CS 425 Distributed Systems, Fall 2007, University of Illinois at Urbana-Champaign

Homework 1 [Time, Synchronization, and Global States]

Out - Aug 30, 2007. Due Date - Sep 11, 2007 (Tuesday).

Note: (1) All problem numbers below refer to the 4th Edition of the textbook by Colouris, Dollimore and Kindberg. (2) 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. (3) Please **start each problem on a fresh sheet**, and **type your name at the top of each sheet**. (4) Homeworks will be **due at the beginning of class on the day of the deadline.** (5) Each problem has the same grade value as the others.

Relevant Reading for this Homework: Sections 11.1-11.5.

1. 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 delay 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).

2. In Figure 11.9 in the textbook, list *all* pairs of concurrent events.

3. Databases-R-Us runs a cluster of three servers A, B, and C, which communicate with one another. You are told that the current clock skews between server pairs are as follows: A-B: 3 ms; B-C: **1** ms; C-A: -4 ms. Further, you are told that correctness in the database requires that no two server clocks be more than 30 ms apart. If each of the servers has an absolute clock drift of 2 ms per minute, how many minimum (i.e., worst-case) minutes can the cluster go without running a synchronization algorithm among its servers?

4. For the figure on slide 2-18 (slide number 18 dated 8/28), give the vector timestamps for each of the events. You may assume all vector timestamps start initially with all zeroes.

5. A time synchronization program running on a Web server uses the NTP algorithm, but incorrectly sets back a PC's hardware clock to the estimated clock value, based on the message received from the server. Describe a possible pathological situation that might arise out of this bug w.r.t. the Web server application (e.g., you might want to think of this happening on the departmental Web server). Please be as specific as possible, i.e., an actual example of something that could go wrong is desirable, compared to an abstract description.

6. From the viewpoint of a pedestrian on the roads in the US, give two examples of liveness properties and two examples of safety properties (that the US road system tries to guarantee for you). State the properties as concretely as you can, and briefly explain why each is a liveness/safety property.

7. If the FIFO channel assumption is violated, then which step of the proof for the Chandy-Lamport algorithm giving a consistent cut (slide 3-18, i.e., slide number 18 dated 8/30) breaks down? Explain briefly.

8. For Figure 11.7 in the textbook, if process p_1 initiates the Chandy-Lamport algorithm immediately after the event b, draw *all* consistent cuts that are possible. Also, write down the frontiers of all such cuts.