CIS427 Winter 2022 Programming Assignment 3

Understanding Network Delay and Routing Over time

Due Thursday, April 20, 2022

Introduction

Network delays and delay variations are two of the most important network performance metrics, directly impacting applications such as voice over IP and time-critical financial transactions. In this assignment, we will be analyzing changes in network delays and jitter of a diverse and comprehensive set of Internet paths over time. We will observe that routing changes can result in roundtrip delay increase of converged paths. Using *traceroute (for Linux based systems and tracert for windows)* and *ping* utilities network problems can be identified. We will be using these tools to measure link latency for a week and study the latency and number of hops in different times of the day and different days of the week.

The Assignment

This can be one student's work or a group of two students work. A group of two students should work with at least 10 target hosts while one student work with at least 5 target hosts. This assignment is not an extension to programming assignment 1 or 2.

Routing measurement

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 identified either using a host name or an IP address.

The traceroute command on Windows:

C:\>tracert www.yahoo.com

tries to determine the path from the source machine to www.yahoo.com. (Note that the command should be **traceroute www.yahoo.com,** for Linux/UNIX based OS). The machine encountered on the path after the first hop fob.net.umd.umich.edu [141.215.80.1], the next hop is i-cw-elb.net.umd.umich.edu [141.215.2.33], and so on. In all, it takes 15 hops to reach p13.www.dcn.yahoo.com.

```
C:\tracert www.yahoo.com

Tracing route to www.yahoo.akadns.net [216.109.118.71]
over a maximum of 30 hops:

  1   <1 ms   <1 ms   <1 ms  fob.net.umd.umich.edu [141.215.80.1]
  2   <1 ms   <1 ms   <1 ms  i-cw-elb.net.umd.umich.edu [141.215.2.33]
  3   <1 ms   <1 ms   <1 ms  141.215.2.130
  4    1 ms    1 ms   <1 ms  i-merit.net.umd.umich.edu [141.215.2.2]
  5   12 ms   12 ms   13 ms  198.108.22.165
  6   24 ms   12 ms   12 ms  g1.ba21.b002281-1.ord01.atlas.cogentco.com [66.28.21.233]
  7   16 ms   15 ms   13 ms  p12-0.core02.ord01.atlas.cogentco.com [154.54.2.241]
  8   82 ms   38 ms   39 ms  p6-0.core02.jfk02.atlas.cogentco.com [66.28.4.85]
```

```
 9   54 ms    40 ms    40 ms  p14-0.core01.phl01.atlas.cogentco.com [66.28.4.2]
10   51 ms    43 ms    44 ms  p4-0.core01.dca01.atlas.cogentco.com [66.28.4.17]
11   47 ms    45 ms    45 ms  p2-0.core01.iad01.atlas.cogentco.com [154.54.2.202]
12   45 ms    47 ms    46 ms  yahoo.iad01.atlas.cogentco.com [154.54.10.2]
13   52 ms    47 ms    45 ms  ae1.p400.msr1.dcn.yahoo.com [216.115.96.181]
14   48 ms    47 ms    50 ms  ge5-2.bas1-m.dcn.yahoo.com [216.109.120.151]
15   45 ms    46 ms    78 ms  p8.www.dcn.yahoo.com [216.109.118.71]

Trace complete.
```

For this part of the assignment, **you will monitor the routing stability of the Internet using traceroute.** *Choose 5 destination hosts (`targets') if you are working individually or 10 targets if you work in a pair.* The targets should be distributed around the world. Please do not monitor hosts of the .MIL domain. In addition, you should avoid routers and hosts that disable or don't support ICMP functions (e.g., hosts that timeout without a response).

