CS 331 Name _____
Computer Networks Date _____

Lab 3 - Ping and Traceroute - Solution

**1a. What do the statistics at the end of the output represent?**

The statistics at the end of the ping command tell you the total packets that were sent, received, and lost and also the approximate minimum, maximum, and average round trip times in milli-seconds. These statistics help you understand connectivity and if there is traffic in the network between the two hosts.

**1b. What type of insight does it give you about the network (i.e. packet loss, delay, link failure)?**

If the minimum and maximum round trip time varies greatly or if the average round trip time is closer to the maximum round trip time, this might indicate that the network is congested.

If you receive the "Request Timed Out" message continuously, the destination device may not be connected to the network, is powered off, is not configured correctly, or some intermediate device is not operating correctly. If you occasional receive a "Request Timed Out" message, this might indicate the packet was dropped by a router.

**2. What type of delay can we use ping to estimate?**

The ping command does not tell which routers the packet passed through. Therefore, we do not know the total distance the packet traveled and can not accurately calculate propagation delay. Since we do not know the total routers the packet passed through, calculating queuing and processor delay would be very difficult too. The ping command can only reveal round trip time.

**3. Pick a host in the east coast and try to ping. Write your output.**

Pinging www.mit.edu [18.7.22.83] with 32 bytes of data:

Reply from 18.7.22.83: bytes=32 time=40ms TTL=237
Reply from 18.7.22.83: bytes=32 time=41ms TTL=237
Reply from 18.7.22.83: bytes=32 time=42ms TTL=237
Reply from 18.7.22.83: bytes=32 time=41ms TTL=237

Ping statistics for 18.7.22.83:
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 40ms, Maximum = 42ms, Average = 41ms

**4. Pick a host in the west coast and try to ping. Write your output.**

Pinging www.w3.berkeley.edu [169.229.131.81] with 32 bytes of data:

Reply from 169.229.131.81: bytes=32 time=106ms TTL=48
Reply from 169.229.131.81: bytes=32 time=110ms TTL=48
Reply from 169.229.131.81: bytes=32 time=108ms TTL=48
Reply from 169.229.131.81: bytes=32 time=107ms TTL=48

Ping statistics for 169.229.131.81:
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 106ms, Maximum = 110ms, Average = 107ms

**5. Compare the results from questions 3 and 4. Which one has a greater delay?**

The host on the west coast (www.berkeley.edu) had greater minimum, maximum, and average round trip times (106, 110, and 107) compared to the host on the east coast (www.mit.edu) (40, 42, and 41). Also, the host on the west coast had a much lower TTL value (48) compared to the host on the east coast (237). Overall, the host on the west coast had a much greater RTT maybe du to longer propagation delay since packets may travel longer distances than the host on the east coast.

**6. Repeat questions 3, 4, and 5 for universities outside of North America? How does your results compare with the previous results?**

University of Melbourne – Australia

Pinging www.unimelb.edu.au [128.250.6.182] with 32 bytes of data:

Reply from 128.250.6.182: bytes=32 time=249ms TTL=234
Reply from 128.250.6.182: bytes=32 time=248ms TTL=234
Reply from 128.250.6.182: bytes=32 time=247ms TTL=234
Reply from 128.250.6.182: bytes=32 time=247ms TTL=234

Ping statistics for 128.250.6.182:
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 247ms, Maximum = 249ms, Average = 247ms

Heidelberg University – Germany

Pinging www.uni-heidelberg.de [129.206.13.27] with 32 bytes of data:

Reply from 129.206.13.27: bytes=32 time=131ms TTL=48
Reply from 129.206.13.27: bytes=32 time=129ms TTL=48

Reply from 129.206.13.27: bytes=32 time=130ms TTL=48
Reply from 129.206.13.27: bytes=32 time=124ms TTL=48

Ping statistics for 129.206.13.27:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 124ms, Maximum = 131ms, Average = 128ms

The two universities outside the USA had longer minimum, maximum, and average round trip times than the two universities in the USA. This should be expected since the physical distance is greater, which affects propagation delay.

