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## Lab 2

### **Basic Network Utilities**

**ping** — The command `ping <host>` sends a series of packets and expects to receive a response to each packet. 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 response 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:

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.

### Solution:

- 64 bytes:

```
C:\Users\Abhir>ping -n 10 -l 64 google.com

Pinging google.com [216.58.196.78] with 64 bytes of data:
Reply from 216.58.196.78: bytes=64 time=135ms TTL=119
Reply from 216.58.196.78: bytes=64 time=10ms TTL=119
Reply from 216.58.196.78: bytes=64 time=3ms TTL=119
Reply from 216.58.196.78: bytes=64 time=8ms TTL=119
Reply from 216.58.196.78: bytes=64 time=4ms TTL=119
Reply from 216.58.196.78: bytes=64 time=55ms TTL=119
Reply from 216.58.196.78: bytes=64 time=50ms TTL=119
Reply from 216.58.196.78: bytes=64 time=4ms TTL=119
Reply from 216.58.196.78: bytes=64 time=7ms TTL=119
Reply from 216.58.196.78: bytes=64 time=19ms TTL=119

Ping statistics for 216.58.196.78:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 3ms, Maximum = 135ms, Average = 29ms
```

- 100 bytes:

```
C:\Users\Abhir>ping -n 10 -l 100 google.com

Pinging google.com [216.58.196.78] with 100 bytes of data:
Reply from 216.58.196.78: bytes=68 (sent 100) time=3ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=6ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=3ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=3ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=5ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=4ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=41ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=6ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=5ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=4ms TTL=119

Ping statistics for 216.58.196.78:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 3ms, Maximum = 41ms, Average = 8ms
```

- 500 bytes:

```
C:\Users\Abhir>ping -n 10 -l 500 google.com

Pinging google.com [216.58.196.78] with 500 bytes of data:
Reply from 216.58.196.78: bytes=68 (sent 500) time=7ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 500) time=3ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 500) time=8ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 500) time=4ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 500) time=3ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 500) time=5ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 500) time=4ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 500) time=4ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 500) time=3ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 500) time=3ms TTL=119

Ping statistics for 216.58.196.78:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 3ms, Maximum = 8ms, Average = 4ms
```

- 1000 bytes:

```
C:\Users\Abhir>ping -n 10 -l 1000 google.com

Pinging google.com [216.58.196.78] with 1000 bytes of data:
Reply from 216.58.196.78: bytes=68 (sent 1000) time=7ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1000) time=12ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1000) time=3ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1000) time=29ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1000) time=26ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1000) time=71ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1000) time=5ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1000) time=4ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1000) time=62ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1000) time=4ms TTL=119

Ping statistics for 216.58.196.78:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 3ms, Maximum = 71ms, Average = 22ms
```

- 1400 bytes:

```
C:\> Command Prompt

C:\Users\Abhir>ping -n 10 -l 1400 google.com

Pinging google.com [216.58.196.78] with 1400 bytes of data:
Reply from 216.58.196.78: bytes=68 (sent 1400) time=8ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1400) time=30ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1400) time=293ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1400) time=79ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1400) time=14ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1400) time=132ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1400) time=6ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1400) time=6ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1400) time=11ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 1400) time=8ms TTL=119

Ping statistics for 216.58.196.78:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 6ms, Maximum = 293ms, Average = 58ms
```

### Questions on Latency:

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

```
C:\Users\Abhir>ping -n 10 -l 64 google.com

Pinging google.com [216.58.196.78] with 64 bytes of data:
Reply from 216.58.196.78: bytes=64 time=135ms TTL=119
Reply from 216.58.196.78: bytes=64 time=10ms TTL=119
Reply from 216.58.196.78: bytes=64 time=3ms TTL=119
Reply from 216.58.196.78: bytes=64 time=8ms TTL=119
Reply from 216.58.196.78: bytes=64 time=4ms TTL=119
Reply from 216.58.196.78: bytes=64 time=55ms TTL=119
Reply from 216.58.196.78: bytes=64 time=50ms TTL=119
Reply from 216.58.196.78: bytes=64 time=4ms TTL=119
Reply from 216.58.196.78: bytes=64 time=7ms TTL=119
Reply from 216.58.196.78: bytes=64 time=19ms TTL=119

Ping statistics for 216.58.196.78:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 3ms, Maximum = 135ms, Average = 29ms
```

```
C:\Users\Abhir>ping -n 10 -l 64 www.hellotech.com

Pinging www.hellotech.com [35.244.216.127] with 64 bytes of data:
Reply from 35.244.216.127: bytes=64 time=77ms TTL=119
Reply from 35.244.216.127: bytes=64 time=4ms TTL=119
Reply from 35.244.216.127: bytes=64 time=4ms TTL=119
Reply from 35.244.216.127: bytes=64 time=4ms TTL=119
Reply from 35.244.216.127: bytes=64 time=3ms TTL=119
Reply from 35.244.216.127: bytes=64 time=13ms TTL=119
Reply from 35.244.216.127: bytes=64 time=307ms TTL=119
Reply from 35.244.216.127: bytes=64 time=4ms TTL=119
Reply from 35.244.216.127: bytes=64 time=11ms TTL=119
Reply from 35.244.216.127: bytes=64 time=6ms TTL=119

Ping statistics for 35.244.216.127:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 3ms, Maximum = 307ms, Average = 43ms
```

