Assignment 2

Maximum points 100

Note: Solve **all** problems. **I will only grade Problems 7, 8 and 9 and four other problems chosen at random.** Your solutions should be precise to the point. You **must** have the answers typed using a word processor. **Handwritten assignments will not be accepted.** You are allowed to draw figures by hand if you really do not want to use a drawing utility. **You are not allowed to collaborate or look up other sources such as Internet for answers.**

1. Prove that synchronous communication could lead to deadlock. (15 points)
2. Exercise 3.10 (give one example for each, not two) from Pradeep Sinha's book (15 points)
3. Exercise 3.13 from Pradeep Sinha's book (15 points)
4. Exercise 3.14 from Pradeep Sinha's book (15 points)
5. Exercise 3.16 from Pradeep Sinha's book (15 points)
6. Exercise 3.18 from Pradeep Sinha's book (15 points)
7. For each of the following statements state whether it is true or false. **Justify your answer. i.e., if it is true, prove it; otherwise, give a counter example.** (15 points)
   (a) Lamport's timestamp is not useful for determining the happened before relation ($\rightarrow$) between events of a distributed computation
   (b) If channels are FIFO (i.e., messages sent between any pair of processes are received in the same order they were sent), then messages will be automatically causally ordered.
   (c) If messages are causally ordered, then channels will be ensured to be FIFO.
   (d) Vector timestamps are useful for determining happened before relation ($\rightarrow$) between events of a distributed computation.
8. Consider a distributed computation consisting of n processes $P_1, P_2, \cdots, P_n$. Propose an algorithm for ensuring channels to be FIFO (i.e., messages sent from any process P_i to any other process $P_j (i \neq j)$ are delivered to P_j in the same order in which they were sent by P_i) but does not ensure causal ordering of messages. (10 points)
9. If a and b are any two events in a distributed computation consisting of n processes and VT_a and VT_b are their respective vector timestamps, then prove the following. (15 points)
   (a) $a \rightarrow b$ if and only if $VT_a < VT_b$,

(b) $a \| b$ if and only if ($VT_a \not< VT_b \ \wedge \ VT_a \not> VT_b$), and

(c) ($VT_a \neq VT_b$) if and only if $a \neq b$

10. Exercise 4.3 from Pradeep Sinha's book (15 points)

11. Exercise 4.5 from Pradeep Sinha's book (15 points)

12. Exercise 4.12 from Pradeep Sinha's book (15 points)

13. Exercise 4.14 from Pradeep Sinha's book (15 points)

14. Exercise 4.19 (do not worry about last-one semantics) from Pradeep Sinha's book (15 points)

Expected Learning outcome: Solve synchronization problems in a distributed system, learn tools and techniques for developing your own implementation of a distributed system or component of a distributed system.