CS 254: Assignment 8

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Contents

Traffic Light Controller

Finding Number of States

Let us consider states of the form `(_ _ _ _) (_)`, where the first set represents the color of lanes and each has value from G, Y, R and the second set represents counter from 0 to 7.

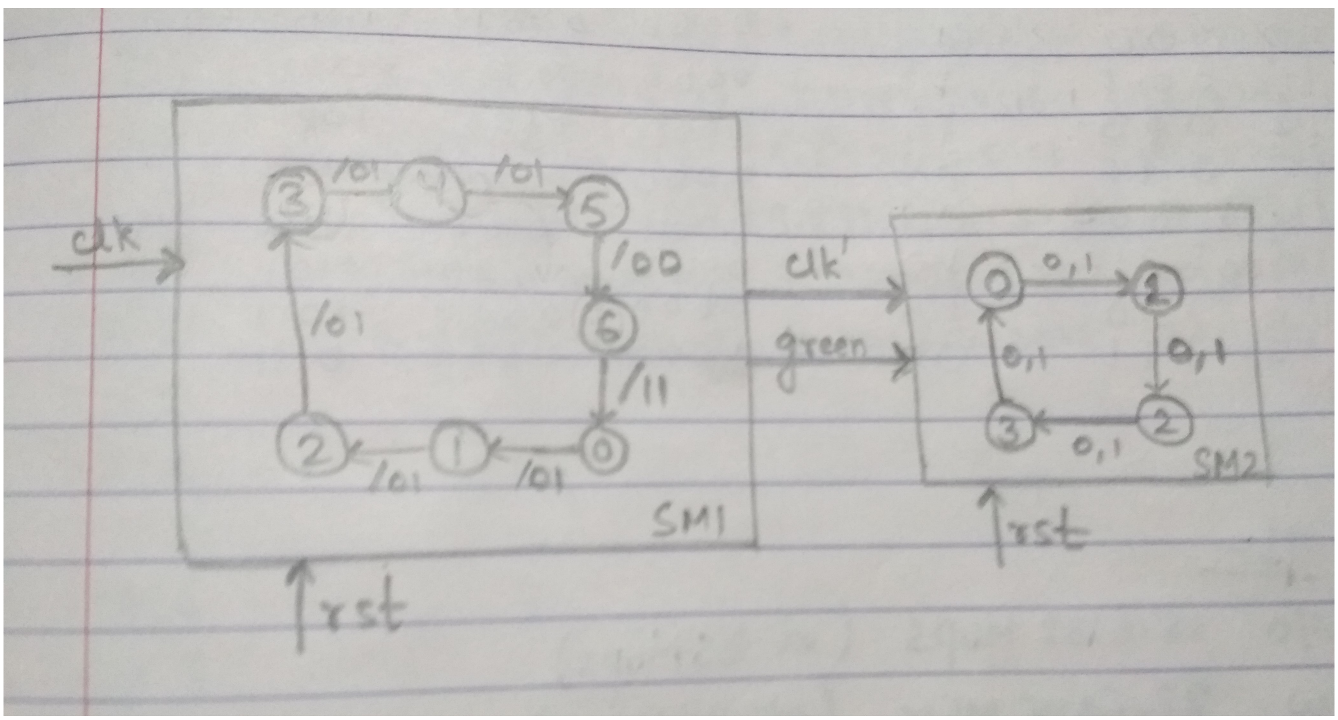
Possible States for Green: the first set will have 3Rs and 1G, second set would be from 0 to 5.

Possible States for Yellow: the first set will have 3Rs and 1Y, second set would be 6.

This gives us totally 28 states, which can be represented in 5 state variables.

For modularity, we split the 5 state variables into set of 3 and 2 state variables - first set (3 variables) storing the counter, second set (2 variables) storing the lane number.

State Diagram



State Machine 1

$\boldsymbol{I} = \phi$
$\boldsymbol{O} = \{(\texttt{clk'} = 0, \texttt{green} = 0), (\texttt{clk'} = 0, \texttt{green} = 1), (\texttt{clk'} = 1, \texttt{green} = 1)\}$
$\boldsymbol{S} = \{(\texttt{time} = 0), (\texttt{time} = 1), (\texttt{time} = 2), (\texttt{time} = 3), (\texttt{time} = 4), (\texttt{time} = 5), (\texttt{time} = 6)\}$
$\boldsymbol{S_0} = (\texttt{time} = 0)$
Number of state variables = $\lceil \log_2(7) \rceil = 3$.
Let state variables be $\boldsymbol{s_2}, \boldsymbol{s_1}, \boldsymbol{s_0}$.