From the above figures, we can clearly conclude that the RTT is dependent on the host on which the 'ping' command is used. **Transmission delay** is the time taken to put a packet onto a link or simply, the time required to put data bits on the wire/communication medium. It depends on the **size of the packet** and the **bandwidth of the network**. Since the hosts are the only parameters changed, there is no transmission delay in the two cases. **Propagation delay** is the time taken by the first bit to travel from sender to receiver end of the link or simply the

time required for bits to reach the destination from the start point. Factors on which propagation delay depends are **distance** and **propagation speed**. So, there exists a propagation delay in the two cases. **Queueing delay** is the time difference between when the packet arrived at its destination and when the packet data was processed or executed. It depends on the **number of packets**, **size of the packet** and **bandwidth** of the network. Since all the parameters are non-varying in both cases, there is hardly any queueing delay.

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

```
C:\Users\Abhir>ping -n 10 -l 64 google.com

Pinging google.com [216.58.196.78] with 64 bytes of data:
Reply from 216.58.196.78: bytes=64 time=135ms TTL=119
Reply from 216.58.196.78: bytes=64 time=10ms TTL=119
Reply from 216.58.196.78: bytes=64 time=3ms TTL=119
Reply from 216.58.196.78: bytes=64 time=8ms TTL=119
Reply from 216.58.196.78: bytes=64 time=4ms TTL=119
Reply from 216.58.196.78: bytes=64 time=55ms TTL=119
Reply from 216.58.196.78: bytes=64 time=50ms TTL=119
Reply from 216.58.196.78: bytes=64 time=4ms TTL=119
Reply from 216.58.196.78: bytes=64 time=7ms TTL=119
Reply from 216.58.196.78: bytes=64 time=19ms TTL=119

Ping statistics for 216.58.196.78:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 3ms, Maximum = 135ms, Average = 29ms
```

```
C:\Users\Abhir>ping -n 10 -l 100 google.com

Pinging google.com [216.58.196.78] with 100 bytes of data:
Reply from 216.58.196.78: bytes=68 (sent 100) time=3ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=6ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=3ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=3ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=5ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=4ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=41ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=6ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=5ms TTL=119
Reply from 216.58.196.78: bytes=68 (sent 100) time=4ms TTL=119

Ping statistics for 216.58.196.78:
    Packets: Sent = 10, Received = 10, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 3ms, Maximum = 41ms, Average = 8ms
```

Yes, average RTT varies with different packet sizes as seen above. As transmission delay and queuing delay depend on packet size they would impact it.

### 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](http://www.uw.edu), [www.cornell.edu](http://www.cornell.edu), [berkeley.edu](http://berkeley.edu), [www.uchicago.edu](http://www.uchicago.edu), [www.ox.ac.uk](http://www.ox.ac.uk) (England), [www.u-tokyo.ac.jp](http://www.u-tokyo.ac.jp) (Japan).

Nslookup- The command nslookup <host> will do a DNS query to find and report the IP address (or addresses) 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 nslookup by adding the server name or IP address to the command: nslookup <host> <server>.

```
C:\Users\Abhir>nslookup www.google.com
DNS request timed out.
    timeout was 2 seconds.
Server:  UnKnown
Address:  192.168.1.1

Non-authoritative answer:
Name:     www.google.com
Addresses: 2404:6800:4009:811::2004
          172.217.160.164
```

Netstat- The netstat command gives information about network connections. I often use netstat -t -n which 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.)



