**CS6014 Homework 1: Packet Delay + Measurement**

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**Question 1 (4pts): Internet Delay**

When 5 packets of the size 500 bytes are transmitted through the link K, (TB – TA) is measured to be 10 ms, 2.8 ms, 2.4 ms, 4 ms, and 5.5 ms. When 5 packets of the size 1000 bytes are transmitted through the link K, (TB – TA) is measured to be 11.0 ms, 10 ms, 2.8 ms, 3.0 ms, and 5.5 ms. Assume that processing delay at the router is negligible.

What is the average queuing delay experienced by the 1000 byte packets?

Assuming the smallest response time 2.8 ms indicates no queuing delay, then the average queuing delay is { (11-2.8)+(10-2.8)+(2.8-2.8)+(3-2.8)+(5.5-2.8) }/5 = 3.66(ms)

What are the reasonable estimates of transmission and propagation delays experienced by a packet of size 600 bytes sent through the link K?

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| --- | --- | --- | --- | --- | --- |
| Size | Total Delay = | Processing + | Queuing + | Transmission + | Propagation |
| 500 bytes | 4.94 | 0 | 2.54 | 5T | P |
| 1000 bytes | 6.46 | 0 | 3.66 | 10T | P |
| 600 bytes |  | 0 |  | 6T | P |

* Get T=0.08, P=2
* Transmission Delay for 600 byte: 6\*0.08=0.48(ms)
* Propagation Delay for 600 byte: 2(ms)

**Question 2(18 pts): Traceroute**

a. (15 points) Execute the traceroute command to one destination of your choice, at least 10 hops away. Try to pick a destination for which you get as complete data as possible and that the traceroute program terminates normally. Collect the traceroute data in a file (using output redirect on the Unix-shell).

Write a program to parse each line of this file and compute the average delay (averaged over the three delay values) for each hop. Your program should save the IP address of each hop (the address within parentheses in each line of traceroute data) and the corresponding average delay in another file such that each row of this new file contains the IP address of the hop and the average delay.

Use this new file to plot a graph with the x-axis showing the IP address of the hop and the y-axis the average delay corresponding to that hop. Run the same experiment a few hours later and show the new results on the same graph. Thus, your graph should have two curves. Submit the traceroute outputs, your code, and a pdf version of your graph on github.

Note, this is a good opportunity to try a new programming language that's suited to these types of short text processing programs. Python is a good choice. Also note, that it's difficult to get complete data. Justify whatever choice you make for how to deal with incomplete data.

Chosen Rule:

* Choose the first IP address for each hop if there are multiple ones.
* Keep the “\*” response for the IP address to know how many hops have been traced.

b. (3 points) Suppose one of the three traceroute delay values between the source and a given router hop turns out to be unusually high. What are two possible causes for this unusually high delay?

One reason might be the queuing delay for that hop, and the other might be propagation delay because different hops chosen each time between the source and a given router hop caused different distances.

**Question 3(12 pts): Ping**

Execute the ping command to a destination in Europe with the default packet length (i.e., you do not need to specify the packet length). Run the command for a time long enough so that you collect at least 200 packets worth of data. Redirect your output to a file. To kill the ping program, once you think it has run long enough, press control-c (control, not command).

Write a program to parse each line of the file containing ping data to obtain the total round trip delay experienced by each packet (the last field in each line). Then, find the average round trip queuing delay experienced by the packets from the data you collected. Assume that the min delay reported in the last line of your ping data file corresponds to zero queuing. Also assume that the transmission, propagation, and processing delays are constant for your data.

Submit the ping outputs, your code, and your average delay output on github.

Average queuing delay: 29.81205150214595 ms (see code output)