**7. Calculate delays for propagation and transmission by estimating the set of numerical values used by the formulas.**

The default Windows ping packet size is 32 bytes. A wireless connection speed is 54 Mbps. Using Mapquest, the distance from ohio to MIT is 605 miles (or 973,653 meters) and the distance from my house to UC at Berkeley is 2,511 miles (or 4,041,063 meters).

| Host | Average ping round trip time (RTT) | Average ping one-way delay (Average RTT / 2) | Estimated Propagation Delay (total distance / speed of light) | Estimated Transmission Delay (total bits / speed) |
|---|---|---|---|---|
| www.mit.edu | 41 ms | 20.5 ms | $D_P=D/S$<br>$D_P=973653m/2.8x10^8m/s$<br>$D_P=0.00348s$<br>$D_P=3.48ms$ | $D_T=L/R$<br>$D_T=32B/54Mbps$<br>$D_T=256b/54x10^6bps$<br>$D_T=0.00474$ ms |
| www.berkeley.edu | 107 ms | 53.5 ms | $D_P=D/S$<br>$D_P=4041063m /2.8x10^8m/s$<br>$D_P=0.01443s$<br>$D_P=14.43ms$ | $D_T=L/R$<br>$D_T=32B/54Mbps$<br>$D_T=256b/54x10^6bps$<br>$D_T=0.00474$ ms |

For www.mit.edu, the calculated transmission and propagation delay is 3.48 ms + 0.00474 ms = 3.48 ms. This is a big difference compared to the average one-way delay of 20.5 from the ping command.

For www.berkeley.edu, the calculated transmission and propagation delay is 14.43 ms + 0.00474 ms = 14.43 ms. This is a big difference compared to the average one-way delay of 53.5 from the ping command.

Mapquest uses the best direct path to calculate the distance between two points. On the other hand, the ping command is dependent upon routers to choose the best path for the packet to travel, which is usually not the shortest and most direct path as indicated by the trace route command. Because of this, that would explain the differences between what I calculated for transmission and propagation delay and what ping calculated for delay.

**8. Research the command for the Windows traceroute.**

I used the paper "Simple Network Diagnostic Tools Ping and Traceroute" to answer this question. http://www.itl.ohiou.edu/read-tools.pdf

The traceroute command makes use of basic error reporting functions to give us more visibility into the network. When a router cannot forward a packet, it sends an ICMP error message back to the machine that sent the original packet. A host machine will do the same for packets that it is not prepared to handle. traceroute triggers these errors on purpose, to provide a simple "map" of the network between you and your target.

Here is how traceroute works:

1. It creates a packet to the destination and sets the TTL to zero. The first router discards that packet and sends an ICMP Time to Live Exceeded error message. That generates the output in the line starting with "1". Actually, traceroute does this three times by default, and reports the time between sending the packet and receiving the ICMP message for each probe. Note that these times can vary quite a bit.

2. Traceroute now sends the same packet with a TTL=1. That makes it through the first router, but fails on the second one, which sends the ICMP Time Exceeded message. That identifies the hop in line "2".

3. Traceroute keeps sending the same packet with increasing TTLs. Eventually the packet will get to the host specified. By default, traceroute sends UDP packets with a random port number, meaning that the receiving host probably does not know what to do with the packet. The host will respond to the packet with an ICMP Port Unreachable error, which tells traceroute that it is done.

Things to remember when using traceroute:

The description above describes how traceroute is supposed to work. However, it rarely works this smoothly. For our purposes, here are the important ones:

• For many reasons, some of the probes will not return responses. If at least one succeeds for a given hop, the corresponding output line will be filled in, with some of the time values replaced by "*". If all probes fail, the output line will only contain three "*"s.

• If the last ICMP Port Unreachable error is not received — either because the host did not send it, or because the ICMP messages are dropped by a firewall or router, traceroute will continue to probe up to the maximum number of hops requested (typically between 30 and 64). This can take quite some time. You can stop traceroute with "C ".

