Introduction to Computing Systems Homework 3

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Question 1.

a. There're $100^2 \times 4 \times 100 \times 4 \times 101 \times 2 \times 901 = 2912032000000$ possible states in total. Because $\log_2 2912032000000 \approx 41.4 \Rightarrow 2^{42} > 2912032000000 > 2^{41}$, the minimum number of bits that we need to use to store the state required is 42.

b. The numbers of bits it takes to store the state of the seven elements on the scoreboard are :

(a) $2 \times \lceil \log_2 100 \rceil = 14$;
(b) $\lceil \log_2 4 \rceil = 2$;
(c) $\lceil \log_2 100 \rceil = 7$;
(d) $\lceil \log_2 4 \rceil = 2$;
(e) $\lceil \log_2 101 \rceil = 7$;
(f) $\lceil \log_2 2 \rceil = 1$;
(g) $\lceil \log_2 16 \rceil = 4$ for minutes and $\lceil \log_2 60 \rceil = 6$ for seconds.

So 43 bits in total is required.

c. It is easier to decode the state of the scoreboard if we use the method of part b, while it only need to use 1 more bit.

Question 2.

a. See Figure 1.

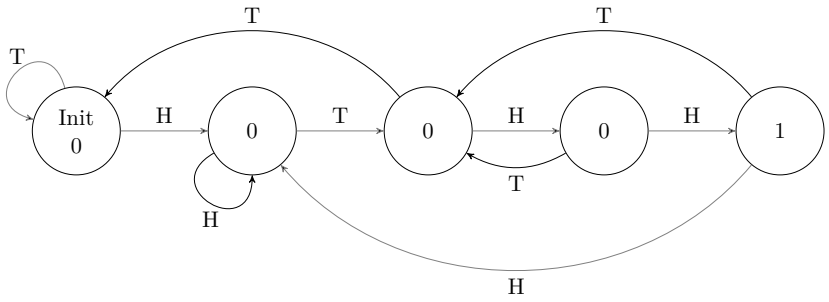

Figure 1: The completed state diagram.

b. $\lceil \log_2 5 \rceil = 3$.

Question 3.

It's $2^8 \times 8 = 2048$ bytes.

Question 4.

a. `A[1:0]` is 10, and `WE` is 0.

b. Because we need 6 bits to address 60 locations, 6 address lines would be needed. Since we would not change the number of bits stored at each location, the addressability would remain to be the same, that is, 3 bits.

c. $2^6 - 60 = 4$, so 4 additional memory locations could be added.

Question 5.

a. 4 memory locations.

b. 16 bits.

c. $\frac{64}{8} = 8$ bytes.

d. See Table 1.

Table 1: The completed table.

`WE`	`A[1:0]`	`Di[15:0]`	`D[15:0]`	Read/Write
0	01	xFADE	x4567	Read
1	10	xDEAD	xDEAD	Write
0	00	xBEEF	x0123	Read
1	11	xFEED	xFEED	Write

Question 6.

a. 8 bits.

b. 7 bits.

c. $32 - 8 - 3 \times 7 = 3$ bits.

Question 7.

See Figure 2.

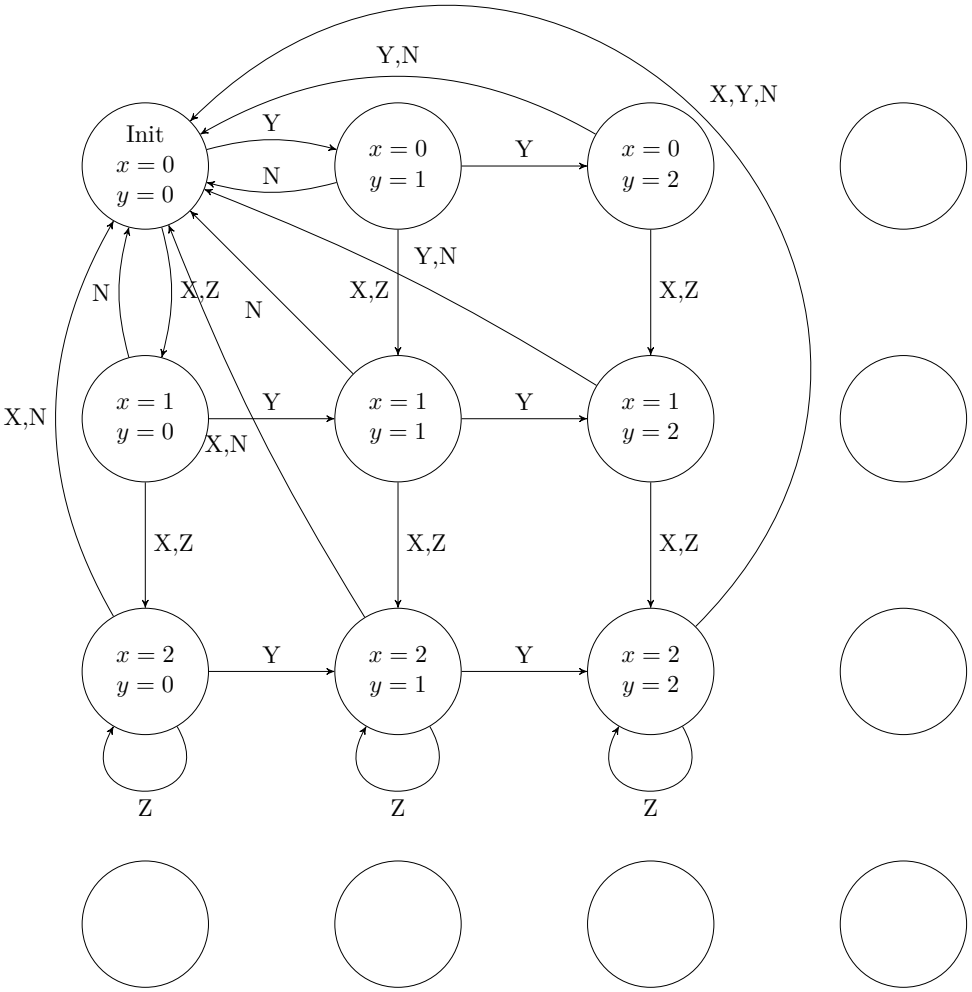

Figure 2: The State Diagram.

Question 8.

See Table 2. The circuit is a MOD-8 Down Counter.

Table 2: The entries for D2, D1, D0.

	cycle 0	cycle 1	cycle 2	cycle 3	cycle 4	cycle 5	cycle 6	cycle 7
D2	0	1	1	1	1	0	0	0
D1	0	1	1	0	0	1	1	0
D0	0	1	0	1	0	1	0	1