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Embedded Systems

Problem 1 (Markov processes)

(a) If A is the initial state, then the initial distribution is $i(A) = 1, i(B) = 0$, so

- $s_0(A) = i(A) = 1$
  $s_0(B) = i(B) = 0$
- $s_1(A) = s_0(A) \cdot t(A, A) + s_0(B) \cdot (B, A) = 0.2$,
  $s_1(B) = s_0(A) \cdot t(A, B) + s_0(B) \cdot (B, B) = 0.8$
- $s_2(A) = s_1(A) \cdot t(A, A) + s_1(B) \cdot (B, A) = 0.52$,
  $s_2(B) = s_1(A) \cdot t(A, B) + s_1(B) \cdot (B, B) = 0.48$

So the probability to be in state A after two steps is 0.52.
In the solution above, we assumed that it is allowed to reenter state A after having left in it the first step. If you assume this is not allowed, then the probability is $1 \cdot 0.2 \cdot 0.2 = 0.04$ because one has to take the transition labelled withh 0.2 two times then. Because of the word "still", it was possibly unclear which solution was wanted, so we accept both.
(b) It is $t(A, A) > 0, t(A, B) > 0, t(B, A) > 0, t(B, B) > 0$, so one can get the limit probability by solving

$$A = 0.2A + 0.6B \wedge B = 0.8A + 0.4B \wedge A + B = 1$$

This leads to $A = \frac{3}{7}, B = \frac{4}{7}$.
(c) For the limit probability, we don't need an initial distribution because the limit is independent of it, as we have seen in the lecture.

Problem 2 (A/D conversion)

Step width: The maximal voltage value is $4.75V$, the minimal one is $1V$ and the maximal discrete value is $1111_2 = 15_{10}$, so the step size is $(4.75V - 1V)/15 = 0.25V$. The reference value is $U_{\text{ref}} = 1V + 0.25V \cdot \text{val}(x)$, where x is the binary value.
Calculation for $2.25V$:

- binary: 1000_2, U_{ref}: $3V > 2.25V \rightarrow$ don't keep digit
- binary: 0100_2, U_{ref}: $2V \leq 2.25V \rightarrow$ keep digit
- binary: 0110_2, U_{ref}: $2.5V > 2.25V \rightarrow$ don't keep digit
- binary: 0101_2, U_{ref}: $2.25V \leq 2.25V \rightarrow$ keep digit
- $\rightarrow$ binary value is 0101_2

Calculation for $3.75V$:

- binary: 1000_2, U_{ref}: $3V \leq 3.75V \rightarrow$ keep digit
- binary: 1100_2, U_{ref}: $4V > 3.75V \rightarrow$ don't keep digit
- binary: 1010_2, U_{ref}: $3.5V \leq 3.75V \rightarrow$ keep digit
- binary: 1011_2, U_{ref}: $3.75V \leq 3.75V \rightarrow$ keep digit
- $\rightarrow$ binary value is 1011_2

Calculation for $1.8V$:

- binary: 1000_2, U_{ref}: $3V > 1.8V \rightarrow$ don't keep digit
- binary: 0100_2, U_{ref}: $2V > 1.8V \rightarrow$ don't keep digit
- binary: 0010_2, U_{ref}: $1.5V \leq 1.8V \rightarrow$ keep digit
- binary: 0011_2, U_{ref}: $1.75V \leq 1.8V \rightarrow$ keep digit
- $\rightarrow$ binary value is 0011_2

Problem 3 (Digital circuits)

(a) $a = 0, b = 0, c = 1, d = 0, e = 1, f = 0$ (for example)
By having $c = 1$ we forward the value of y to the output of the AND gate. By having $d = 0$, the output of the lower multiplexer is x iff $y = 1$ and 0 else, so it is $x \wedge y$. By having $e = 1$ we forward this value to the output of the multiplexer to the right. (b) See figure 1.

