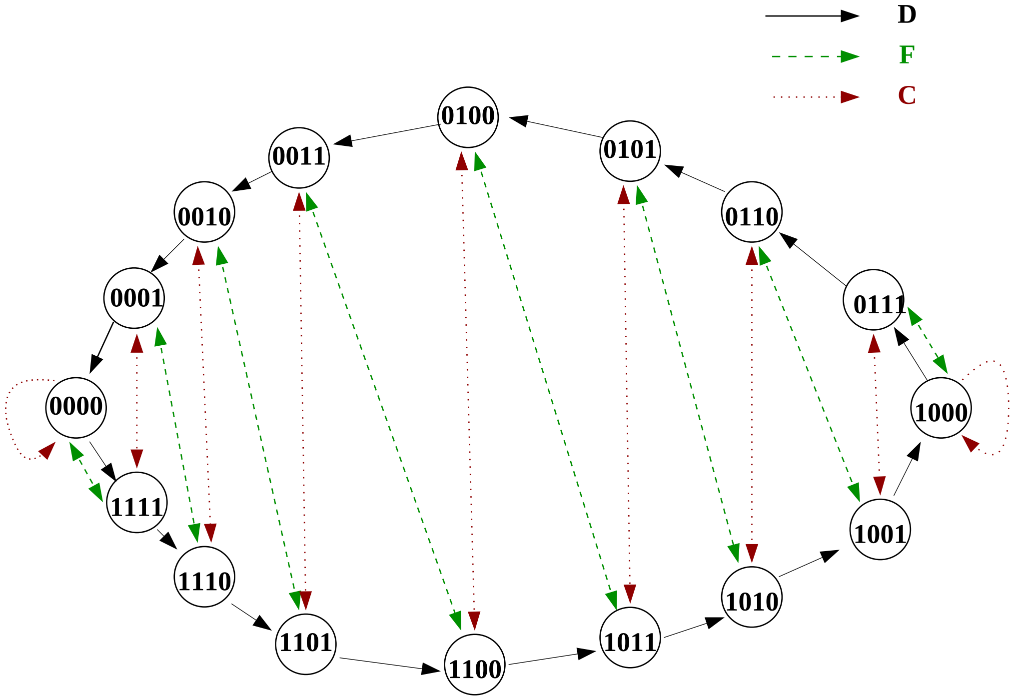
Embedded Real-Time Systems (AME 3623)
Homework 4 Solutions

May 5, 2011

Question 1

Consider a FSM whose state is described by a 4-bit binary number (i.e., there are 2^4 states). This finite state machine has three possible events: decrement (D), flip all bits (F), and two's complement (C). The latter event corresponds to taking the negative of a signed 4-bit binary number.

(20 pts) Draw the FSM diagram that describes the behavior of this device when the different events occur (don't worry about actions in this case)



Question 2

We are designing a control subsystem for a robot foraging task. In this scenario, the robot has a set of blue and green balls scattered around it. Using its camera, the robot can identify whether either type of ball is in front of it or if there are no balls. The robot's task is to gather an equal number of blue and green balls. Here are the rules:

- The robot can observe: no balls (NB), green ball (GB) or blue ball (BB).
- The robot can rotate left (RL) or right (RR). Rotations will result in a change of what the camera can see.
- If the robot has not found a ball in the last one minute of search time, then it must SHUTDOWN.
- The robot can initiate a grasp of a ball of a certain color at any time. The grasp will end in one of two ways: SUCCESS or NoSUCCESS.
  - If the robot is already holding onto a ball, then the result will be NoSUCCESS.
  - If the specified ball color to grasp is not currently being observed, then the grasp action will always end in a NoSUCCESS.
  - If the ball color is currently being observed, then either SUCCESS or NoSUCCESS may arise.
- If the robot is currently grasping a ball, then it may PLACE the object in its on-board basket (freeing it to grasp another object).
- At any time, the difference in the number of green balls versus blue balls may not be any more than one.
- If the robot currently has an equal number of green and blue balls, then it must pick up the first ball that it observes.

1. (5 pts) What are the events?

