LAB 8. Petri Nets

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Agenda

1. **Petri Net models**
   - **cruise control system model**
     - **in-class exercise**
       - **design of PN model from sub-models using PIPE software**
       - **analysis of the model using PIPE software**

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Cruise-control system model

- CCS used to automatically maintain speed of a car
- Pressing brake causes that the system to temporarily revert to manual control until resume is pressed
- CCS can be directed to increase or decrease speed to reach a new maintenance speed
- System Inputs:
  - CCS ON/OFF
  - Engine ON/OFF (CCS only active if the engine is ON)
  - Pulses (generated every revolution of the wheel)
  - Accelerator (accelerator has been pressed)
  - Brake (brake has been pressed)
  - Increase/Decrease maintained speed (only if CCS is ON)
  - Resume (resume the last maintained speed; only if CCS is ON)
- System Output:
  - Throttle (setting for engine throttle)

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State	Engine	CCS	Throttle	CCS maintains speed
S1	off	off	same	no
S2	on	off	manual	no
S3	on	on	same	yes
S4	on	on	increase	yes
S5	on	on	decrease	yes
S6	on	on	increase	no
S7	on	on	decrease	no

Places

- Eng ON (1 token = Engine ON, no tokens = Engine OFF)
- CCS ON (1 token = CCS ON, no tokens = CCS OFF)
- Thr SAME (1 token = Throttle is same, no tokens = Throttle is not same)
- Thr MAN (1 token = Throttle is manual, no tokens = Throttle is not manual)
- Thr INC (1 token = increase Throttle, no tokens = do not increase Throttle)
- Thr DEC (1 token = decrease Throttle, no tokens = do not decrease Throttle)
- CCS maint (1 token = CCS maintains speed, no tokens = CCS does not maintain speed)
- CCS not maint (1 token = CCS does not maintain speed, no tokens = CCS does maintain)

additional places that simulate inputs

- start car (1 token = ready to start, no tokens = already started)
- start CCS (1 token = ready to start, no tokens = already started or Engine OFF)
- below freq (1 token = pulses below desired frequency, no tokens = not)
- above freq (1 token = pulses above desired frequency, no tokens = not)
- at freq (1 token = pulses at desired frequency, no tokens = not)
- accelerate (1 token = driver accelerates, no token = does not)
- brake (1 token = driver presses brake, no token = does not)
- inc setting (1 token = driver increases desired setting, no token = does not)
- dec setting (1 token = driver decreases desired setting, no token = does not)

Transitions

- will be developed based on the transition table

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State	Engine	CCS	Throttle	CCS maintains speed
S1	off	off	same	no
S2	on	off	manual	no
S3	on	on	same	yes
S4	on	on	increase	yes
S5	on	on	decrease	yes
S6	on	on	increase	no
S7	on	on	decrease	no

inputs / states	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12
	Engine ON	Engine OFF	CCS ON	CCS OFF	pulses above desired frequency	pulses below desired frequency	pulses at desired frequency	acceler down	brake	increase speed for CCS	decrease speed for CCS	resume CCS control
S1	S2	–	–	–	–	–	–	–	–	–	–	–
S2	–	S1	S3	–	–	–	–	–	–	–	–	–
S3	–	–	–	S2	S5	S4	–	S4	S7	S4	S5	–
S4	–	–	–	S2	S5	–	S3	–	S7	S3	S3	–
S5	–	–	–	S2	–	S4	S3	S4	S7	S3	S3	–
S6	–	S1	–	S2	–	–	–	–	S7	–	–	S3
S7	–	S1	–	S2	–	–	–	S6	–	–	–	S3

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CCS model

- 7 modules
  - base module
    - models turning on/off engine and CCS
  - 2 pulses modules
    - model increasing and decreasing of car speed controlled by the CCS
  - accelerator module
    - models acceleration by the driver while CCS is ON
  - brake and resume module
    - models pressing brake by the driver while CCS is ON and resuming the CCS while CCS in ON
  - increase/decrease desired speed modules
    - model increasing/decreasing desired speed by the driver while CCS is ON
- first, each module is designed
- next, the modules are combined into a single model

