Name: Ajita Shree

Indian Institute of Technology Kanpur
CS637 Embedded and Cyber-Physical Systems
Homework Assignment 2
Deadline: October 11, 2020

Roll No e.g. 170001: 20111262

Dept. e.g. CSE: Computer Science Engineering

Instructions:

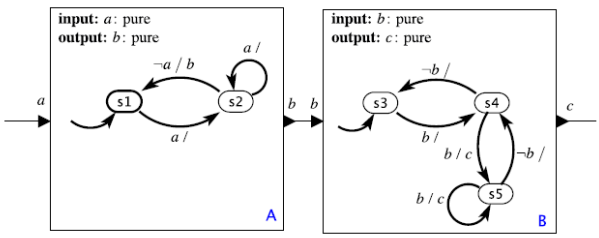
Total: **40 marks**

1. This question paper contains a total of 9 pages (9 sides of paper). Please verify.
2. Write your name, roll number, department, section on **every side of every sheet** of this booklet
3. Write final answers **neatly** in the given boxes.

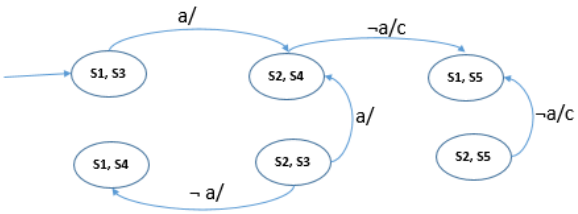
Problem 1. (10 points) Problem 3 in the Exercises of Chapter 5 in [LS15]. [LS15] Edward A. Lee and Sanjit A. Seshia, Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, http://LeeSeshia.org, ISBN 978-1-312-42740-2, 2015.

Answer

We need to create a state machine C representing the synchronous composition of state machine A and B and identify the states that are not reachable. Below diagram shows the representation of synchronous state machine As per the definition, $\text{States}_c = \text{States}_a * \text{States}_b$, and the outgoing edges from these states will be as follows:



State Machine A and B



State Machine C

- **{s1, s3}**: edge to {s2, s4} with condition a/ (as s1− >s2, a/; s3− > s4, b/). Transition to $\{s1, s5\}$, $\{s1, s4\}$, $\{s2, s3\}$, $\{s2, s5\}$ does not exist as edges doesn't exist for both the states in A as well as B.
- **{s2, s4}**: edge to {s1, s5} with condition ¬ a/c (as s2− >s1, ¬ a/b; s4− >s5, b/c)
- **{s1, s5}**:No out-edge possible; two candidate set but update condition will fail i.e.edge to {s2,s5} not possible because s1− >s2; a/ and s5− >s5;b/c ; edge to {s2, s4} not possible because s1− >s2/a and s5− >s4;¬ b/
- **{s1, s4}**: no out-edges; **{s2, s5}**: edge to {s1, s5} with condition ¬a/c (as s2− >s1, ¬a/b and s5− >s5, b/c)
- **{s2, s3}**:edge to {s2, s4} with condition a/ (as s2− >s2, a/ and s3− >s4, b/); edge to {s1, s4} with condition ¬ a/(as s2− >s1, ¬ a/b; s3− >s4, b/)

The number of unreachable states in the state machines are 3 i.e. {s1, s4}, {s2, s3}, {s2, s5}

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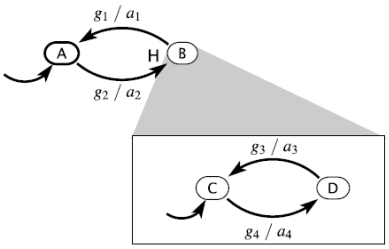
Problem 2. (10 points) In the hierarchical state machine in Figure 5.17 of [LS15], suppose that the transition from state B to state A is a preemptive transition. Construct an equivalent flat finite state machine giving the semantics of the hierarchical state machine.
[LS15] Edward A. Lee and Sanjit A. Seshia, Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, http://LeeSeshia.org, ISBN 978-1-312-42740-2, 2015.

