

CSCI/ECEN 5673: Distributed Systems
Spring 2017
Programming Assignment 1
Due Date: 02/14/2017

You may work on this assignment with one of your classmate (team of size 2). Be aware that the submission deadlines of Homework One and project proposal overlap with this programming assignment, and so plan accordingly. If you haven't done any network programming before, you'll want to start this assignment immediately.

The goal of this assignment is to gain experience with implementing clock synchronization in distributed systems. Write a simple UDP client/server program, where the client sends a *request* to the server and the server sends a *reply* to the client. The client records the local clock times (client machine) of when the request is sent and when the reply is received. The server's reply contains the local clock time (server machine) of when the request is received and when the reply is sent. First, run the client code on machine A and the server code on machine B, and then run the client code on machine B and the server code on machine A for the following four scenarios:

- a) A and B are the same machine
- b) A and B are different machines with in the CS department, e.g. two different CSEL servers
- c) A and B are different machines across the CU-Boulder campus
- d) A and B are different machines, one in CU campus and the other at a different geographic location outside the CU campus

Note that there are plenty of UDP client/server programs available on the Internet. You may download and use one of these. Of course, make sure that you understand the code and the code is working correctly before you use it. For each scenario, repeat your experiment five times by running it at around the same time.

Question 1: Report all the timings recorded, and compute the pairwise latencies (A to B and B to A) along with average and standard deviation. Provide an analysis of your results in terms of why there is a variation in latencies, which ones you expect to be more accurate, etc.

Question 2: What clock time would the client set its clock to if the Cristian's clock synchronization algorithm (Algorithm 1 in Lecture Set Two) is used? Based on your observations, what is a reasonable estimate of absolute minimum latency between machine A and machine B. Using this estimate, calculate the error bound for the synchronized time.

Question 3: Compute the offset (o_i) and delay (d_i) for each of the five time measurements for each scenario using the NTP formula. For each scenario, which ones of the five measurements you think provide the best accuracy. Explain your answer.

What to submit

Please submit a single zip file that contains the following:

- All source code files
- A README file that includes a description of how to compile and run your program. In addition, include any limitations of your program – what works, what doesn't, sources of potential errors, etc.
- A PDF file that contains answers to the three questions.