ECE 6102 Exam 1

Instructions: You have 1 hour, 20 minutes to complete this test. The test is closed book and closed notes. No calculators are allowed. Make sure to show your work on all problems. No credit will be given for answers without sufficient work.

Problem 1 ________

Problem 2 ________

Problem 3 ________

Problem 4 ________

1) 25 points

Consider a distributed system having 3 processes, P0, P1, and P2, with 4 sequential events on each process. All pairs of events that come from different processes are concurrent, i.e. events are ordered only within one process but can be arbitrarily ordered between processes.

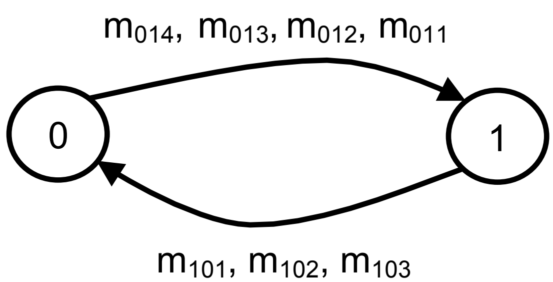
a) How many *distinct* global states are there in this system, beginning from the initial state where no events have occurred and ending with the final state where all 12 events have occurred? Two states reached through the same sequence of events, but in different orders, are *not* considered distinct states. For example, the state reached by event 0 on P0 followed by event 0 on P1 is the same state reached by event 0 on P1 followed by event 0 on P0.

b) Generalize your answer to the case where the number of sequential events on each of the three processes is any value *k*, i.e. come up with a general formula for your answer for any number of events.

For both parts, make sure to show how you calculated your solutions – answers without sufficient work will not receive credit.

2) 25 points

Consider execution of the Chandy, Lamport distributed snapshot algorithm on the below system starting from the given state.



Show the states recorded by the algorithm for C_{01} and C_{10} under the following scenarios:

a) P_0 and P_1 both spontaneously start the algorithm (record their process states) at the time instant shown, i.e. before any messages on the two channels are received.
b) P_0 spontaneously starts the algorithm at the time instant shown but P_1 spontaneously starts the algorithm after receiving m_{011} and m_{012} and sending a new message m_{104} on C_{10}.
c) P_0 spontaneously starts the algorithm at the time instant shown but P_1 only records its state after receiving a marker message from P_0 and without sending any additional messages.

3) 25 points

a) Define the concept of *safety requirement* for a distributed protocol. List the safety requirements for Paxos.

b) Define the concept of *liveness requirement* for a distributed protocol. List the liveness requirements for Paxos.

c) Explain how separation of requirements into the two types, safety and liveness, enables protocols to be designed that work in practical systems despite limitations imposed by unbounded communication delays.

4) 25 points

a) Explain the meaning of each combination of 2-out-of-3 properties discussed in the CAP paper:

- CA-noP
- CP-noA
- AP-noC

b) For the AP-noC case, list two examples of types of systems that use this approach and describe how they perform recovery after the system is repaired, i.e. after the network partition goes away.