6.033 Computer System Engineering

Spring 2009

Hands-on 3: Internet Routes and Measuring Round Trip Times

Complete the following hands-on assignment. Do the activities described, and hand in the answers to the numbered questions at the **beginning of Recitation 11**. Please hand in *t yped* responses, not hand-written.

In this assignment you will get a chance to experiment with two very useful and widely-used network diagnostic tools, `traceroute` and `ping`, to expose you to some of the interesting quirks in network routing and packet round trip times.

We recommend, but do not require, that you perform this assignment on Athena. **Part of this assignment cannot be completed on `athena.dialup.mit.edu` due to security restrictions.** Please note that the TAs cannot guarantee tech support if you do not use an Athena workstation. In either case, please make sure you use a workstation on the MIT network. Some results may be quite different if you use an off-campus network.

0. Measuring Round Trip Times With Ping

In the first two exercises, you will use the ping utility to send echo requests to a number of different hosts. The ping utility is one of the more useful utilities for testing a network. It allows you to measure the time that it takes for a packet to travel through the Internet to a remote host and back. The ping utility works by sending a short message, called an *echo-request*, to a host using the Internet Control Message Protocol (ICMP). A host that supports ICMP (and most do) and receives an echo-request message simply replies by sending an *echo-response* back to the originating host.

In many of the exercises, you will be referring to hosts via their DNS names rather than their IP addresses. (For more information about Internet hostnames and DNS, and how these relate to IP addresses, please see Section 4.4 of the course notes.)

For more information about ping, look at the man page on ping and the specifications for ICMP, located in RFC 792. Section 7.4.4 of the course notes describe ICMP as well.

```
athena% man ping
```

To use the ping command on Athena, run a command such as:

```
athena% ping www.google.com
```

If you run ping from a Sun workstation, you may have to use the `-s` option to get it to display the results that you want. Type `machtype` to determine the type of machine you are using. If you have any more questions, see the man pages for more details on how to use ping.

A. Round Trip Times:

In the following two questions, you are asked to use the ping utility to measure the round trip times to several hosts on the Internet.

For the following hosts, send 10 packets, each with a length of 56 data bytes. *Note*: You may find that the packet responses are 64 bytes instead of 56 bytes. Look at RFC 792 to find out the reason.

The hosts are:

```
www.csail.mit.edu
www.berkeley.edu
www.usyd.edu.au
www.kyoto-u.ac.jp
```

> **Question 1:** Indicate what percentage of packets sent resulted in a successful response. For the packets from which you received a response, write down the minimum, average, and maximum round trip times in milliseconds. Note that ping reports these times to you if you tell it how many packets to send on the command line.

> **Question 2:** Explain the differences in minimum round trip time to each of these hosts.

Question 3: Now send pings with 56, 512 and 1024 byte packets to the 4 hosts above. Write down the minimum, average, and maximum round trip times in milliseconds for each of the 12 pings. Why are the minimum round-trip times to the same hosts different when using 56, 512, and 1024 byte packets?

B. Unanswered Pings:

For the following hosts, send 100 packets that have a length of 56 data bytes. Indicate what percentage of the packets resulted in a successful response.

```
www.wits.ac.za        (University of the Witwatersrand, Johannesburg)
www.microsoft.com
```

> **Question 4:** For some of the hosts, you may not have received any responses for the packets you sent. What are some reasons as to why you might have not gotten a response? (Be sure to check the hosts in a web browser.)

1. Understanding Internet routes using traceroute

As the name implies, `traceroute` essentially allows you to trace the entire route from your machine to a remote machine. The remote machine can be specified either as a name or as an IP address.

The `athena.dialup.mit.edu` machines have security restrictions against using `icmp` sockets. Icmp has been disabled on the dialups because icmp traffic can be used to explore the topology of the network and a compromised athena account results in easy access to the powerful dialup machines. You'll

need to use an accessible linux machine or visit a cluster in order to complete the traceroute portion of the hands-on.