Command Prompt

C:\Users\Abhir>netstat -t -n

Active Connections

Proto	Local Address	Foreign Address	State	Offload State
TCP	192.168.1.108:60853	192.168.1.100:8009	ESTABLISHED	InHost
TCP	192.168.1.108:60855	40.119.211.203:443	ESTABLISHED	InHost
TCP	192.168.1.108:60861	40.119.211.203:443	ESTABLISHED	InHost
TCP	192.168.1.108:60878	40.90.22.190:443	TIME_WAIT	InHost
TCP	192.168.1.108:60887	192.168.1.100:8008	ESTABLISHED	InHost
TCP	192.168.1.108:60889	40.81.30.101:443	TIME_WAIT	InHost
TCP	192.168.1.108:60890	40.81.30.101:443	TIME_WAIT	InHost
TCP	192.168.1.108:60894	192.168.1.105:8008	ESTABLISHED	InHost
TCP	192.168.1.108:60895	192.168.1.105:8008	ESTABLISHED	InHost
TCP	192.168.1.108:60896	74.125.200.188:5228	ESTABLISHED	InHost
TCP	192.168.1.108:60897	172.217.166.34:443	ESTABLISHED	InHost
TCP	192.168.1.108:60898	172.217.160.170:443	ESTABLISHED	InHost
TCP	192.168.1.108:60899	104.120.78.191:443	ESTABLISHED	InHost
TCP	192.168.1.108:60900	184.50.202.104:443	CLOSE_WAIT	InHost
TCP	192.168.1.108:60901	192.168.1.105:8009	ESTABLISHED	InHost
TCP	192.168.1.108:60903	216.58.199.176:443	TIME_WAIT	InHost
TCP	192.168.1.108:60924	131.253.14.229:443	TIME_WAIT	InHost
TCP	192.168.1.108:60972	117.18.237.29:80	TIME_WAIT	InHost
TCP	192.168.1.108:60973	162.254.196.68:27031	ESTABLISHED	InHost
TCP	192.168.1.108:61008	142.250.67.163:443	ESTABLISHED	InHost
TCP	192.168.1.108:61015	34.213.232.243:443	ESTABLISHED	InHost
TCP	192.168.1.108:61017	161.69.226.22:443	ESTABLISHED	InHost
TCP	192.168.1.108:61019	67.26.55.254:80	TIME_WAIT	InHost
TCP	192.168.1.108:61020	67.26.55.254:80	TIME_WAIT	InHost
TCP	192.168.1.108:61021	67.26.55.254:80	TIME_WAIT	InHost
TCP	192.168.1.108:61022	67.26.55.254:80	TIME_WAIT	InHost
TCP	192.168.1.108:61023	54.244.7.118:443	ESTABLISHED	InHost
TCP	192.168.1.108:61025	161.69.13.35:443	ESTABLISHED	InHost
TCP	192.168.1.108:61026	52.109.12.19:443	ESTABLISHED	InHost
TCP	192.168.1.108:61028	40.74.108.123:443	TIME_WAIT	InHost
TCP	192.168.1.108:61030	40.74.108.123:443	TIME_WAIT	InHost
TCP	192.168.1.108:61033	15.72.228.56:443	TIME_WAIT	InHost
TCP	192.168.1.108:61034	52.114.128.9:443	TIME_WAIT	InHost
TCP	192.168.1.108:61035	40.74.108.123:443	TIME_WAIT	InHost
TCP	192.168.1.108:61036	40.74.108.123:443	TIME_WAIT	InHost
TCP	192.168.1.108:61039	40.74.108.123:443	TIME_WAIT	InHost
TCP	192.168.1.108:61040	13.78.168.230:443	TIME_WAIT	InHost
TCP	192.168.1.108:61041	40.74.108.123:443	TIME_WAIT	InHost
TCP	192.168.1.108:61042	40.126.18.36:443	ESTABLISHED	InHost
TCP	192.168.1.108:61043	117.18.237.29:80	ESTABLISHED	InHost
TCP	192.168.1.108:61045	40.74.108.123:443	TIME_WAIT	InHost
TCP	192.168.1.108:61046	35.163.187.205:443	ESTABLISHED	InHost
TCP	192.168.1.108:61048	40.126.18.36:443	ESTABLISHED	InHost
TCP	192.168.1.108:61051	13.78.168.230:443	TIME_WAIT	InHost

**telnet**- Telnet is an old program for remote login. It's not used so much for that any more, since it has no security features. But basically, all it does is open a connection to a server and allow the 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 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: telnet <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  $n = 1, 2, 3, \dots$ , 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:

tracert <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).

```
C:\Program Files (x86)>tracert cs.stanford.edu

Tracing route to cs.stanford.edu [171.64.64.64]
over a maximum of 30 hops:

  0  9 ms    1 ms    2 ms  192.168.1.1
  1  4 ms    12 ms   2 ms  183.87.161.62.server.jprrdigital.net [183.87.161.62]
  2  *        *        *    Request timed out.
  3  3 ms    3 ms    2 ms  10.20.20.1
  4  5 ms    5 ms    4 ms  static-85.141.143.114-tataidc.co.in [114.143.141.85]
  5  30 ms   4 ms    5 ms  static-10.79.156.182-tataidc.co.in [182.156.79.10]
  6  6 ms    5 ms    6 ms  10.117.137.146
  7  8 ms    7 ms    5 ms  14.141.63.225.static-Mumbai.vsnl.net.in [14.141.63.225]
  8  *        *        *    Request timed out.
  9  *        *        *    Request timed out.
 10 38 ms   38 ms   37 ms ix-ae-4-2.tcore2.cxr-chennai.as6453.net [180.87.37.1]
 11 273 ms  313 ms  298 ms if-ae-10-4.tcore2.svw-singapore.as6453.net [180.87.67.16]
 12 313 ms  237 ms  238 ms if-ae-7-2.tcore2.lvw-losangeles.as6453.net [180.87.15.26]
 13 272 ms  241 ms  267 ms if-ae-2-2.tcore1.lvw-losangeles.as6453.net [66.110.59.1]
 14 236 ms  236 ms  291 ms las-b24-link.teliana.net [80.239.128.214]
 15 315 ms  306 ms  303 ms palo-b24-link.teliana.net [62.115.119.90]
 16 252 ms  297 ms  406 ms palo-b1-link.teliana.net [62.115.122.169]
 17 304 ms  316 ms  297 ms hurricane-ic-308019-palo-b1.c.teliana.net [80.239.167.174]
 18 280 ms  303 ms  307 ms stanford-university.100gigabitethernet5-1.core1.pao1.he.net [184.105.177.238]
 19 314 ms  305 ms  290 ms csee-west-rtr-vl3.SUNet [171.66.255.140]
 20 364 ms  304 ms  365 ms CS.stanford.edu [171.64.64.64]

Trace complete.
```

