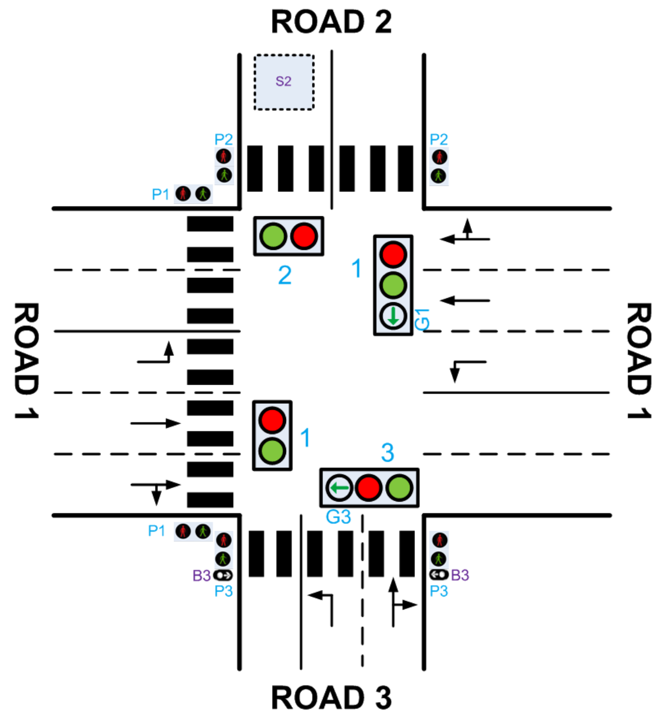

ECE 321 Assignment 4 (individual work; 10 pts total)

This question asks you to provide the Petri Net (PN) model of the traffic light system that was elicited during the laboratories and which is shown on the right.

Your solution should include:

1. (4 pts) A **graph** representing your model, i.e., a screenshot showing the initial marking that represents the **Default** state included in the PDF **AND** the model as **xml** file submitted on eClass before the deadline. The xml file **must be created with PIPE 4.3.0** that can be downloaded from

   https://sourceforge.net/projects/pipe2/files/PIPEv4/PIPEv4.3.0/
   Try to make your model as neat as possible.
2. (4 pts) A **description of all transitions** used in the graph
   1. List all transitions and describe what each of them does
3. (2 pts) The **answer** to the following three questions
   1. Is your model conservative? Explain why.
   2. Can we have a deadlock in your model?
   3. Can we have a starvation in your model? If yes then show an example corresponding cycle and list the transitions that will starve. Discuss if this starvation could happen in the actual live traffic lights system, and if yes, explain in words how to prevent it.

Your system will use the following definition of states to derive the PN model:

Inputs	1	2	3	G1	G3	P1	P2	P3	M	C	T1	T2	B3*	S2**
Valid states for given input / System states	G, R, Off	G, R, FR	G, R, FR	On, Off	On, Off	G, R, Off	G, R, Off	G, R, Off	On, Off	D, N	On, Off	On, Off	On, Off	On, Off
Default	G	R	R	Off	Off	R	G	R	Off	D	On	Off	Off	Off
DefaultB3	G	R	R	Off	Off	R	G	R	Off	D	On	Off	On	Off
DefaultS2	G	R	R	Off	Off	R	G	R	Off	D	On	Off	Off	On
DefaultB3S2	G	R	R	Off	Off	R	G	R	Off	D	On	Off	On	On
GreenP3	G	R	R	Off	Off	R	G	G	Off	D	Off	On	On	Off
GreenP3S2	G	R	R	Off	Off	R	G	G	Off	D	Off	On	On	On
GreenG1	R	R	R	On	Off	G	R	R	Off	D	Off	On	Off	Off
GreenG1S2	R	R	R	On	Off	G	R	R	Off	D	Off	On	Off	On
Green3	R	R	G	Off	On	R	R	R	Off	D	Off	On	Off	Off
Green3S2	R	R	G	Off	On	R	R	R	Off	D	Off	On	Off	On
Green2and3	R	G	G	Off	Off	R	R	R	Off	D	Off	On	Off	Off
Emergency	Off	FR	FR	Off	Off	Off	Off	Off	On	D/N	Off	Off	Off	Off
Night	Off	FR	FR	Off	Off	Off	Off	Off	Off	N	Off	Off	Off	Off

M denotes malfunction flag; C clock (day vs. night); T1 and T2 are timers
* “B3 = On” only if B3 was pressed before leaving the Default state
** “S2 = On” only if S2 was active before leaving the Default state

The transitions between the states are described by the following transition function table:

System inputs / States	Timer T1 fires	B3 pressed	S2 activated	Timer T2 fires	Clock C indicates Daytime	Clock C indicates Nighttime	Malfunction M occurs	Reset button R is pressed and no malfunction M and Clock C indicates Daytime	Reset button R is pressed and no malfunction M and Clock C indicates Nighttime
Default	GreenG1	DefaultB3	DefaultS2			Night	Emergency		
DefaultB3	GreenP3		DefaultB3S2			Night	Emergency		
DefaultS2	GreenG1S2	DefaultB3S2				Night	Emergency		
DefaultB3S2	GreenP3S2					Night	Emergency		
GreenP3				GreenG1			Emergency		
GreenP3S2				GreenG1S2			Emergency		
GreenG1				Green3			Emergency		
GreenG1S2				Green3S2			Emergency		
Green3				Default			Emergency		
Green3S2				Green2and3			Emergency		
Green2and3				Default			Emergency		
Emergency							Emergency	Default	Night
Night					Default		Emergency		