We include a sample output of an execution of traceroute and explain the salient features. The command:

```
% traceroute www.google.com
```

tries to determine the path from the source machine (vinegar-pot.mit.edu) to www.google.com. The machine encountered on the path after the first hop is NW12-RTR-2-SIPB.MIT.EDU, the next is EXTERNAL-RTR-1-BACKBONE-2.MIT.EDU, and so on. In all, it takes 13 hops to reach py-in-f99.google.com. The man page for traceroute (athena% man traceroute) contains explanations for the remaining fields on each line.

```
% traceroute www.google.com
traceroute: Warning: www.google.com has multiple addresses; using 64.233.167.99
traceroute to www.l.google.com (64.233.167.99), 30 hops max, 40 byte packets
 1  NW12-RTR-2-SIPB.MIT.EDU (18.181.0.1)  0.476 ms  0.318 ms  0.237 ms
 2  EXTERNAL-RTR-1-BACKBONE-2.MIT.EDU (18.168.1.18)  0.827 ms  0.624 ms  0.753 ms
 3  EXTERNAL-RTR-2-BACKBONE.MIT.EDU (18.168.0.27)  1.097 ms  0.772 ms  0.887 ms
 4  207.210.142.233 (207.210.142.233)  0.578 ms  0.549 ms  0.713 ms
 5  207.210.142.1 (207.210.142.1)  0.750 ms  2.530 ms  1.178 ms
 6  207.210.142.2 (207.210.142.2)  5.886 ms  15.387 ms  5.762 ms
 7  64.57.29.21 (64.57.29.21)  24.732 ms  24.693 ms  24.695 ms
 8  72.14.236.215 (72.14.236.215)  31.733 ms  27.588 ms 216.239.49.34 (216.239.49.34)  27.810 ms
 9  66.249.94.235 (66.249.94.235)  12.495 ms 209.85.252.166 (209.85.252.166)  36.961 ms  26.459 ms
10  216.239.46.224 (216.239.46.224)  33.736 ms  33.396 ms 209.85.248.221 (209.85.248.221)  26.130 ms
11  66.249.94.133 (66.249.94.133)  26.126 ms 72.14.232.53 (72.14.232.53)  25.744 ms  25.611 ms
12  66.249.94.133 (66.249.94.133)  26.183 ms  27.460 ms 72.14.232.70 (72.14.232.70)  37.800 ms
13  py-in-f99.google.com (64.233.167.99)  28.249 ms  26.050 ms  26.398 ms
```

A. Basics:

Question 5:

In at most 50 words, explain how traceroute discovers a path to a remote host. The man page might be useful in answering this question.

B. Routine Asymmetries:

For this exercise, you need to use the traceroute server at http://looking-glass.optus.net.au. When you view this web page, execute a traceroute (trace) to your machine (run hostname to find the name of your machine.) Be sure to select "International" in the drop-down box on this site. **Note**: It is important to be running this on Athena machines.

Now run

```
athena% traceroute looking-glass.optus.net.au
```

on your machine.

Question 6: Show the output of traceroute from each direction above.

Question 7: Describe anything unusual about the output. Are the same routers traversed in both directions? Why might this happen?

C. Blackholes:

At the command prompt, type:

```
athena% traceroute 18.31.0.200
```

Question 8: Show the output of the above command. Describe what is strange about the observed output, and why traceroute gives you such an output. Refer to the traceroute man page for useful hints.

2. Border Gateway Protocol (BGP)

For this last question on the topic of Internet routing, you need to refer to the BGP routing table data below. This table shows all of the BGP routing entries that a particular router (near the University of Oregon) refers to when forwarding any packets to MIT (IP Address 18.*.*.*).