Variable Mapping

State	$\boldsymbol{s_2}$	$\boldsymbol{s_1}$	$\boldsymbol{s_0}$
$(\texttt{time} = 0)$	0	0	0
$(\texttt{time} = 1)$	0	0	1
$(\texttt{time} = 2)$	0	1	0
$(\texttt{time} = 3)$	0	1	1
$(\texttt{time} = 4)$	1	0	0
$(\texttt{time} = 5)$	1	0	1
$(\texttt{time} = 6)$	1	1	0

Output	$\boldsymbol{\lambda_1}$	$\boldsymbol{\lambda_0}$
$(\texttt{clk'} = 0, \texttt{green} = 0)$	0	0
$(\texttt{clk'} = 0, \texttt{green} = 1)$	0	1
$(\texttt{clk'} = 1, \texttt{green} = 1)$	1	1

State Transition Table

$\boldsymbol{s_2}$	$\boldsymbol{s_1}$	$\boldsymbol{s_0}$	$\boldsymbol{\delta_2}$	$\boldsymbol{\delta_1}$	$\boldsymbol{\delta_0}$	$\boldsymbol{\lambda_1}$	$\boldsymbol{\lambda_0}$
0	0	0	0	0	1	0	1
0	0	1	0	1	0	0	1
0	1	0	0	1	1	0	1
0	1	1	1	0	0	0	1
1	0	0	1	0	1	0	1
1	0	1	1	1	0	0	0
1	1	0	0	0	0	1	1

K-Maps

$\boldsymbol{\delta_2}$

$s_2 \backslash s_1 s_0$	00	01	11	10
0	0	0	1	0
1	1	1	X	0

$$\boldsymbol{\delta_2 = s_1 s_0 + s_2 \bar{s}_1}$$

$\boldsymbol{\delta_1}$

$s_2 \backslash s_1 s_0$	00	01	11	10
0	0	1	0	1
1	0	1	X	0

$$\boldsymbol{\delta_1 = \bar{s}_1 s_0 + \bar{s}_2 s_1 \bar{s}_0}$$

$\boldsymbol{\delta_0}$

$s_2 \backslash s_1 s_0$	00	01	11	10
0	1	0	0	1
1	1	0	X	0

$$\boldsymbol{\delta_0 = \bar{s}_1 \bar{s}_0 + \bar{s}_2 \bar{s}_0}$$

$\boldsymbol{\lambda_1}$

$s_2 \backslash s_1 s_0$	00	01	11	10
0	0	0	0	0
1	0	0	X	1

$$\boldsymbol{\lambda_1 = s_2 s_1}$$

$\boldsymbol{\lambda_0}$

$s_2 \backslash s_1 s_0$	00	01	11	10
0	1	1	1	1
1	1	0	X	1

$$\boldsymbol{\lambda_0 = \bar{s}_2 + \bar{s}_0}$$

State Machine 2

$\boldsymbol{I} = \{(\texttt{green} = 0), (\texttt{green} = 1)\}$
$\boldsymbol{O} = \{(\texttt{RRRG}), (\texttt{RRGR}), (\texttt{RGRR}), (\texttt{GRRR}), (\texttt{RRRY}), (\texttt{RRYR}), (\texttt{RYRR}), (\texttt{YRRR})\}$
$\boldsymbol{S} = \{(\texttt{lane} = 0), (\texttt{lane} = 1), (\texttt{lane} = 2), (\texttt{lane} = 3)\}$
$\boldsymbol{S_0} = (\texttt{lane} = 0)$
Number of state variables $= \lceil \log_2(4) \rceil = 2$.
Let state variables be $\boldsymbol{s_1}, \boldsymbol{s_0}$.

Variable Mapping

State	$\boldsymbol{s_1}$	$\boldsymbol{s_0}$
$(\texttt{lane} = 0)$	0	0
$(\texttt{lane} = 1)$	0	1
$(\texttt{lane} = 2)$	1	0
$(\texttt{lane} = 3)$	1	1

Input	$\boldsymbol{a}$
$(\texttt{green} = 0)$	0
$(\texttt{green} = 1)$	1

Output	$\boldsymbol{g_3}$	$\boldsymbol{g_2}$	$\boldsymbol{g_1}$	$\boldsymbol{g_0}$	$\boldsymbol{y_3}$	$\boldsymbol{y_2}$	$\boldsymbol{y_1}$	$\boldsymbol{y_0}$	$\boldsymbol{r_3}$	$\boldsymbol{r_2}$	$\boldsymbol{r_1}$	$\boldsymbol{r_0}$
$(\texttt{RRRG})$	0	0	0	1	0	0	0	0	1	1	1	0
$(\texttt{RRGR})$	0	0	1	0	0	0	0	0	1	1	0	1
$(\texttt{RGRR})$	0	1	0	0	0	0	0	0	1	0	1	1
$(\texttt{GRRR})$	1	0	0	0	0	0	0	0	0	1	1	1
$(\texttt{RRRY})$	0	0	0	0	0	0	0	1	1	1	1	0
$(\texttt{RRYR})$	0	0	0	0	0	0	1	0	1	1	0	1
$(\texttt{RYRR})$	0	0	0	0	0	1	0	0	1	0	1	1
$(\texttt{YRRR})$	0	0	0	0	1	0	0	0	0	1	1	1