• Occasionally, a router downstream will be misconfigured and the probe packet will trigger an unusual error message. Traceroute displays these in place of the times, for example "Host Unreachable", "Network Unreachable".

These can give you valuable diagnostic information when your network is not working properly.

• The traceroute command is called tracert in Windows.

• Use tracert /? to get usage information.

• tracert probes for 30 hops by default.

**9. Use traceroute for the host of questions 3 and 4. What insight can you conclude from the results?**

Tracing route to www.mit.edu [18.7.22.83] over a maximum of 30 hops:

| | | | | |
|---|---|---|---|---|
| 1 | 11 ms | 20 ms | 11 ms | dynamic-acs-24-144-151-1.zoominternet.net [24.144.151.1] |
| 2 | 13 ms | 10 ms | 11 ms | dynamic-acs-72-23-2-229.zoominternet.net [72.23.2.229] |
| 3 | 15 ms | 16 ms | 14 ms | dynamic-acs-72-23-2-193.zoominternet.net [72.23.2.193] |
| 4 | 14 ms | 11 ms | 12 ms | dynamic-acs-72-23-2-13.zoominternet.net [72.23.2.13] |
| 5 | 10 ms | 11 ms | 12 ms | static-acs-24-154-0-181.zoominternet.net [24.154.0.181] |
| 6 | 14 ms | 15 ms | 15 ms | sl-st3-pit-2-3.sprintlink.net [144.228.178.37] |
| 7 | 21 ms | 19 ms | 20 ms | sl-bb23-rly-15-0.sprintlink.net [144.232.20.216] |
| 8 | 21 ms | 20 ms | 19 ms | sl-bb21-rly-9-0.sprintlink.net [144.232.14.133] |
| 9 | 23 ms | 23 ms | 23 ms | sl-crs1-rly-0-4-0-0.sprintlink.net [144.232.3.94] |
| 10 | 34 ms | 34 ms | 35 ms | 144.232.20.182 |
| 11 | 38 ms | 39 ms | 35 ms | sl-crs1-spr-0-0-0-0.sprintlink.net [144.232.18.207] |
| 12 | 39 ms | 35 ms | 35 ms | sl-crs2-spr-0-1-0-0.sprintlink.net [144.232.21.13] |
| 13 | 39 ms | 41 ms | 42 ms | sl-st20-bos-0-0-0.sprintlink.net [144.232.8.48] |
| 14 | 43 ms | 43 ms | 43 ms | 208.30.223.6 |
| 15 | 42 ms | 39 ms | 40 ms | W92-RTR-1-BACKBONE-2.MIT.EDU [18.168.1.25] |
| 16 | 40 ms | 39 ms | 39 ms | WWW.MIT.EDU [18.7.22.83] |

Trace complete.

Tracing route to www.w3.berkeley.edu [169.229.131.81] over a maximum of 30 hops:

| | | | | |
|---|---|---|---|---|
| 1 | 9 ms | 11 ms | 20 ms | dynamic-acs-24-144-151-1.zoominternet.net [24.144.151.1] |
| 2 | 21 ms | 12 ms | 11 ms | dynamic-acs-72-23-2-229.zoominternet.net [72.23.2.229] |
| 3 | 12 ms | 16 ms | 15 ms | dynamic-acs-72-23-2-193.zoominternet.net [72.23.2.193] |
| 4 | 11 ms | 11 ms | 11 ms | dynamic-acs-72-23-2-13.zoominternet.net [72.23.2.13] |
| 5 | 11 ms | 11 ms | 11 ms | static-acs-24-154-0-181.zoominternet.net [24.154.0.181] |
| 6 | 37 ms | 35 ms | 35 ms | 209.220.16.85.ptr.us.xo.net [209.220.16.85] |
| 7 | 40 ms | 38 ms | 39 ms | 207.88.13.50.ptr.us.xo.net [207.88.13.50] |
| 8 | 106 ms | 106 ms | 104 ms | te-11-0-0.rar3.sanjose-ca.us.xo.net [207.88.12.69] |
| 9 | 107 ms | 109 ms | 106 ms | 207.88.12.178.ptr.us.xo.net [207.88.12.178] |
| 10 | 107 ms | 103 ms | 104 ms | paix-px1--xo-ge.cenic.net [198.32.251.41] |

