, UDP is much faster than TCP. This may be because TCP does retransmission of packet losses and congestion control, whereas UDP does not do either. There is no overhead for opening a connection, maintaining a connection, and terminating a connection in UDP, whereas TCP requires this [1]. Although UDP is faster, TCP is more "reliable" due to the same reasons listed above. Thus, there seems to be a tradeoff between "reliability" and speed.

[1] `https://www.geeksforgeeks.org/differences-between-tcp-and-udp/`