State Transition Table

$\boldsymbol{a}$	$\boldsymbol{s_1}$	$\boldsymbol{s_0}$	$\boldsymbol{\delta_1}$	$\boldsymbol{\delta_0}$	$\boldsymbol{g_3}$	$\boldsymbol{g_2}$	$\boldsymbol{g_1}$	$\boldsymbol{g_0}$	$\boldsymbol{y_3}$	$\boldsymbol{y_2}$	$\boldsymbol{y_1}$	$\boldsymbol{y_0}$	$\boldsymbol{r_3}$	$\boldsymbol{r_2}$	$\boldsymbol{r_1}$	$\boldsymbol{r_0}$
0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	1	0
0	0	1	1	0	0	0	0	0	0	0	1	0	1	1	0	1
0	1	0	1	1	0	0	0	0	0	1	0	0	1	0	1	1
0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	1	1
1	0	0	0	1	0	0	0	1	0	0	0	0	1	1	1	0
1	0	1	1	0	0	0	1	0	0	0	0	0	1	1	0	1
1	1	0	1	1	0	1	0	0	0	0	0	0	1	0	1	1
1	1	1	0	0	1	0	0	0	0	0	0	0	0	1	1	1

K-Maps

$\boldsymbol{\delta_1}$

$a \backslash s_1 s_0$	00	01	11	10
0	0	1	0	1
1	0	1	0	1

$$\boldsymbol{\delta_1 = \bar{s}_1 s_0 + s_1 \bar{s}_0 = s_1 \oplus s_0}$$

$\boldsymbol{\delta_0}$

$a \backslash s_1 s_0$	00	01	11	10
0	1	0	0	1
1	1	0	0	1

$$\boldsymbol{\delta_0 = \bar{s}_0}$$

$\boldsymbol{g_3}$

$a \backslash s_1 s_0$	00	01	11	10
0	0	0	0	0
1	0	0	1	0

$$\boldsymbol{g_3 = a s_1 s_0}$$

$\boldsymbol{g_2}$

$a \backslash s_1 s_0$	00	01	11	10
0	0	0	0	0
1	0	0	0	1

$$\boldsymbol{g_2 = a s_1 \bar{s}_0}$$

$\boldsymbol{g_1}$

$a \backslash s_1 s_0$	00	01	11	10
0	0	0	0	0
1	0	1	0	0

$$\boldsymbol{g_1 = a \bar{s}_1 s_0}$$

$\boldsymbol{g_0}$

$a \backslash s_1 s_0$	00	01	11	10
0	0	0	0	0
1	1	0	0	0

$$g_0 = a\bar{s}_1\bar{s}_0$$

$\boldsymbol{y_3}$

$a \backslash s_1 s_0$	00	01	11	10
0	0	0	1	0
1	0	0	0	0

$$y_3 = \bar{a}s_1s_0$$

$\boldsymbol{y_2}$

$a \backslash s_1 s_0$	00	01	11	10
0	0	0	0	1
1	0	0	0	0

$$y_2 = \bar{a}s_1\bar{s}_0$$

$\boldsymbol{y_1}$

$a \backslash s_1 s_0$	00	01	11	10
0	0	1	0	0
1	0	0	0	0

$$y_1 = \bar{a}\bar{s}_1s_0$$

$\boldsymbol{y_0}$

$a \backslash s_1 s_0$	00	01	11	10
0	1	0	0	0
1	0	0	0	0

$$y_0 = \bar{a}\bar{s}_1\bar{s}_0$$

r_3

a \ s_1s_0	00	01	11	10
0	1	1	0	1
1	1	1	0	1

$$r_3 = \bar{s}_1 + \bar{s}_0$$

r_2

a \ s_1s_0	00	01	11	10
0	1	1	1	0
1	1	1	1	0

$$r_2 = \bar{s}_1 + s_0$$

r_1

a \ s_1s_0	00	01	11	10
0	1	0	1	1
1	1	0	1	1

$$r_1 = s_1 + \bar{s}_0$$

r_0

a \ s_1s_0	00	01	11	10
0	0	1	1	1
1	0	1	1	1

$$r_0 = s_1 + s_0$$