| | | | | |
|---|---|---|---|---|
| 11 | 107 ms | 107 ms | 107 ms | dc-svl-core1--svl-dc1-ge-3.cenic.net [137.164.46.68] |
| 12 | 109 ms | 110 ms | 108 ms | dc-oak-core1--svl-core1-ge-1.cenic.net [137.164.46.213] |
| 13 | 106 ms | 106 ms | 107 ms | dc-oak-agg2--oak-core1-10ge.cenic.net [137.164.47.116] |
| 14 | 108 ms | 109 ms | 112 ms | ucb--oak-dc2-ge.cenic.net [137.164.23.30] |
| 15 | 108 ms | 107 ms | 107 ms | t2-3.inr-202-reccev.Berkeley.EDU [128.32.0.39] |
| 16 | 106 ms | 107 ms | 108 ms | t1-1.inr-211-srb.Berkeley.EDU [128.32.255.43] |
| 17 | 107 ms | 108 ms | 107 ms | webfarm.Berkeley.EDU [169.229.131.81] |

Trace complete.

Using the Windows tracert command to www.mit.edu, the packet had to pass through 15 routers. The round trip times (40, 39, and 39) on the last line agree with the average round trip time for the ping command (41). There were no timeouts reported.

Using the Windows tracert command to www.berkeley.edu, the packet had to pass through 16 routers. The round trip times (107, 108, and 107) on the last line agree with the average round trip time for the ping command (107). There were no timeouts reported.

**10. Wait a day until executing trace route for question 9 again. Do the results differ from the ones obtained previously. If so, why or why not?**

After waiting two days, I ran the trace route command again.

Tracing route to WWW.MIT.EDU [18.7.22.83] over a maximum of 30 hops:

| | | | | |
|---|---|---|---|---|
| 1 | 11 ms | 11 ms | 14 ms | dynamic-acs-24-144-151-1.zoominternet.net [24.144.151.1] |
| 2 | 13 ms | 11 ms | 25 ms | dynamic-acs-72-23-2-229.zoominternet.net [72.23.2.229] |
| 3 | 24 ms | 16 ms | 16 ms | dynamic-acs-72-23-2-193.zoominternet.net [72.23.2.193] |
| 4 | 16 ms | 11 ms | 11 ms | dynamic-acs-72-23-2-13.zoominternet.net [72.23.2.13] |
| 5 | 12 ms | 11 ms | 11 ms | static-acs-24-154-0-181.zoominternet.net [24.154.0.181] |
| 6 | 16 ms | 15 ms | 16 ms | sl-st3-pit-2-3.sprintlink.net [144.228.178.37] |
| 7 | 22 ms | 23 ms | 20 ms | sl-bb23-rly-15-0.sprintlink.net [144.232.20.216] |
| 8 | 23 ms | 23 ms | 23 ms | sl-bb21-rly-9-0.sprintlink.net [144.232.14.133] |
| 9 | 20 ms | 24 ms | 23 ms | sl-crs1-rly-0-4-0-0.sprintlink.net [144.232.3.94] |
| 10 | 37 ms | 44 ms | 41 ms | 144.232.20.182 |
| 11 | 39 ms | 40 ms | 39 ms | sl-crs1-spr-0-0-0-0.sprintlink.net [144.232.18.207] |
| 12 | 40 ms | 36 ms | 36 ms | sl-crs2-spr-0-1-0-0.sprintlink.net [144.232.21.13] |
| 13 | 42 ms | 39 ms | 39 ms | sl-st20-bos-0-0-0.sprintlink.net [144.232.8.48] |
| 14 | 41 ms | 43 ms | 43 ms | 208.30.223.6 |
| 15 | 41 ms | 44 ms | * | W92-RTR-1-BACKBONE-2.MIT.EDU [18.168.1.25] |
| 16 | 39 ms | 40 ms | 43 ms | WWW.MIT.EDU [18.7.22.83] |

Trace complete.