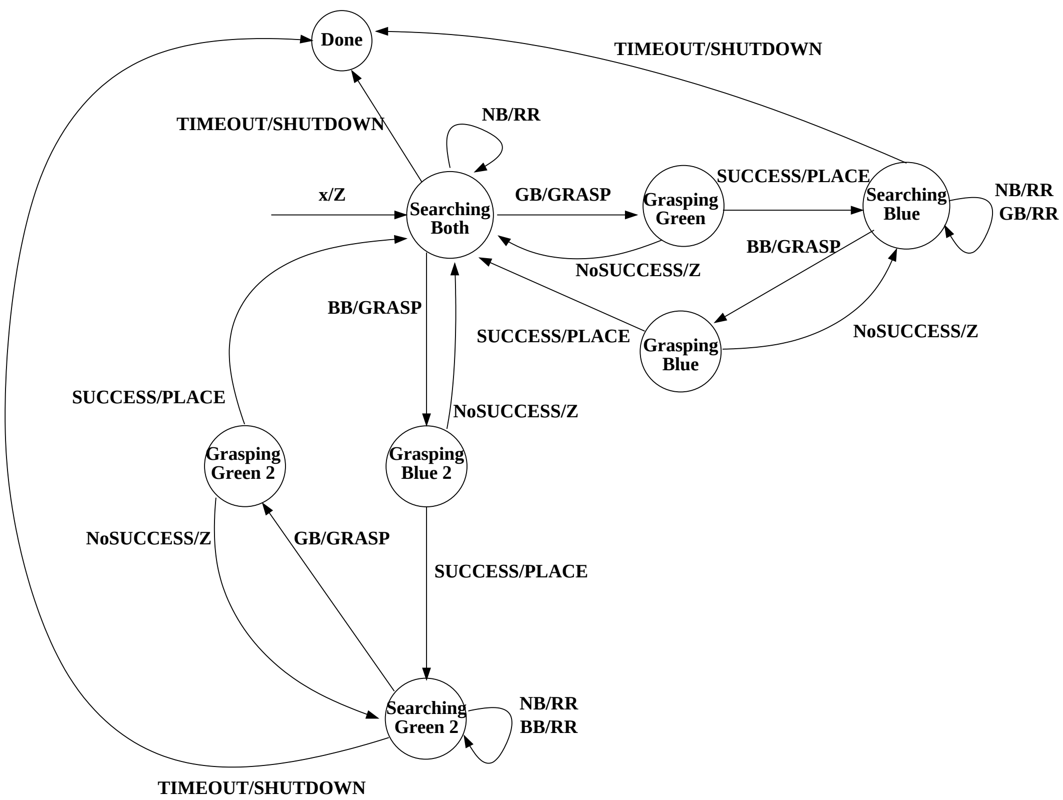
   NB, BB, GB, SUCCESS, NoSUCCESS, TIMEOUT (1 minute)

2. (5 pts) What are the actions?

   RL, RR, GRASP, PLACE, SHUTDOWN, Nothing (Z)

3. (20 pts) Show the states and transitions. Label the transitions with events and actions.

   Note: we need separate branches to handle having more green than blue and having more blue than green.



Question 3

Consider a keypad and two locked doors with the following properties:

1. The keypad has 4 keys, labeled: 1, 2, 3, 4
2. Entering the sequence: 2, 2, 1, 4 results in unlocking the left door
3. Entering the sequence: 2, 2, 2, 3 results in unlocking the right door
4. Entering any key after a door is unlocked will result in the door being locked again. This "locking" key can be the first in the next unlocking sequence.
5. Extraneous button presses result in a resetting of the sequence
6. The first occurrence of the above sequences should result in the unlocking of the respective door (i.e., the sequence 2, 3, 2, 2, 1, 4 will unlock the left door as soon as the 4 is pressed)

We will design a finite state machine that performs this control task. Remember that every state must respond to each event in exactly one way.

1. (10 pts) What are the events?

   Pressing 1, 2, 3 and 4

2. (10 pts) What are the actions?

   Unlock left (UL)

   Unlock right (UR)

   Lock left (LL)

   Lock right (LR)

   Nothing (Z)

3. (20 pts) Show the states and transitions. Label the transitions with events and actions.