## 1.2.1 EXPERIMENTS WITH TRACEROUTE

From your machine traceroute to the following hosts:

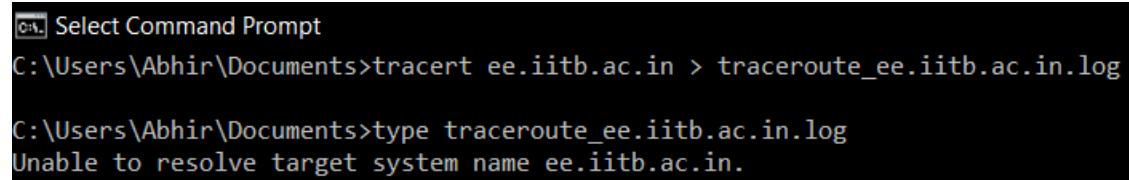
1. ee.iitb.ac.in
2. mscs.mu.edu
3. www.cs.grinnell.edu
4. csail.mit.edu
5. cs.stanford.edu

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`).

### **SOLUTIONS:**

A screenshot of a Windows Command Prompt window. The title bar reads "Select Command Prompt". The command prompt shows the user's current directory as "C:\Users\Abhir\Documents". The user has entered the command "tracert ee.iitb.ac.in > traceroute\_ee.iitb.ac.in.log". The prompt then shows the user entering "type traceroute\_ee.iitb.ac.in.log", followed by the output "Unable to resolve target system name ee.iitb.ac.in.".

```
C:\Users\Abhir\Documents>tracert ee.iitb.ac.in > traceroute_ee.iitb.ac.in.log

C:\Users\Abhir\Documents>type traceroute_ee.iitb.ac.in.log
Unable to resolve target system name ee.iitb.ac.in.
```

```
C:\Users\Abhir\Documents>tracert mscs.mu.edu > traceroute_mscs.mu.edu.log
```

```
C:\Users\Abhir\Documents>type traceroute_mscs.mu.edu.log
```

```
Tracing route to mscs.mu.edu [134.48.4.5]  
over a maximum of 30 hops:
```

1	1 ms	2 ms	3 ms	192.168.1.1
2	1 ms	1 ms	2 ms	183.87.161.62.server.jprrdigital.net [183.87.161.62]
3	*	*	*	Request timed out.
4	3 ms	2 ms	18 ms	10.20.20.1
5	11 ms	4 ms	1181 ms	static-85.141.143.114-tataidc.co.in [114.143.141.85]
6	6 ms	6 ms	5 ms	static-10.79.156.182-tataidc.co.in [182.156.79.10]
7	68 ms	7 ms	5 ms	10.117.137.146
8	6 ms	5 ms	6 ms	14.141.63.225.static-Mumbai.vsnl.net.in [14.141.63.225]
9	*	*	*	Request timed out.
10	21 ms	17 ms	6 ms	ix-ae-0-100.tcore1.mlv-mumbai.as6453.net [180.87.38.5]
11	278 ms	*	235 ms	if-ae-5-2.tcore1.wyn-marseille.as6453.net [80.231.217.29]
12	*	*	*	Request timed out.
13	203 ms	203 ms	128 ms	if-ae-11-2.tcore1.pvu-paris.as6453.net [80.231.153.49]
14	*	222 ms	203 ms	80.231.153.66
15	*	*	239 ms	ae-2-3603.ear3.Chicago2.Level3.net [4.69.159.186]
16	247 ms	224 ms	300 ms	MARQUETTE-U.ear3.Chicago2.Level3.net [4.16.38.70]
17	283 ms	306 ms	305 ms	134.48.10.27
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.
26	*	*	*	Request timed out.
27	*	*	*	Request timed out.
28	*	*	*	Request timed out.
29	*	*	*	Request timed out.
30	*	*	*	Request timed out.

```
Trace complete.
```

```
C:\Users\Abhir\Documents>tracert www.cs.grinnell.edu > traceroute_www.cs.grinnell.edu.log
```

```
C:\Users\Abhir\Documents>type traceroute_www.cs.grinnell.edu.log
```

```
Tracing route to www.cs.grinnell.edu [132.161.132.159]  
over a maximum of 30 hops:
```