Tracing route to www.w3.BERKELEY.EDU [169.229.131.81] over a maximum of 30 hops:

| | | | | |
|---|---|---|---|---|
| 1 | 10 ms | 11 ms | 12 ms | dynamic-acs-24-144-151-1.zoominternet.net [24.144.151.1] |
| 2 | 12 ms | 11 ms | 12 ms | dynamic-acs-72-23-2-229.zoominternet.net [72.23.2.229] |
| 3 | 15 ms | 15 ms | 15 ms | dynamic-acs-72-23-2-193.zoominternet.net [72.23.2.193] |
| 4 | 12 ms | 11 ms | 11 ms | dynamic-acs-72-23-2-13.zoominternet.net [72.23.2.13] |
| 5 | 12 ms | 12 ms | 16 ms | static-acs-24-154-0-181.zoominternet.net [24.154.0.181] |
| 6 | 38 ms | 38 ms | 36 ms | 209.220.16.85.ptr.us.xo.net [209.220.16.85] |
| 7 | 37 ms | 39 ms | 37 ms | 207.88.13.50.ptr.us.xo.net [207.88.13.50] |
| 8 | 105 ms | 107 ms | 103 ms | te-11-0-0.rar3.sanjose-ca.us.xo.net [207.88.12.69] |
| 9 | 128 ms | 107 ms | 108 ms | 207.88.12.178.ptr.us.xo.net [207.88.12.178] |
| 10 | 106 ms | 106 ms | 108 ms | paix-px1--xo-ge.cenic.net [198.32.251.41] |
| 11 | 108 ms | 107 ms | 108 ms | dc-svl-core1--svl-dc1-ge-3.cenic.net [137.164.46.68] |
| 12 | 108 ms | 107 ms | 107 ms | dc-oak-core1--svl-core1-ge-1.cenic.net [137.164.46.213] |
| 13 | 109 ms | 107 ms | 108 ms | dc-oak-agg2--oak-core1-10ge.cenic.net [137.164.47.116] |
| 14 | 111 ms | 107 ms | 111 ms | ucb--oak-dc2-ge.cenic.net [137.164.23.30] |
| 15 | 108 ms | 107 ms | 108 ms | t2-3.inr-202-reccev.Berkeley.EDU [128.32.0.39] |
| 16 | 110 ms | 107 ms | 108 ms | t1-1.inr-211-srb.Berkeley.EDU [128.32.255.43] |
| 17 | 114 ms | 108 ms | 110 ms | webfarm.Berkeley.EDU [169.229.131.81] |

Trace complete.

Using the Windows tracert command to www.mit.edu, the packet traveled through the same 15 routers. The round trip times (39, 40, and 43) were similar to the round trip times from two days ago (40, 39, and 39). There was one timeout reported.

Using the Windows tracert command to www.berkeley.edu, the packet traveled through the same 16 routers. The round trip times (114, 108, 110) were just slightly higher than the round trip times from two days ago (107, 108, and 107). There were no timeouts reported.

Overall, the results were very similar for the two times. As long as I started from the same location using the same ISP and the same routers remained up and running, the same results should be obtained.

**11. How can you use the traceroute and ping command to explain an operational approach to packet switched networks and the idea of a hierarchical networks of networks.**

The Internet is a network of networks and can be very difficult to grasp due to its complexity. When using the traceroute and ping commands, one can get a feel for packet delay and how the packet travels on the network. The ping command does not reveal anything about the hierarchy of the Internet. On the other hand, traceroute helps show the hierarchical networks of networks because it can show the routers of your ISP, the routers on the Internet backbone, and the routers of the your final destination node.