CS 522

Embedded Systems

Department of CSE, IIT Guwahati

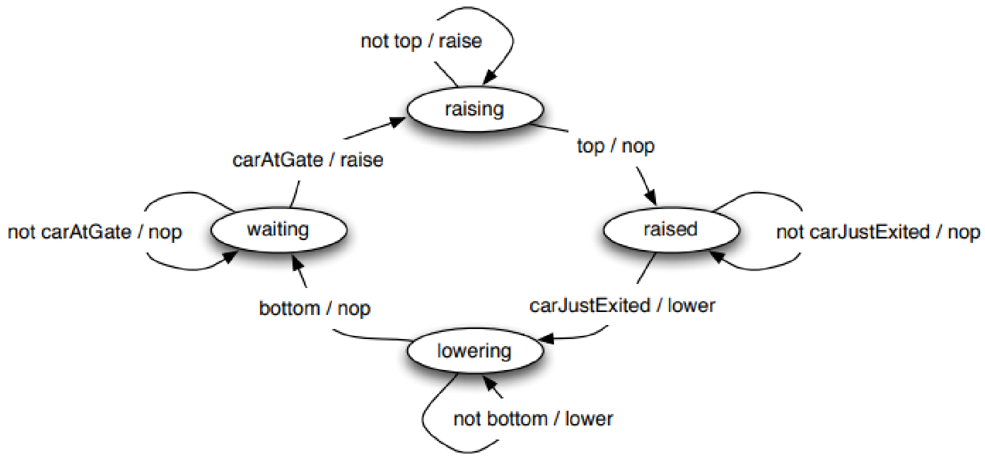
End-semester Exam, Autumn 2023-24

Time: 3 hours, Total Marks: 50

[Q1] The diagram below shows the state transitions of a parking gate controller. Specify

(a) two desirable and
(b) two undesirable behaviors

for this control system.



(Marks: 4 + 4 = 8)

ANSWER (sample):

Desirable behaviors:

(1) The system shall continue to raise the gate until it reaches the top, when a car is at the gate waiting to enter the parking area.

(2) The system shall remain waiting with the gate lowered until a car arrives at the gate.

Undesirable behaviors:

(1) The system starts to lower the gate before the car has exited the parking lot.

(2) The system stops raising the gate before it reaches the top.

[Q2] A cruise control system is in one of the following states [Accelerating, Cruising, Decelerating]. For this system, describe:

(a) one temporal property,

(b) one state machine-based property (e.g.: describing conditions for state transitions), and
(c) one assertion.

(Marks: 2 + 2 +2 = 6)

ANSWER (sample):

Temporal property: When the cruise control system is engaged, the vehicle speed should reach the set speed within 5 seconds.

State machine-based property: The system shall transition from Cruising to Decelerating state only when the driver presses the brake pedal or presses the disengage button on the steering wheel.

Assertion property: The vehicle speed should not exceed the set speed by more than 5 kph when the cruise control system is engaged.

[Q3] Consider an embedded control system that regulates the temperature of a room using a thermostat. Before activating appropriate control logic, the system should check if the user input is within acceptable range, consider possibilities for integer overflow error and dead logic in the system implementation and apply appropriate ways to handle them.

Consider the following pseudocode of an example implementation logic and answer the following questions.

(a) Does this implementation appropriately check for and handle integer overflow error? (1 mark)
(b) If yes, highlight the portion where it's handled. If no, modify the pseudocode to include integer overflow detection and handling block (5 Marks).
(c) The implementation contains a dead logic. Highlight the block and briefly describe potential consequences of this (2 marks for highlighting, 2 marks for consequences).

```
# Variables

desiredTemperature: integer

currentTemperature: integer

# User Input

desiredTemperature = getUserInput()
```

```
# Temperature Control Loop
while (true):
  if (desiredTemperature < MIN_TEMPERATURE):
```

```
    displayErrorMessage("Invalid temperature input")
    break

  currentTemperature = getRoomTemperature()

  if (currentTemperature < MIN_TEMPERATURE):
    turnOffHeatingCoolingSystem()

  # Temperature Control Logic
  if (currentTemperature < desiredTemperature):
    # Heating logic
    turnOnHeatingSystem()
    turnOffCoolingSystem()
  elif (currentTemperature > desiredTemperature):
    # Cooling logic
    turnOnCoolingSystem()
    turnOffHeatingSystem()
```

(Marks: 10)

ANSWER:

(a) Integer Overflow Error: The implementation did not appropriately check for and handle integer overflow error.