As described in the Internet routing paper, recall that BGP is a path vector protocol. Each line of this table lists a distinct path from this router to MIT, from which it will choose one to use. The Next Hop field is the IP address of the router that forwards packets for each path listed in the table. The Path field is the list of autonomous systems the path traverses on its way to MIT. The other fields (Metric, LocPrf, Weight) may be used by the router to decide which one of the possible paths to use.

```
BGP table version is 9993576, local router ID is 198.32.162.100
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
*  18.0.0.0         216.140.8.59          413                0 6395 3356 3 i
*                   216.140.2.59          982                0 6395 3356 3 i
*                   141.142.12.1                             0 1224 22335 11537 10578 3 i
*                   209.249.254.19        125                0 6461 3356 3 i
*                   202.232.0.2                              0 2497 3356 3 i
*                   209.10.12.125        8204                0 4513 3356 3 i
*                   208.51.113.253                           0 3549 174 16631 3 3 3 i
*                   209.123.12.51                            0 8001 1784 10578 3 i
*                   209.10.12.156           0                0 4513 3356 3 i
*                   195.66.224.82                            0 4513 3356 3 i
*                   209.10.12.28         8203                0 4513 3356 3 i
*                   203.181.248.233                          0 7660 11537 10578 3 i
```

```
*                      64.50.230.2                                  0 4181 174 174 174 16631 3 3 3 i
*                      195.66.232.254                               0 5459 2649 174 174 174 16631 3 3 3 i
*                      195.66.232.239                               0 5459 2649 174 174 174 16631 3 3 3 i
*                      64.50.230.1                                  0 4181 174 174 174 16631 3 3 3 i
*                      194.85.4.55                                  0 3277 8482 29281 702 701 3356 3 i
*                      207.172.6.227           83                   0 6079 10578 3 i
*                      207.172.6.162           62                   0 6079 10578 3 i
*                      129.250.0.85            11                   0 2914 174 16631 3 3 3 i
*                      206.220.240.95                               0 10764 11537 10578 3 i
*                      217.75.96.60                                 0 16150 8434 3257 3356 3 i
*                      66.185.128.48          514                   0 1668 3356 3 i
*                      206.24.210.26                                0 3561 3356 3 i
*                      216.191.65.118                               0 15290 174 16631 3 3 3 i
*                      216.191.65.126                               0 15290 174 16631 3 3 3 i
*                      209.161.175.4                                0 14608 19029 3356 3 i
*                      202.249.2.86                                 0 7500 2497 3356 3 i
*                      208.186.154.35           0                   0 5650 3356 3 i
*                      167.142.3.6                                  0 5056 1239 3356 3 i
*                      64.200.151.12                                0 7911 3356 3 i
*                      195.219.96.239                               0 6453 3356 3 i
*                      208.186.154.36           0                   0 5650 3356 3 i
*                      203.194.0.12                                 0 9942 16631 174 174 174 16631 3 3 3 i
*                      213.200.87.254          40                   0 3257 3356 3 i
*                      216.218.252.145                              0 6939 3356 3 i
*                      216.18.63.137                                0 6539 174 16631 3 3 3 i
*                      216.218.252.152                              0 6939 3356 3 i
*                      195.249.0.135                                0 3292 3356 3 i
*                      65.106.7.139             3                   0 2828 174 16631 3 3 3 i
*                      207.45.223.244                               0 6453 3356 3 i
*                      207.246.129.14                               0 11608 6461 3356 3 i
*                      207.46.32.32                                 0 8075 174 16631 3 3 3 i
*                      129.250.0.11             0                   0 2914 174 16631 3 3 3 i
*                      134.55.200.1                                 0 293 11537 10578 3 i
*                      193.0.0.56                                   0 3333 3356 3 i
*                      216.140.14.186           3                   0 6395 3356 3 i
*                      198.32.8.196           960                   0 11537 10578 3 i
*                      64.200.95.239                                0 7911 3356 3 i
*                      196.7.106.245                                0 2905 701 3356 3 i
*                      154.11.63.86                                 0 852 174 16631 3 3 3 i
*                      134.222.85.45            0                   0 286 209 3356 3 i
*                      213.140.32.146                               0 12956 174 16631 3 3 3 i
*                      164.128.32.11                                0 3303 3356 3 i
*                      213.248.83.240                               0 1299 3356 3 i
*                      154.11.98.18                                 0 852 174 16631 3 3 3 i
*>                     4.68.0.243               0                   0 3356 3 i
*                      204.42.253.253           0                   0 267 2914 174 16631 3 3 3 i
*                      206.186.255.223                              0 2493 3602 174 16631 3 3 3 i
*                      193.251.128.22                               0 5511 3356 3 i
*                      203.62.252.26                                0 1221 4637 3356 3 i
```

```
*                    12.0.1.63                              0 7018 3356 3 i
*                    144.228.241.81   4294967294            0 1239 3356 3 i
```

Question 9: From the path entry data, which Autonomous System (AS) number corresponds to MIT?

Question 10: What are the Autonomous System (AS) numbers of each AS which advertises a direct link to MIT?

If you'd like to explore BGP and Internet routing in more depth, you may wish to take take 6.829 Computer Networks.