1	73 ms	1 ms	2 ms	192.168.1.1
2	3 ms	1 ms	3 ms	183.87.161.62.server.jprrdigital.net [183.87.161.62]
3	*	*	*	Request timed out.
4	11 ms	14 ms	18 ms	10.20.20.1
5	60 ms	14 ms	7 ms	static-85.141.143.114-tataidc.co.in [114.143.141.85]
6	72 ms	7 ms	5 ms	static-10.79.156.182-tataidc.co.in [182.156.79.10]
7	5 ms	27 ms	88 ms	10.117.137.146
8	5 ms	6 ms	5 ms	14.141.63.225.static-Mumbai.vsnl.net.in [14.141.63.225]
9	*	*	*	Request timed out.
10	*	*	*	Request timed out.
11	23 ms	22 ms	23 ms	ix-ae-4-2.tcore2.cxr-chennai.as6453.net [180.87.37.1]
12	397 ms	255 ms	314 ms	if-ae-9-2.tcore2.mlv-mumbai.as6453.net [180.87.37.10]
13	359 ms	*	268 ms	if-ae-12-2.tcore1.l78-london.as6453.net [180.87.39.21]
14	281 ms	*	684 ms	if-ae-2-2.tcore2.l78-london.as6453.net [80.231.131.1]
15	249 ms	253 ms	318 ms	if-ae-8-49.tcore2.nton-newyork.as6453.net [216.6.81.34]
16	282 ms	302 ms	307 ms	if-ae-26-2.tcore1.ct8-chicago.as6453.net [216.6.81.29]
17	350 ms	306 ms	411 ms	63.243.129.121
18	*	*	*	Request timed out.
19	464 ms	279 ms	305 ms	et3-1-0-0.agr03.desm01-ia.us.windstream.net [40.128.250.43]
20	254 ms	333 ms	306 ms	et4-1-0-0.agr04.desm01-ia.us.windstream.net [40.136.117.253]
21	365 ms	251 ms	368 ms	ae4-0.pe05.grn101-ia.us.windstream.net [40.128.251.179]
22	373 ms	305 ms	306 ms	grn1-static-grinnellcollege0-0001.flex.iowatelecom.net [69.66.111.181]
23	*	*	*	Request timed out.
24	*	*	*	Request timed out.
25	*	*	*	Request timed out.
26	*	*	*	Request timed out.
27	*	*	*	Request timed out.
28	*	*	*	Request timed out.
29	*	*	*	Request timed out.
30	*	*	*	Request timed out.

```
Trace complete.
```

Command Prompt

C:\Users\Abhir\Documents>tracert csail.mit.edu >traceroute\_csail.mit.edu.log

C:\Users\Abhir\Documents>type traceroute\_csail.mit.edu.log

Tracing route to csail.mit.edu [128.30.2.109]  
over a maximum of 30 hops:

1	460 ms	1 ms	2 ms	192.168.1.1
2	4 ms	1 ms	2 ms	183.87.161.62.server.jprrdigital.net [183.87.161.62]
3	*	*	*	Request timed out.
4	10 ms	2 ms	3 ms	10.20.20.1
5	18 ms	5 ms	203 ms	static-85.141.143.114-tataidc.co.in [114.143.141.85]
6	6 ms	7 ms	6 ms	static-10.79.156.182-tataidc.co.in [182.156.79.10]
7	18 ms	5 ms	8 ms	10.117.137.146
8	5 ms	6 ms	7 ms	14.141.63.225.static-Mumbai.vsnl.net.in [14.141.63.225]
9	*	*	*	Request timed out.
10	6 ms	5 ms	6 ms	ix-ae-0-100.tcore1.mlv-mumbai.as6453.net [180.87.38.5]
11	257 ms	307 ms	305 ms	if-ae-2-2.tcore2.mlv-mumbai.as6453.net [180.87.38.2]
12	207 ms	*	409 ms	if-ae-12-2.tcore1.l78-london.as6453.net [180.87.39.21]
13	213 ms	297 ms	213 ms	if-ae-66-9.tcore2.nto-newyork.as6453.net [80.231.130.20]
14	210 ms	228 ms	306 ms	if-ae-12-2.tcore1.n75-newyork.as6453.net [66.110.96.5]
15	274 ms	212 ms	299 ms	66.110.96.134
16	322 ms	305 ms	306 ms	be-10390-cr02.newyork.ny.ibone.comcast.net [68.86.83.89]
17	292 ms	308 ms	213 ms	be-1302-cs03.newyork.ny.ibone.comcast.net [96.110.38.41]
18	301 ms	299 ms	299 ms	96.110.42.10
19	245 ms	306 ms	306 ms	ae0-0-eg-bstpmall74w.boston.ma.boston.comcast.net [68.86.238.34]
20	285 ms	305 ms	410 ms	50-201-57-174-static.hfc.comcastbusiness.net [50.201.57.174]
21	288 ms	306 ms	247 ms	dmz-rtr-1-external-rtr-3.mit.edu [18.0.161.13]
22	218 ms	303 ms	307 ms	dmz-rtr-2-dmz-rtr-1-2.mit.edu [18.0.162.6]
23	317 ms	217 ms	218 ms	mitnet.core-1-ext.csail.mit.edu [18.4.7.65]
24	*	*	307 ms	core-1-ext.bdr.csail.mit.edu [128.30.13.26]
25	225 ms	287 ms	275 ms	bdr.core-1.csail.mit.edu [128.30.0.246]
26	251 ms	218 ms	292 ms	inquir-3ld.csail.mit.edu [128.30.2.109]

Trace complete.