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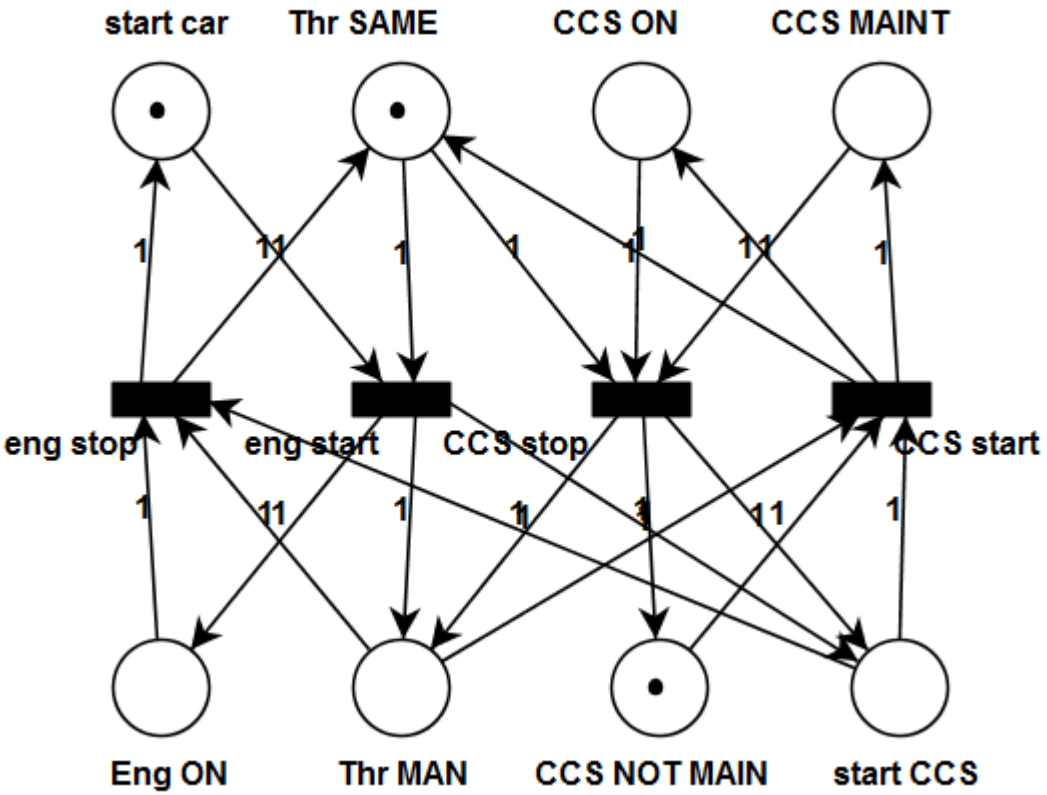
CCS model: base

inputs / states	I1 Engine ON	I2 Engine OFF	I3 CCS ON	I4 CCS OFF	I5 pulses above freq	I6 pulses below freq	I7 pulses at freq	I8 acceler down	I9 brake	I10 increase speed for CCS	I11 decrease speed for CCS	I12 resume CCS control
S1	S2	–	–	–	–	–	–	–	–	–	–	–
S2	–	S1	S3	–	–	–	–	–	–	–	–	–
S3	–	–	–	S2	S5	S4	–	S4	S7	S4	S5	–
S4	–	–	–	S2	S5	–	S3	–	S7	S3	S3	–
S5	–	–	–	S2	–	–	S3	S4	S7	S3	S3	–
S6	–	S1	–	S2	–	–	–	–	S7	–	–	S3
S7	–	S1	–	S2	–	–	–	S6	–	–	–	S3