1. Using traceroute from a fixed machine, monitor and record the routing path to each target for an entire week. You should perform at least 2 measurements every day, for a total of about 10 measurements per target for the duration of the week.
2. You should perform all your measurements from a fixed location, for example at home or on campus. Alternatively, you can log into the UMD Login server (login.umd.umich.edu) and perform the measurement from the server.
3. Some host names may be dynamically mapped to a number of geographically dispersed servers (e.g., www.cnn.com). Therefore, after you learn the IP address of a host name, you need to use the IP address instead of the host name (e.g. tracert 23.235.40.73).
4. For which targets do you observe the same routing path in all measurements? For which targets do you observe several different paths? Comment on the **stability** of the routes that you have monitored.
5. For the paths **that do tend to change**, what is the nature of the routing change (e.g., differences in the number of hops, differences in the network providers that traffic goes through, or differences in the exact router interfaces that traffic goes through)? *Hint: To identify the Autonomous System Number or ISP for each router, you can use the command "whois -h whois.arin.net ASN" or "whois -h radb.ra.net IPaddr" or visit http://www.arin.net/whois/ for more information.*
6. For a path **that is not stable**, attempt to (roughly) estimate how often does the route change. You may need to perform more frequent measurements to those targets.

Loss and Round-Trip Time (RTT) measurements

The ping utility is one of the more useful utilities for testing a network. The ping utility works by sending a short message of type echo-request to a host using a network protocol called ICMP, the Internet Control Message Protocol. A host that supports ICMP (and most do) and receives an echo-request message simply replies by sending a short ICMP message of type echo-response back to the originating host.

The following is a sample output of an execution of ping:

```
C:\ping -n 14 amazon.in
```

```
Pinging amazon.in [52.95.116.115] with 32 bytes of data:
Reply from 52.95.116.115: bytes=32 time=113ms TTL=223
Reply from 52.95.116.115: bytes=32 time=195ms TTL=223
Reply from 52.95.116.115: bytes=32 time=117ms TTL=223
Reply from 52.95.116.115: bytes=32 time=182ms TTL=223
Reply from 52.95.116.115: bytes=32 time=188ms TTL=223
Reply from 52.95.116.115: bytes=32 time=190ms TTL=223
Reply from 52.95.116.115: bytes=32 time=195ms TTL=223
Reply from 52.95.116.115: bytes=32 time=199ms TTL=223
Reply from 52.95.116.115: bytes=32 time=115ms TTL=223
Reply from 52.95.116.115: bytes=32 time=114ms TTL=223
Reply from 52.95.116.115: bytes=32 time=205ms TTL=223
Reply from 52.95.116.115: bytes=32 time=194ms TTL=223
Reply from 52.95.116.115: bytes=32 time=178ms TTL=223
Reply from 52.95.116.115: bytes=32 time=161ms TTL=223

Ping statistics for 52.95.116.115:
   Packets: Sent = 14, Received = 14, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
   Minimum = 113ms, Maximum = 205ms, Average = 167ms
```

In this part of the assignment, **you will monitor the loss and delay performance characteristics of some Internet paths using ping.** You can use the same set of targets as in the previous part of the assignment. It is better, however, to choose targets that do not experience frequent routing changes.

1. As in the previous part of the assignment, measure the loss rate and RTTs for each target for the duration of a week. You should perform at least 2 measurements every day, for a total of about 10 measurements per target for the duration of the week. Each measurement should send **120 echo requests** by using the *-n count* (number of echo requests to send) option.
2. Use the previous measurements to classify your targets as `loss free', `minor losses' (0 < loss rate < 5%), `significant losses' (5% < loss rate <10%), and `major losses' (loss rate > 10%). Does this classification remain the same throughout the week for each target?
3. Measure the minimum/maximum/mean RTT for each target.
4. Plot the loss rate and RTTs for each target as a function of time. Do you observe any significant changes between different times-of-day or days-of-week?

Deliverables

Write an experiment report (approximately 7-15 pages) that describes your methodology and results. Avoid verbose discussion of the results. Also, include any additional results, insight, and analysis of the results. Do not include raw results and command runs in your report. In general, your report should include the following components:

- Abstract (summary) of your experiment and findings
- Introduction (background and **hypothesis**)
- Methodology used
- Results (plots and findings)

- Conclusions
- What did you learn?

Please submit **the report and raw DATA files** as a single zip file to Canvas.