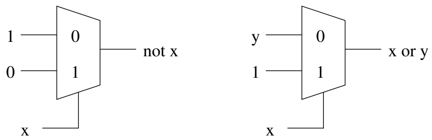

Figure 1: Exercise 3 (b)

Problem 4 (D/A conversion)

(a) From the lecture you get the formula

$$-U = \frac{U_{\text{ref}} R_1}{2^{n-1} R} \text{val}(x)$$

Resolving the equation to R_1, one gets

$$R_1 = \frac{2^{n-1} R U}{-U_{\text{ref}} \text{val}(x)}$$

We already know the reference value of current $U_{\text{ref}} = 5V$ as well as $n = 8$ and $R = 1k\Omega$. The maximal number $x = 11111111_2$ should be mapped to the maximal voltage $U = 10V$, so we can insert these values to the formula. Notice however, that the voltages U or U_{ref} should have different signs to get a resonable result that is, a positive resistor value. Because of this, we assume $U_{\text{ref}} = -5V$. If we insert this, we get

$$R_1 = \frac{128 \cdot 1k\Omega \cdot 10V}{- - 5V \cdot 255} = 256/255k\Omega \approx 1.0039k\Omega$$

(b) We have

$$I = x_7 \cdot \frac{V_{\text{rel}}}{R} + \cdot + x_0 \cdot \frac{V_{\text{rel}}}{128R}$$

so for $x = 01111111_2$ this is $4.9609375mA$ and for $x = 10000000_2$ we have $5mA$.

(c) We have to find out how much we can increase the value for the resistor R to make the value for 10000000 become the same as the one for 01111111, so

$$4.9609375mA = \frac{5V}{1k\Omega + \varepsilon}$$

Solving this we get $\varepsilon \approx 7.874\Omega$.

Problem 5 (SDL/Flexray)

(b) See figure 2. The while-loops are replaced by timers waiting for the alarm. To take into account that `getTime()` adds `correction` to the current time, we have to substract it from `alarm` before setting the timer `T`. Checking the buffer for non-emptyness is removed by just waiting for `q`. Actually, this is better because we don't have busy waiting anymore. `broadcast` can be replaced by the SDL message sending mechanism. Everything else is straightforward.

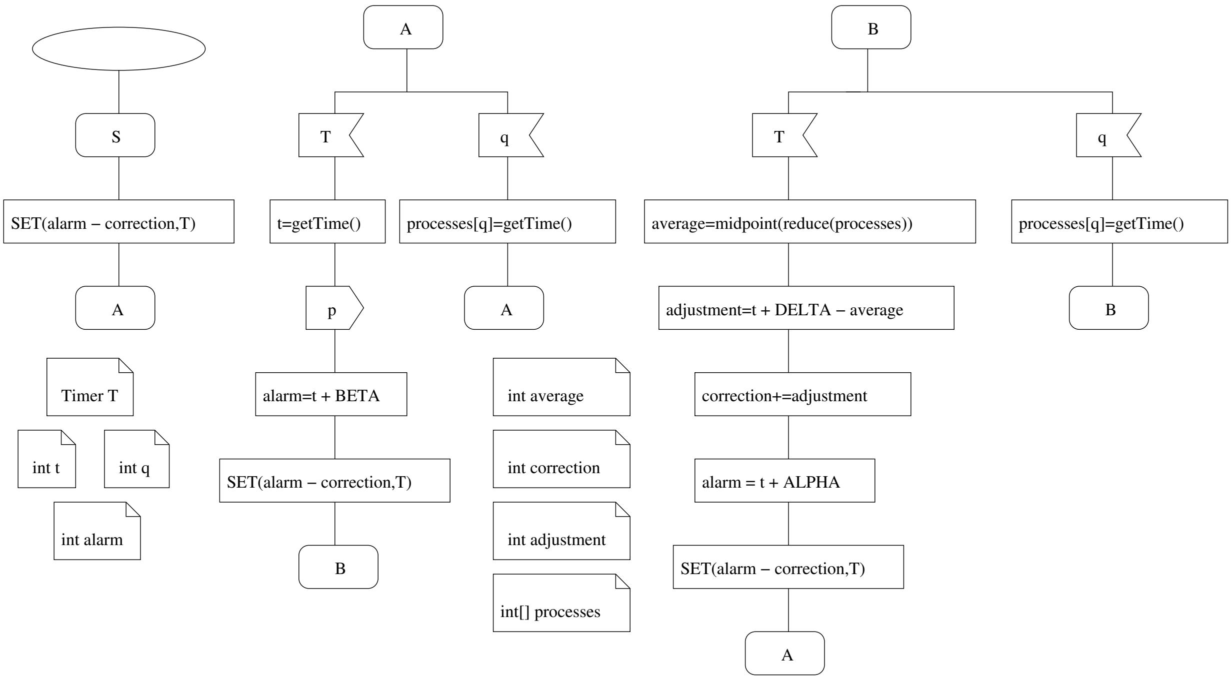

Figure 2: Exercise 5