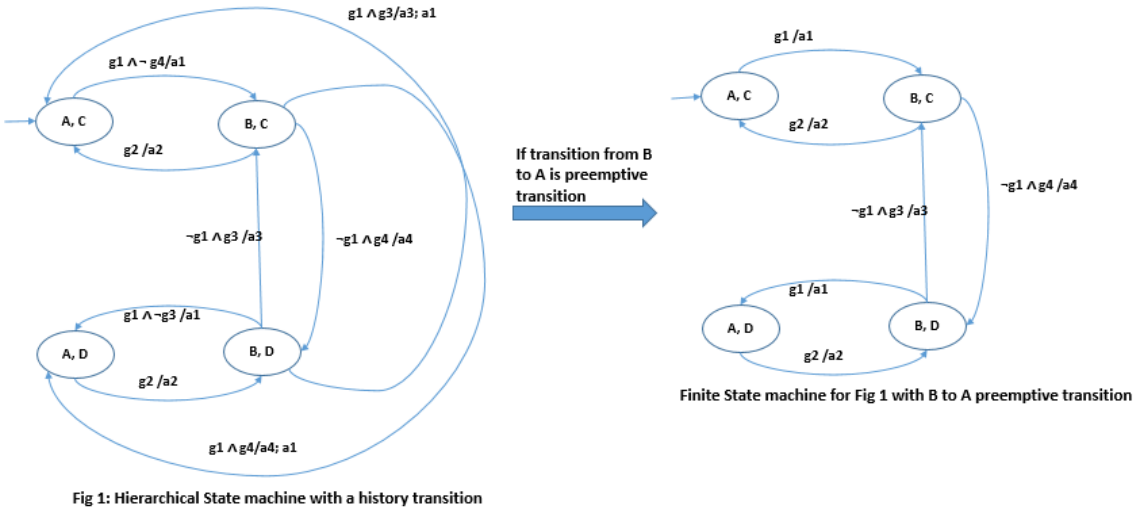
Answer

As per the question, we need to construct equivalent flat finite state machine giving the semantics of hierarchical state machine (as shown below which has the history transition) under the condition that the transition from state B to A is preemptive.



Hierarchical State Machine

Figure on the left hand side represents that flat finite state machine for above diagram with history transition and figure on the right hand side represents the hierarchical state machine with history transition under the condition that B to A is preemptive.



Flat finite state machine

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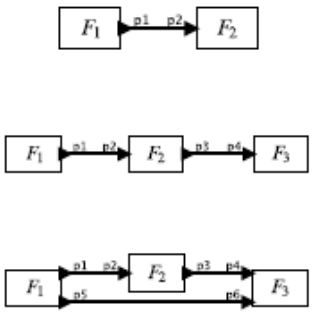
Problem 3. (10 points) Problem 1 in the Exercises of Chapter 6 in [LS15].
[LS15] Edward A. Lee and Sanjit A. Seshia, Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, http://LeeSeshia.org, ISBN 978-1-312-42740-2, 2015.

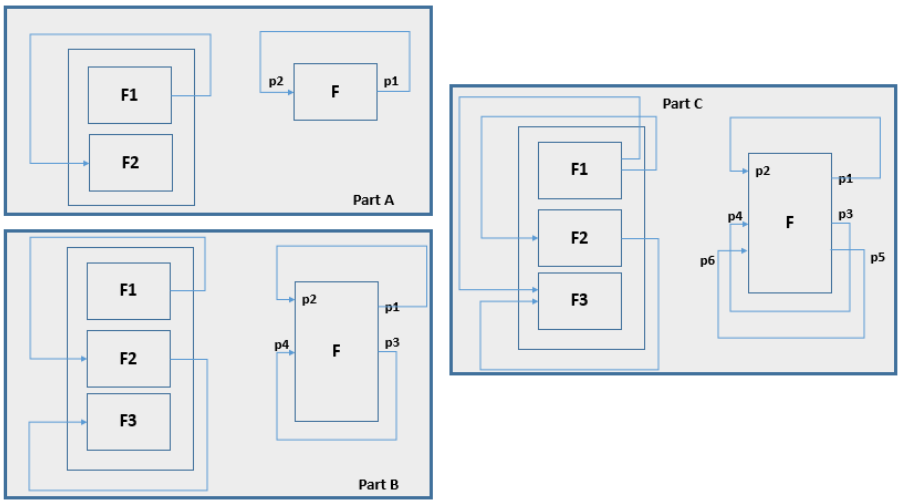
Answer

We need to create the transformation of the following actor models into the feedback system:



Actor models

Below diagram represents the feedback system representation for the above actor models (a, b, c in that order).



