

**COEN 317: Distributed Systems**  
**Spring 2020**  
**Homework Assignment 2**  
**Due: Tuesday, 5/11/2020 @11:59pm**

1. A system of four processes, ( $P_1, P_2, P_3, P_4$ ), performs the following events:
  - a.  $P_1$  sends a message to  $P_3$  (to event e).
  - b.  $P_1$  receives a message from  $P_3$  (from event g).
  - c.  $P_2$  executes a local event.
  - d.  $P_2$  receives a message from  $P_3$  (from event f).
  - e.  $P_3$  receives a message from  $P_1$  (from event a).
  - f.  $P_3$  sends a message to  $P_2$  (to event d).
  - g.  $P_3$  sends a message to  $P_1$  (to event b).
  - h.  $P_4$  executes a local event.

When taking place on the same processor, the events occur in the order listed.

Assign Lamport timestamps to each event. Assume that the clock on each processor is initialized to 0 and incremented before each event. For example, event  $a$  will be assigned a timestamp of 1.

a. <b>1</b>	b.	c.	d.
e.	f.	g.	h.

2. Assign vector timestamps to each event in question 1. Assume that the vector clock on each processor is initialized to (0,0,0,0) with the elements corresponding to ( $P_1, P_2, P_3, P_4$ ). For example, event  $a$  will be assigned a timestamp of (1, 0, 0, 0).
  - a. Which events are concurrent with event  $d$ ?
3. You are synchronizing your clock from a time server using Cristian's algorithm and observe the following times:
  - timestamp at client when the message leaves the client: 6:22:15.100
  - timestamp generated by the server: 6:21:10.700
  - timestamp at client when the message is received at client: 6:22:15.250
  - a. To what value do you set the client's clock?
  - b. If the best-case *round-trip* message transit time is 124 msec (0.124 sec), what is the error of the clock on the client?

4. You are synchronizing your clock from a time server using NTP (the Network Time Protocol) and observe the following times:
- timestamp at client when the message leaves the client: 6:22:15.100
  - timestamp at which the server receives the message: 7:05:10.700
  - timestamp at which the server sends the reply: 7:05:10.710
  - timestamp at client when the message is received at client: 6:22:15.250

To what value do you set the client's clock?