Command Prompt

C:\Users\Abhir\Documents>tracert cs.stanford.edu > traceroute\_cs.stanford.edu.log

C:\Users\Abhir\Documents>type traceroute\_cs.stanford.edu.log

Tracing route to cs.stanford.edu [171.64.64.64]  
over a maximum of 30 hops:

1	335 ms	4 ms	1 ms	192.168.1.1
2	3 ms	1 ms	5 ms	183.87.161.62.server.jprrdigital.net [183.87.161.62]
3	*	*	*	Request timed out.
4	4 ms	3 ms	1 ms	10.20.20.1
5	63 ms	4 ms	5 ms	static-85.141.143.114-tataidc.co.in [114.143.141.85]
6	5 ms	4 ms	4 ms	static-10.79.156.182-tataidc.co.in [182.156.79.10]
7	16 ms	9 ms	5 ms	10.117.137.146
8	14 ms	6 ms	11 ms	14.141.63.225.static-Mumbai.vsnl.net.in [14.141.63.225]
9	*	*	*	Request timed out.
10	*	*	*	Request timed out.
11	34 ms	34 ms	31 ms	ix-ae-4-2.tcore2.cxr-chennai.as6453.net [180.87.37.1]
12	239 ms	287 ms	306 ms	if-ae-10-4.tcore2.svw-singapore.as6453.net [180.87.67.16]
13	341 ms	271 ms	239 ms	if-ae-7-2.tcore2.lvw-losangeles.as6453.net [180.87.15.26]
14	*	266 ms	307 ms	if-ae-2-2.tcore1.lvw-losangeles.as6453.net [66.110.59.1]
15	333 ms	235 ms	235 ms	las-b24-link.telial.net [80.239.128.214]
16	292 ms	306 ms	306 ms	palo-b24-link.telial.net [62.115.119.90]
17	363 ms	306 ms	251 ms	palo-b1-link.telial.net [62.115.122.169]
18	312 ms	306 ms	307 ms	hurricane-ic-308019-palo-b1.c.telial.net [80.239.167.174]
19	304 ms	250 ms	319 ms	stanford-university.100gigabitethernet5-1.core1.pao1.he.net [184.105.177.238]
20	317 ms	315 ms	318 ms	csee-west-rtr-vl3.SUNet [171.66.255.140]
21	252 ms	307 ms	403 ms	CS.stanford.edu [171.64.64.64]

Trace complete.



```

C:\Users\Abhir\Documents>tracert cs.manchester.ac.uk > traceroute_cs.manchester.ac.uk.log

C:\Users\Abhir\Documents>type traceroute_cs.manchester.ac.uk.log

Tracing route to cs.manchester.ac.uk [130.88.101.49]
over a maximum of 30 hops:

  1  569 ms    1 ms    2 ms  192.168.1.1
  2   2 ms    2 ms    3 ms  183.87.161.62.server.jprrdigital.net [183.87.161.62]
  3   *        *        *    Request timed out.
  4   7 ms    3 ms    3 ms  10.20.20.1
  5  27 ms    6 ms    5 ms  static-85.141.143.114-tataidc.co.in [114.143.141.85]
  6   5 ms    4 ms    4 ms  static-10.79.156.182-tataidc.co.in [182.156.79.10]
  7  11 ms    8 ms    7 ms  10.117.137.146
  8   9 ms   11 ms    5 ms  14.141.63.225.static-Mumbai.vsnl.net.in [14.141.63.225]
  9   *        *        *    Request timed out.
 10 171 ms    6 ms    6 ms  ix-ae-0-100.tcore1.mlv-mumbai.as6453.net [180.87.38.5]
 11 212 ms   250 ms    *    if-ae-5-2.tcore1.wyn-marseille.as6453.net [80.231.217.29]
 12   *      236 ms    *    if-ae-21-2.tcore1.pye-paris.as6453.net [80.231.154.208]
 13 209 ms   204 ms   204 ms  if-ae-11-2.tcore1.pvu-paris.as6453.net [80.231.153.49]
 14   *        *        *    Request timed out.
 15 242 ms   132 ms   180 ms  ae-1-9.bear1.Manchesteruk1.Level3.net [4.69.167.38]
 16 161 ms   203 ms   132 ms  JANET.bear1.Manchester1.Level3.net [212.187.174.238]
 17 216 ms   189 ms   134 ms  ae22.manckh-sbr2.ja.net [146.97.35.189]
 18 186 ms   204 ms   131 ms  ae23.mancrh-rbr1.ja.net [146.97.38.42]
 19 219 ms    *      205 ms  universityofmanchester.ja.net [146.97.169.2]
 20 218 ms   199 ms   204 ms  130.88.249.194
 21   *        *        *    Request timed out.
 22   *        *        *    Request timed out.
 23 216 ms   127 ms   200 ms  eps.its.man.ac.uk [130.88.101.49]

Trace complete.

```

## Exercise 2:

Use traceroute to trace the route from your computer to math.hws.edu and to www.hws.edu. Explain the difference in the results.