(b) The following block needs to be included:

```
if (desiredTemperature > MAX_TEMPERATURE):
# Handle integer overflow error
displayErrorMessage("Invalid temperature input";)
break
```

(c) Dead Logic: The block highlighted in yellow checks if the current temperature is less than the minimum temperature. However, in this case, the condition is always false. This means that the block that turns off the heating/cooling system will never be executed, regardless of the actual temperature. This results in dead logic and incorrect temperature control.

[Q4] Consider the following periodic tasks with their execution times and periods, and assume that the deadline interval of each task is equal to its period. Recall that the response time of a job is its finishing time minus its arrival time.

Task	Execution	Period
T1	2	6
T2	3	9
T3	2	12

(a) If rate monotonic scheduling is used, which task has the highest priority and which has lowest priority. (Marks: 1)
(b) Calculate the worst-case response time (WCRT) for each of the tasks if they are scheduled using the rate monotonic scheduling policy. (Marks: 4)
(c) Suppose we decide to schedule these tasks using EDF scheduling. Are these tasks schedulable? If so create a schedule. Otherwise justify your answer. (Marks: 5)

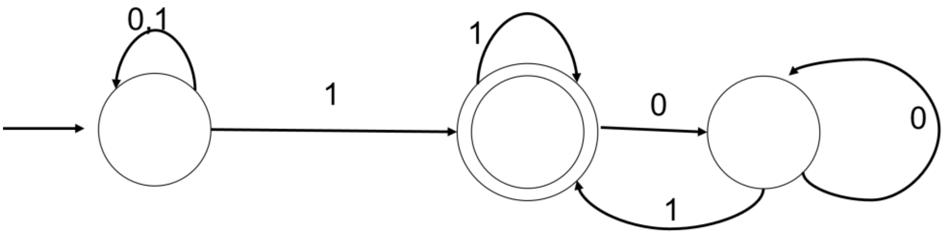
(Marks: 10)

Ans:

(a) Highest Priority is T1 and Lowest is T3.
(b) WCRT: T1: 2, T2: 5, T3: 9
(c) Yes, it is schedulable. The schedule is:

Time	0-2	2-5	5-6	6-8	8-9	9-12	12-14	14-16	16-18
Task	T1	T2	T3	T1	T3	T2	T1	T3	Idle
Time	18-20	20-23	23-24	24-26	26-27	27-28	28-31	31-33	33-36
Task	T1	T2	Idle	T1	T3	T3	T2	T1	Idle

[Q5] Consider the following Büchi automaton over the alphabet {0,1}.



a) Give one infinite sequence accepted by this automaton and one infinite sequence not accepted by this automaton. (Marks: 2)
b) What happens to the set accepted by this automaton if the self-loop in the initial state has only label 0? (Marks: 4)
c) Assume that the label 1 represents the atomic proposition p to be true and 0 representing p to be false. Give an example temporal logic formula which describes the set of all sequences accepted by this automaton. (Marks: 4)

(Marks: 10)

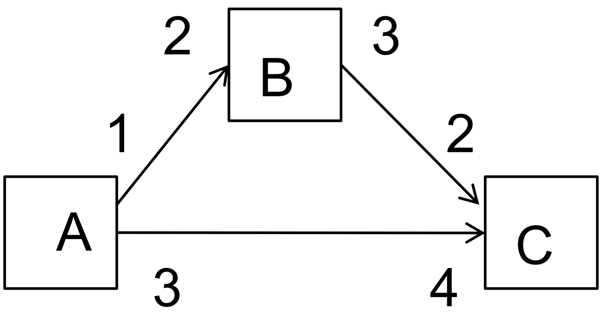
Answer:

a) The automaton accepts all infinite words with an infinite number of 1's. Any infinite word with a finite number of 1's is not accepted.
b) The set accepted by the automaton does not change.
c) □◊p (or GF p).

[Q6] Consider the following SDF model, where numbers adjacent to the ports indicate the number of tokens produced or consumed by the actor when it fires. Answer the following questions with proper justification.

(a) Is there an infinite schedule of these actors so that all actors are infinitely often fired and no overflow of tokens in the channels connecting the actors? (3 Marks)

(b) If so, what is the minimum size of buffer required? (3 Marks)



(Marks: 6)

Answer:

(a) The SDF corresponds to the following equation: 1.a = 2.b, 3.b = 2.c, 3.a = 4.c where a,b and c are the number of times the actors A, B and C are fired so that there is no tokens left in the FIFO channels. This equation is consistent and has the least solution: a=4, b=2, c=3. So there exists a schedule with no overflow of buffers. One schedule is: (aaaabbccc) . . .

(b) The minimum buffer size corresponds to the schedule (aabcaabcc) . . . and needs the following buffer sizes

- 2 on the AB link,
- 4 on the BC link, and
- 8 on the AC link.

This leads to the minimum buffer requirement of 14 units of memory.