Feedback System

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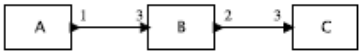
Problem 4. (10 points) Problem 8 in the Exercises of Chapter 6 in [LS15].
[LS15] Edward A. Lee and Sanjit A. Seshia, Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, http://LeeSeshia.org, ISBN 978-1-312-42740-2, 2015.

Answer

Below is the SDF model where q_a, q_b, q_c denote the number of firing actors A, B and C respectively.



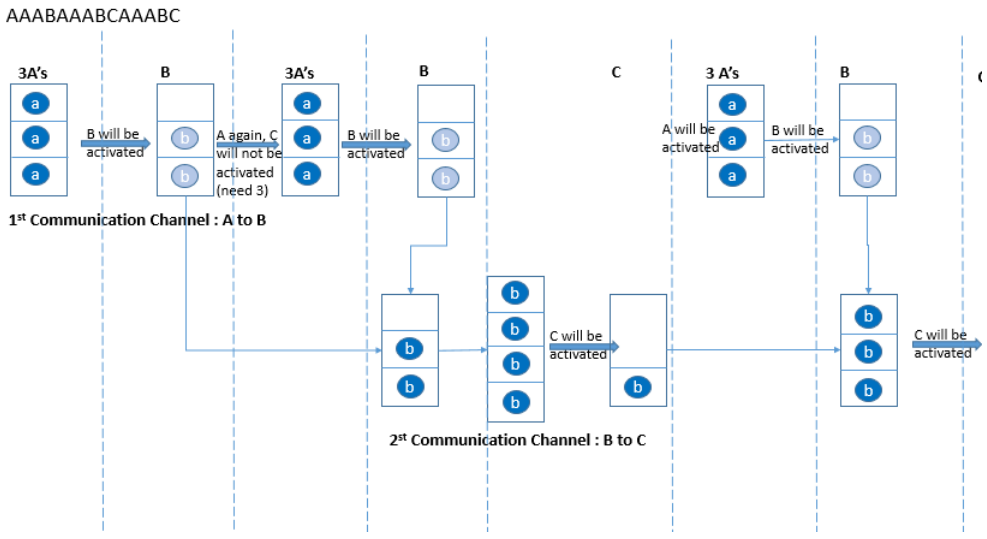
SDF Model

a) As per the above diagram, A produce 1 token at a time; B will be activated after receiving 3 tokens from A and will produce 2 tokens as output. Further, C will be activated after receiving 3 tokens from B. Hence, the equation will be the following form.

- **Balanced Equation**: $q_a = 3q_b$ and $2q_b = 3q_c$
- **Least positive integer solution**: If we multiply equation 1 with 2 and equation 2 by 3, we have $\mathbf{2q_a = 6q_b}$ **and** $\mathbf{6q_b = 9q_c}$ **giving** $\mathbf{2q_a = 6q_b = 9q_c}$.
  Hence, the least integer that satisfies this is $\mathbf{q_a = 9, q_b = 3, q_c = 2}$

b) The Schedule for an unbounded execution that minimizes the buffer sizes on both the communication channels is **AAABAAABCAAABC**.

- The following diagram shows the sequence of steps.



Unbounded Execution Schedule

- As shown in the above diagram, in the 1st communication channel from A− >B, the size of buffer needed is 3 while communicating channel from B− >C needs the buffer of size 4.

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BLANK SPACE: Any answers written here will be left ungraded.
No exceptions.
You may use this space for rough work.