Command Prompt

```
C:\Users\Abhir\Documents>tracert math.hws.edu && tracert www.hws.edu
```

```
Tracing route to math.hws.edu [64.89.144.237]  
over a maximum of 30 hops:
```

1	201 ms	3 ms	3 ms	192.168.1.1
2	2 ms	1 ms	1 ms	183.87.161.62.server.jprdigital.net [183.87.161.62]
3	*	*	*	Request timed out.
4	2 ms	3 ms	2 ms	10.20.20.1
5	5 ms	5 ms	5 ms	static-85.141.143.114-tataidc.co.in [114.143.141.85]
6	5 ms	11 ms	4 ms	static-10.79.156.182-tataidc.co.in [182.156.79.10]
7	17 ms	23 ms	24 ms	10.117.137.146
8	8 ms	5 ms	7 ms	14.141.63.225.static-Mumbai.vsnl.net.in [14.141.63.225]
9	*	*	*	Request timed out.
10	83 ms	15 ms	6 ms	ix-ae-0-100.tcore1.mlv-mumbai.as6453.net [180.87.38.5]
11	193 ms	201 ms	129 ms	if-ae-5-2.tcore1.wyn-marseille.as6453.net [80.231.217.29]
12	129 ms	190 ms	127 ms	if-ae-8-1600.tcore1.pye-paris.as6453.net [80.231.217.6]
13	210 ms	133 ms	165 ms	if-ae-11-2.tcore1.pvu-paris.as6453.net [80.231.153.49]
14	*	*	*	Request timed out.
15	183 ms	130 ms	479 ms	ae-1-3104.edge3.Paris1.Level3.net [4.69.161.110]
16	343 ms	127 ms	133 ms	global-crossing-xe-level3.paris1.level3.net [4.68.63.230]
17	212 ms	207 ms	400 ms	roc1-ar5-xe-11-0-0-0.us.twtelecom.net [35.248.1.162]
18	303 ms	307 ms	303 ms	66-195-65-170.staticctl.one [66.195.65.170]
19	274 ms	303 ms	303 ms	64.89.144.100
20	*	*	*	Request timed out.
21	*	*	*	Request timed out.
22	*	*	*	Request timed out.
23	*	*	*	Request timed out.
24	*	*	*	Request timed out.
25	*	*	*	Request timed out.
26	*	*	*	Request timed out.
27	*	*	*	Request timed out.
28	*	*	*	Request timed out.
29	*	*	*	Request timed out.
30	*	*	*	Request timed out.

```
Trace complete.
```

```
C:\> Command Prompt
Tracing route to www.hws.edu [64.89.145.159]
over a maximum of 30 hops:

 1  73 ms    1 ms     1 ms    192.168.1.1
 2   3 ms    2 ms     2 ms    183.87.161.62.server.jprrdigital.net [183.87.161.62]
 3   *       *       *       Request timed out.
 4   8 ms    5 ms     3 ms    10.20.20.1
 5   6 ms    4 ms     5 ms    static-85.141.143.114-tataidc.co.in [114.143.141.85]
 6   5 ms    4 ms     4 ms    static-10.79.156.182-tataidc.co.in [182.156.79.10]
 7  30 ms    4 ms     5 ms    10.117.137.146
 8   8 ms    6 ms     5 ms    14.141.63.225.static-Mumbai.vsnl.net.in [14.141.63.225]
 9   *       *       *       Request timed out.
10   6 ms    6 ms     6 ms    ix-ae-0-100.tcore1.mlv-mumbai.as6453.net [180.87.38.5]
11 179 ms    *       220 ms   if-ae-5-2.tcore1.wyn-marseille.as6453.net [80.231.217.29]
12   *       *       *       Request timed out.
13 133 ms   180 ms   202 ms   if-ae-11-2.tcore1.pvu-paris.as6453.net [80.231.153.49]
14   *       *       *       Request timed out.
15 129 ms   189 ms   130 ms   ae-1-3104.edge3.Paris1.Level3.net [4.69.161.110]
16 127 ms   127 ms   167 ms   global-crossing-xe-level3.paris1.level3.net [4.68.63.230]
17 276 ms   304 ms   207 ms   roc1-ar5-xe-11-0-0-0.us.twtelecom.net [35.248.1.162]
18 209 ms   209 ms   299 ms   66-195-65-170.static.ctl.one [66.195.65.170]
19 309 ms   305 ms   406 ms   64.89.144.100
20   *       *       *       Request timed out.
21   *       *       *       Request timed out.
22   *       *       *       Request timed out.
23   *       *       *       Request timed out.
24   *       *       *       Request timed out.
25   *       *       *       Request timed out.
26   *       *       *       Request timed out.
27   *       *       *       Request timed out.
28   *       *       *       Request timed out.
29   *       *       *       Request timed out.
30   *       *       *       Request timed out.

Trace complete.
```

As seen above there is not much of a difference for the two domains. A domain name might have multiple IP addresses associated. If this is the case, multiple traces may access two or more IP addresses. This will yield trace paths that differ from one another, even if the origin and destinations are the same.

Domains may also use multiple servers for its subdomains. Tracing the path to the base domain might result in a completely different path when tracing to the subdomain. A URL with the www prefix is technically a subdomain, so it's possible that traces to example.com and www.example.com follow two very different paths.

Many domains use separate hosting for email. If you try to trace the domain, you'll get data for the website server, not the email server. This concept is popularly known as Caveats.