IMPORTANT NOTES

- The Petri Net model has to follow the below assumptions
  - **Places represent the objects, not the states of the entire system** (in contrast to the Finite State Machine model), e.g. you will have a place for traffic lights 1, traffic lights 2, etc. See below for the list of places that are in the model.
  - **Each transition is enabled based on its input places**
    - You may need to define multiple (duplicate) transitions that will model the same physical input that changes system state, e.g. for the timer in the default state, but which will be enabled in different states
  - Inputs from the two sensors (B3 and S2) are considered/acknowledged **only** in the Default state; columns B3 and S2 represent the state of the inputs as read in the Default state. If they were not triggered in Default but became triggered in a subsequent state, then they are not going to be acted upon until after the Default states. It is possible that both inputs, one of the inputs, or none of the inputs are triggered. They are activated (set to On) one at the time, i.e., never at the same time. At the time when Timer1 (T1) expires, the possible configurations are that both inputs, one of the inputs, or none of the inputs are triggered.
  - The switch to the Night state is possible **only** in the "Default" states (including Default, DefaultB3, DefaultS2 and DefaultB3S2). Your model has to **reset the values in the B3 and S2 columns** (set them to Off) when you transition out of the Default state, i.e., when the Night time input is read.

- To simplify the model, the Emergency state is disregarded (shadowed cells in the tables above should be ignored). Other than that, the Petri Net model must represent the complete behavior of the system
- It is not allowed to modify the above physical representation of the system states (colors of the lights, setup of the timers, malfunction input, etc.)
- Remember to list any additional assumptions about your model, if you make any
- **Use the input and input state abbreviations, as defined in the above table, in your model. Renaming will result in deductions.**
- **Use PIPE 4.3.0**
- **Remember that Petri Nets are nondeterministic**
  - They fire one of the enabled transitions non-deterministically
  - You do not have the control of which one
  - One of the enabled transitions is selected randomly, which means that you need to simulate and verify all possibilities

Due Dates and Notes
Your assignment must be received by 11:00am MST, on Wednesday, December 5, 2018.
Please submit one PDF file and one XML file.

HINT: LIST OF STATES
To make the task a bit simpler, the list of all states (21 in total) with their meanings is listed below. Please use the same names in your model.

- ***1** and **1_OFF*** – status of lights 1
  - 0 tokens in *1* & 1 token in *1 OFF* – 1 is turned off
  - 1 token in *1* & 0 tokens in *1 OFF* – Green
  - 0 tokens in *1* & 0 tokens in *1 OFF* – Red
- ***2** and **2_FR*** – status of lights 2
  - 0 tokens in *2* & 1 token in *2 FR* – Flashing Red
  - 1 token in *2* & 0 tokens in *2 FR* – Green
  - 0 tokens in *2* & 0 tokens in *2 FR* – Red
- ***3** and **3_FR*** – status of lights 3
  - 0 tokens in *3* & 1 token in *3 FR* – Flashing Yellow
  - 1 token in *3* & 0 tokens in *3 FR* – Green
  - 0 tokens in *3* & 0 tokens in *3 FR* – Red
- ***G1*** – status of arrow G1
  - 0 tokens – Off
  - 1 token – On
- ***G3*** – status of arrow G3
  - 0 tokens – Off
  - 1 token – On
- ***P1** and **P1_OFF*** – status of pedestrian lights P1
  - 0 tokens in *P1* & 1 token in *P1 OFF* – Off
  - 1 token in *P1* & 0 tokens in *P1 OFF* – Green
  - 0 tokens in *P1* & 0 tokens in *P1 OFF* – Red
- ***P2** and **P2_OFF*** – status of pedestrian lights P2
  - 0 tokens in *P2* & 1 token in *P2 OFF* – Off
  - 1 token in *P2* & 0 tokens in *P2 OFF* – Green
  - 0 tokens in *P2* & 0 tokens in *P2 OFF* – Red
- ***P3** and **P3_OFF*** – status of pedestrian lights P3

    - 0 tokens in *P3* & 1 token in *P3 OFF* – Off
    - 1 token in *P3* & 0 tokens in *P3 OFF* – Green
    - 0 tokens in *P3* & 0 tokens in *P3 OFF* – Red
- ***T1*** **–** status of Timer1
    - 0 tokens in T1 – Timer1 Off
    - 1 token in T1 – Timer1 On
- ***T2*** **–** status of Timer2
    - 0 tokens in T2 – Timer2 Off
    - 1 token in T2 – Timer2 On
- ***S2_ON*** *and* ***S2_OFF*** **–** status of sensor S2 as read in default state
    - 0 tokens in *S2* ON & 1 token in *S2 OFF* – S2 is Off
    - 1 tokens in *S2* ON & 0 tokens in *S2 OFF* – S2 is On
- ***B3_ON*** *and* ***B3_OFF*** **–** status of pedestrian button B3 as read in default state
    - 0 tokens in *B3* ON & 1 token in *B3 OFF* – B3 is Off
    - 1 tokens in *B3* ON & 0 tokens in *B3 OFF* – B3 is On
- ***Clock*** **–** status of Clock
    - 0 tokens in *Clock* – Clock indicates *Day time*
    - 1 token in *Clock* – Clock indicates *Night time*