Homework 1 (Time, Synchronization and Global State) - 100 Points

CS425/ECE 428 Distributed Systems, Fall 2009, Instructor: Klara Nahrstedt

Out: Thursday, September 3, **Due Date**: Thursday, September 17

Instructions: (1) Please, hand in hardcopy solutions that are typed (you may use your favorite word processor). We will not accept handwritten solutions. Figures and equations (if any) may be drawn by hand. (2) Please, start each problem on a fresh sheet and type your name at the top of each sheet. (3) Homework will be due at the **beginning of class** on the day of the deadline.

Relevant Reading for this Homework: Sections 11.1-11.5

1. (**10 Points**) At 10:27:540 (hr, min, 1/100 sec.), server **B** requests time from the time-server **A**. At 10:27:610, server **B** receives a reply from timeserver **A** with the timestamp of 10:27:375.

    a. (5 Points) Find out the drift of **B**'s clock with respect to the time-server **A**'s clock (assume there is no processing time at the time-server for time service).

    b. (2 Points) Is **B's** clock going too fast or too slow? If the answer is yes, by how much is the clock going too fast or too slow?

    c. (3 Points) How should **B** adjust its clock?

2. (**5 Points**) In the symmetric mode of synchronization in NTP, suppose you are given that server **A** and server **B** are connected by a **symmetric channel**, i.e., the channel shows the same (but unknown) message delay both ways, i.e., the **A** to **B** delays is the same as **B** to **A** delay. Show using the equations for analyzing the NTP protocol, that under this situation, one can estimate the clock skew accurately (i.e., with an error of 0).

3. (**20 Points**) Consider **Figure 1** that shows four processes ***(P1, P2, P3, P4)*** with events ***a, b, c,*** … and messages communicating between them. Assume that initial logical clock values are all initialized to ***0***.

    a. (5 Points) List the **Lamport timestamps** for each event shown in Figure 1. Assume that each process maintains a logical clock as a single integer value as a Lamport clock. Provide Lamport clock for all labeled events (but consider all labeled and unlabeled events).

b. (10 Points) List the **Vector Clock timestamps** for each event shown in Figure 1. . Provide Vector clock for all labeled events (but consider all labeled and unlabeled events).

c. (5 Points) Is there the potential for a causal violation? Explain why.

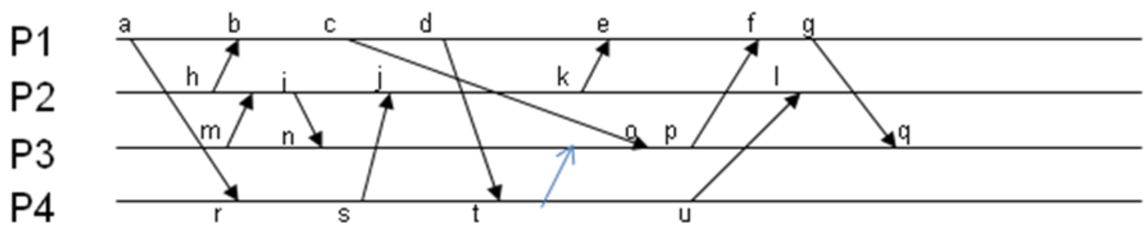

Figure 1: Four *Processes P1, P2, P3, P4 run events a,b,c,d,…. to send and receive messages*

4. (**35 Points**) Consider Figure 2 showing three processes ***P1, P2, P3***.

   a. (5 Points) Is the run <e_1^1, e_2^2, e_2^3, e_3^2 e_2^4, e_3^3> a **linearization** of events? Explain why or why not.

   b. (5 Points) Is the cut, shown by curve **X,** a **consistent cut**? Why?

   c. (10 Points) Determine **two other consistent cuts** in Figure 2 and specify their **frontiers**.

   d. (15 Points) In the Figure 2, determine all the events that **happen before** event e_2^4 (as per Lamport's Happened-Before relation). Also determine the events that are concurrent with event e_2^4.

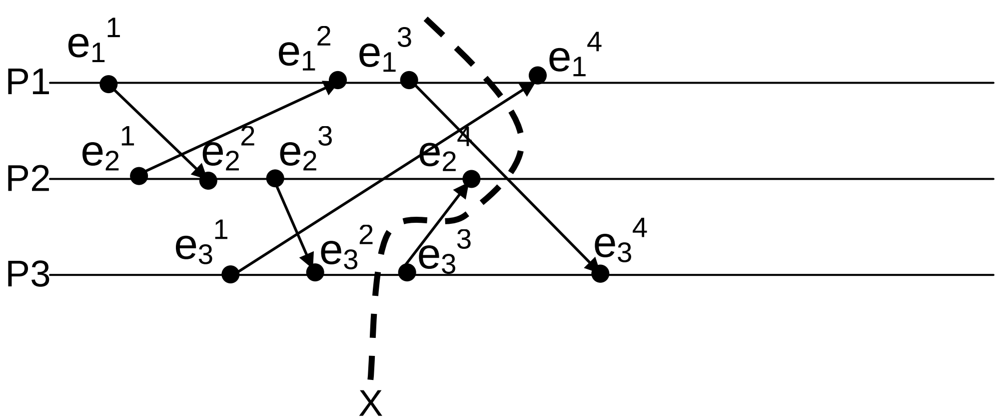

Figure 2: *Three Processes run events to send and receive messages with a Cut X through the processes.*

5. (**10 Points**) ***a, b,*** and ***c*** are events and no two events belong to the same process. Prove or disprove (give counter-example) the following:

    a. (5 Points) ***a*** is concurrent with ***b*** **and** ***b*** is before ***c*** implies that ***a*** is before ***c***.

    b. (5 Points) ***a*** is concurrent with ***b*** **and** ***b*** is concurrent with ***c*** implies that ***a*** is concurrent with ***c***.

6. **(10 Points)** Give an example where the Lamport's clock algorithm comes short (i.e., the Lamport's algorithm cannot clearly conclude that event ***e*** happens before ***e'***, even those ***L(e) < L(e'),*** where ***L(e)*** is the Lamport's timestamp of the event e), and the vector clock algorithm concludes clearly that event ***e*** happened before ***e'*** or NOT.

7. **(10 Points)** If the FIFO channel assumption in the Chandy-Lamport algorithm is violated, then which step of the proof for the Chandy-Lamport algorithm given a consistent cut, breaks down (see Textbook/Coulouris et al, 4th edition).