Reference for exercise 2: <https://network-tools.com/trace/>

### Exercise 3:

Two packets sent from the same source to the same destination do not necessarily follow the same 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.

```
Command Prompt
C:\Users\Abhir\Documents>tracert cs.stanford.edu > traceroute_cs.stanford.edu.log

C:\Users\Abhir\Documents>type traceroute_cs.stanford.edu.log

Tracing route to cs.stanford.edu [171.64.64.64]
over a maximum of 30 hops:

  1  335 ms    4 ms    1 ms  192.168.1.1
  2   3 ms    1 ms    5 ms  183.87.161.62.server.jprrdigital.net [183.87.161.62]
  3   *        *        *    Request timed out.
  4   4 ms    3 ms    1 ms  10.20.20.1
  5  63 ms    4 ms    5 ms  static-85.141.143.114-tataidc.co.in [114.143.141.85]
  6   5 ms    4 ms    4 ms  static-10.79.156.182-tataidc.co.in [182.156.79.10]
  7  16 ms    9 ms    5 ms  10.117.137.146
  8  14 ms    6 ms   11 ms  14.141.63.225.static-Mumbai.vsnl.net.in [14.141.63.225]
  9   *        *        *    Request timed out.
 10   *        *        *    Request timed out.
 11  34 ms   34 ms   31 ms  ix-ae-4-2.tcore2.cxr-chennai.as6453.net [180.87.37.1]
 12 239 ms  287 ms  306 ms  if-ae-10-4.tcore2.svw-singapore.as6453.net [180.87.67.16]
 13 341 ms  271 ms  239 ms  if-ae-7-2.tcore2.lvw-losangeles.as6453.net [180.87.15.26]
 14   *    266 ms  307 ms  if-ae-2-2.tcore1.lvw-losangeles.as6453.net [66.110.59.1]
 15 333 ms  235 ms  235 ms  las-b24-link.telial.net [80.239.128.214]
 16 292 ms  306 ms  306 ms  palo-b24-link.telial.net [62.115.119.90]
 17 363 ms  306 ms  251 ms  palo-b1-link.telial.net [62.115.122.169]
 18 312 ms  306 ms  307 ms  hurricane-ic-308019-palo-b1.c.telial.net [80.239.167.174]
 19 304 ms  250 ms  319 ms  stanford-university.100gigabitethernet5-1.core1.pao1.he.net [184.105.177.238]
 20 317 ms  315 ms  318 ms  csee-west-rtr-vl3.SUNet [171.66.255.140]
 21 252 ms  307 ms  403 ms  CS.stanford.edu [171.64.64.64]

Trace complete.
```

```
C:\Program Files (x86)>tracert cs.stanford.edu

Tracing route to cs.stanford.edu [171.64.64.64]
over a maximum of 30 hops:

  1    9 ms    1 ms    2 ms  192.168.1.1
  2    4 ms   12 ms    2 ms  183.87.161.62.server.jprrdigital.net [183.87.161.62]
  3    *      *      *      Request timed out.
  4    3 ms    3 ms    2 ms  10.20.20.1
  5    5 ms    5 ms    4 ms  static-85.141.143.114-tataidc.co.in [114.143.141.85]
  6   30 ms    4 ms    5 ms  static-10.79.156.182-tataidc.co.in [182.156.79.10]
  7    6 ms    5 ms    6 ms  10.117.137.146
  8    8 ms    7 ms    5 ms  14.141.63.225.static-Mumbai.vsnl.net.in [14.141.63.225]
  9    *      *      *      Request timed out.
 10   *      *      *      Request timed out.
 11   38 ms   38 ms   37 ms  ix-ae-4-2.tcore2.cxr-chennai.as6453.net [180.87.37.1]
 12  273 ms  313 ms  298 ms  if-ae-10-4.tcore2.svw-singapore.as6453.net [180.87.67.16]
 13  313 ms  237 ms  238 ms  if-ae-7-2.tcore2.lvw-losangeles.as6453.net [180.87.15.26]
 14  272 ms  241 ms  267 ms  if-ae-2-2.tcore1.lvw-losangeles.as6453.net [66.110.59.1]
 15  236 ms  236 ms  291 ms  las-b24-link.teliana.net [80.239.128.214]
 16  315 ms  306 ms  303 ms  palo-b24-link.teliana.net [62.115.119.90]
 17  252 ms  297 ms  406 ms  palo-b1-link.teliana.net [62.115.122.169]
 18  304 ms  316 ms  297 ms  hurricane-ic-308019-palo-b1.c.teliana.net [80.239.167.174]
 19  280 ms  303 ms  307 ms  stanford-university.100gigabitethernet5-1.core1.pao1.he.net [184.105.177.238]
 20  314 ms  305 ms  290 ms  csee-west-rtr-vl3.SUNet [171.66.255.140]
 21  364 ms  304 ms  365 ms  CS.stanford.edu [171.64.64.64]

Trace complete.
```

## Questions:

- Is any part of the path common for all hosts you tracerouted ?

Yes, the first one which is the source's IP address

- 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?

No, the number of nodes and the location of the host are not related to each other. It even depends on the physical interface that is being used.

- 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?

There is a direct relationship between the number of nodes and the latency of the host. The amount of latency is largely dependent on how far the visitor is from the server location and how many nodes the signal has to travel through.

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

```
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: ns2.google.com
Name Server: ns4.google.com
Name Server: ns3.google.com
Name Server: ns1.google.com
DNSSEC: unsigned
URL of the ICANN WHOIS Data Problem Reporting System: http://wdprs.internic.net/
>>> Last update of WHOIS database: 2020-08-22T05:54:07-0700 <<<
```