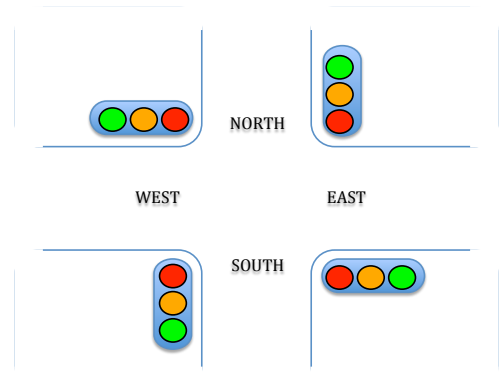


COL719 Synthesis of Digital Systems

Lab Assignment 1

A 4-way traffic intersection having roads labelled as NORTH | EAST | SOUTH | WEST (N|E|S|W, in short) as shown in the figure, has an adaptive signal controller. The signals go through cycles in the order NORTH => EAST => SOUTH => WEST with usual sequences of Green, Orange and Red.



Various timings in seconds are as follows.

T_{cyc} = total duration of a cycle

$T_{G,i}$ = duration of Green signal for road i , for $i \in \{N, E, S, W\}$

$T_{R,i}$ = duration of Red signal for road i , for $i \in \{N, E, S, W\}$

T_O = duration of Orange signal for each road

The following equations relate these timings.

$$T_{cyc} = 4 * T_O + \sum_{i \in \{N, E, S, W\}} T_{G,i}$$

$$T_{cyc} = T_{R,i} + T_O + T_{G,i}, \quad \text{for } i \in \{N, E, S, W\}$$

The system consists of several interconnected modules: four *sensor units*, one for each road (four instances of same module), one *adaptation unit* and one *display timer unit*. Each *sensor unit* finds the number of vehicles waiting at the corresponding road when the signal is just turning from Red to Green and averages it over k cycles. Average value for road i is denoted by N_i .

The *adaptation unit* performs updation of the Green signal durations ($T_{G,i}$) after getting the N_i values from the *sensor units* as follows.

$$T_{G,i} \leq T_{G,i} + \beta * (N_i - .25 * \sum_{j \in \{N, E, S, W\}} N_j), \quad \text{for } i \in \{N, E, S, W\}$$

If this formula were to make some result negative or fall below τ , adaptation in that cycle is skipped. Initially when the system starts, all $T_{G,i}$ durations are initialised to equal values.

The *display timer unit* takes the $T_{G,i}$ values provided by the *adaptation unit*, rounds these off to multiples of τ and uses these to turn the signals on or off. It also takes care of the following features.

- Drives a 3 digit 7-segment display for each road showing the time 888 remaining for the next change.
- Inserts an "all red" phase for 10 sec for pedestrians to cross if any of the pedestrian buttons has been pressed. This phase is introduced at the earliest possible after an orange phase.
- Inserts an "all red" phase for 10 sec for an emergency vehicle (Police/Ambulance/Fire tender) to cross if an emergency request is received. This phase is introduced at the earliest possible after an orange phase, aborting any ongoing green phase.

T_{cyc} , T_O , k , β and τ are the configuration parameters of the system, with value ranges given below. These may be considered as constants for this exercise.

T_{cyc} : 150 to 250 T_O : 5 to 10 k : 50 to 100 β : 0.5 or 1 or 2 τ : 10 to 15

Part 1: Design and simulate *display timer unit* using VHDL.

Submission due by 25.08.2021

Part 2: Design and simulate *adaptation unit* and *sensor unit* using VHDL.

Submission due by 01.09.2021

Part 3: Design and simulate complete traffic light system using VHDL.

Submission due by 08.09.2021