CSE 6333
Homework 1 (due in class, Wednesday, March 6)

Note: If you submission is received in time, you will get an emailed solution set on the 6th itself. This will help you as you prepare for the midterm to be held on March 8.

1. *(Variant functions - 5 pts)*

Give a variant function for the proof of liveness of the termination detection program presented in class.

2. *(Termination Detection - 5pts)*

Carefully explain how the program for termination detection on a ring can be modified for termination detection on a spanning tree. Hint: Recall the Chandy-Lamport snapshot procedure.

3. *(Logical Clocks and Global Snapshot - 5pts)*

Definitions: A "consistent" global state of a distributed system is one where the local state of each process does not depend on the receipt of a message that is yet to be sent. A "transitless" global state is one where each message that has been sent has been received.

Consider the following algorithm: Each process j maintains a logical clock (that is initially 0) using Lamport's algorithm. Let T be some integer constant, $T > 0$. When its logical clock advances to or past T for the first time, each process takes a tentative checkpoint. Whenever the process receives a message that was sent at or before T (at the sender) and was received after T (at the receiver), it appends that message in its tentative checkpoint. When the process has received from each neighbor a message that was sent after T, it makes its checkpoint permanent. (Assume that each process communicates with each neighbor infinitely often, and that channels are FIFO and reliable.)
(a) Does the algorithm yield a consistent global checkpoint? State your assumptions and explain fully.

(b) Does the algorithm yield a transitless global checkpoint? State your assumptions and explain fully.

(c) Is the global checkpoint reachable from the initial state of the computation? Is the final state of the computation reachable from the global checkpoint? State your assumptions and explain fully.

4. *(Lamport's Clock Synchronization – 15 points)*

In his paper on 'Time, Clocks, and the Ordering of Events in a Distributed System', Lamport describes a program for internal clock synchronization. The difference between clocks in this program is maintained to be at most

$d(2\ \kappa\ \tau + \zeta)$.

Give an intuitive explanation of why this formula captures the maximum possible difference between the clocks.

5. *(Detection of Unstable Predicates - 5 pts)*

Consider a distributed system that consists of two processes which communicate with each other. Let P be a state predicate on the local state of one process and Q be a state predicate on the local state of the other process. Assume that neither P nor Q are stable (i.e. closed).

Design a superimposed computation which detects that there exists an interleaving of underlying events in this system where at some state $P \wedge Q$ holds. (A superposed computation is one that does not affect the underlying system; it may "read" but not "write" the state of the underlying system. Events in a superposed computation may occur in at the same instant as the underlying events and/or at different instants.) State any assumptions you make.

Hint: Use vector clocks.