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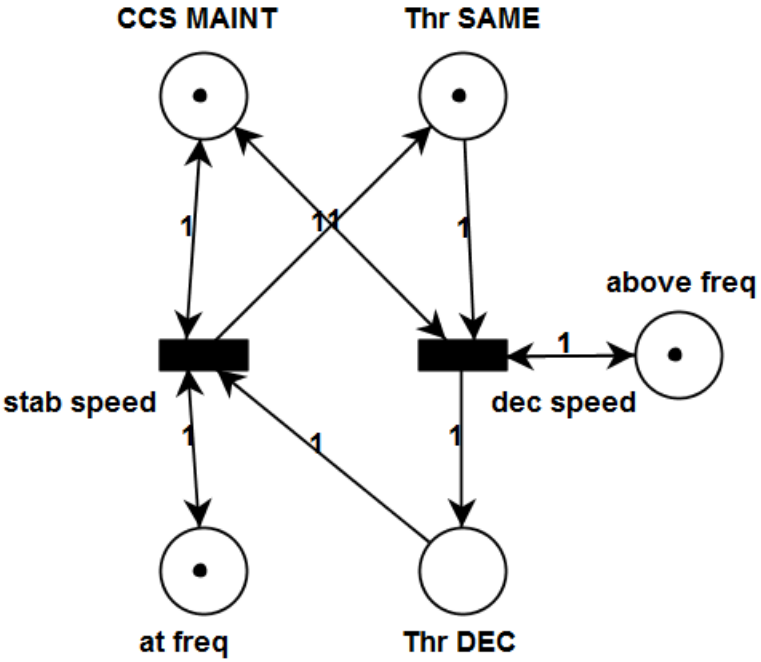
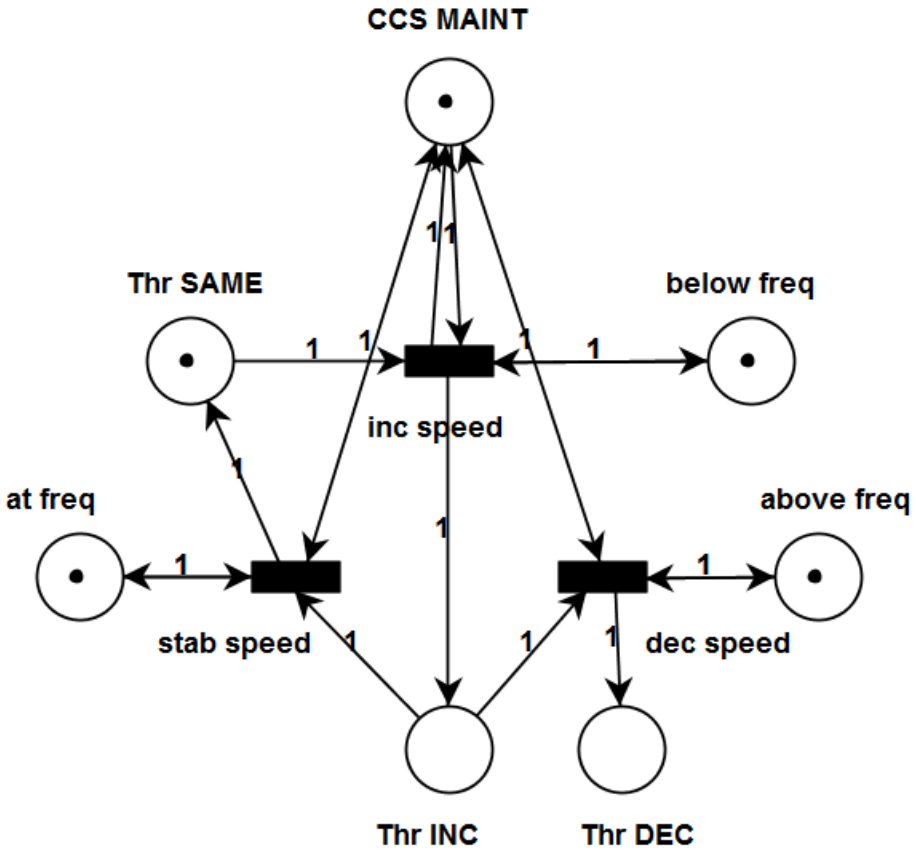
CCS model: pulses

inputs / states	I1 Engine ON	I2 Engine OFF	I3 CCS ON	I4 CCS OFF	I5 pulses above freq	I6 pulses below freq	I7 pulses at freq	I8 acceler down	I9 brake	I10 increase speed for CCS	I11 decrease speed for CCS	I12 resume CCS control
S1	S2	–	–	–	–	–	–	–	–	–	–	–
S2	–	S1	S3	–	–	–	–	–	–	–	–	–
S3	–	–	–	S2	S5	S4	–	S4	S7	S4	S5	–
S4	–	–	–	S2	S5	–	S3	–	S7	S3	S3	–
S5	–	–	–	S2	–	–	S3	S4	S7	S3	S3	–
S6	–	S1	–	S2	–	–	–	–	S7	–	–	S3
S7	–	S1	–	S2	–	–	–	S6	–	–	–	S3





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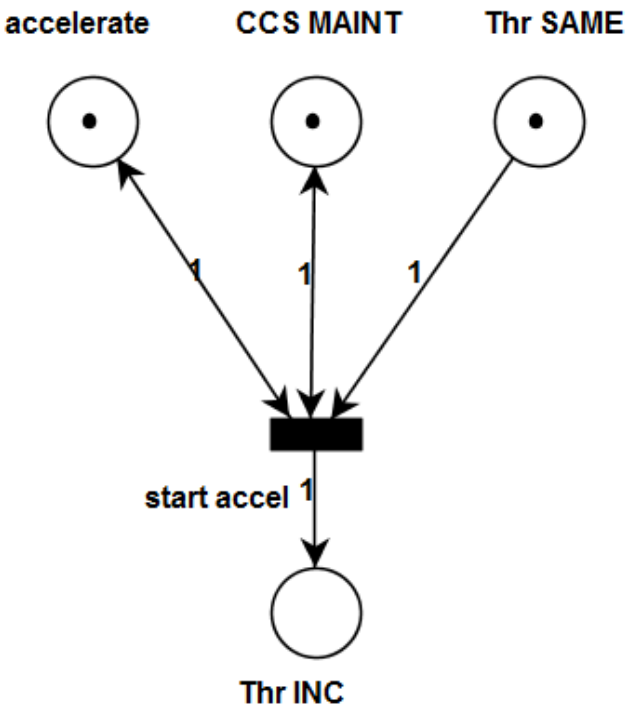
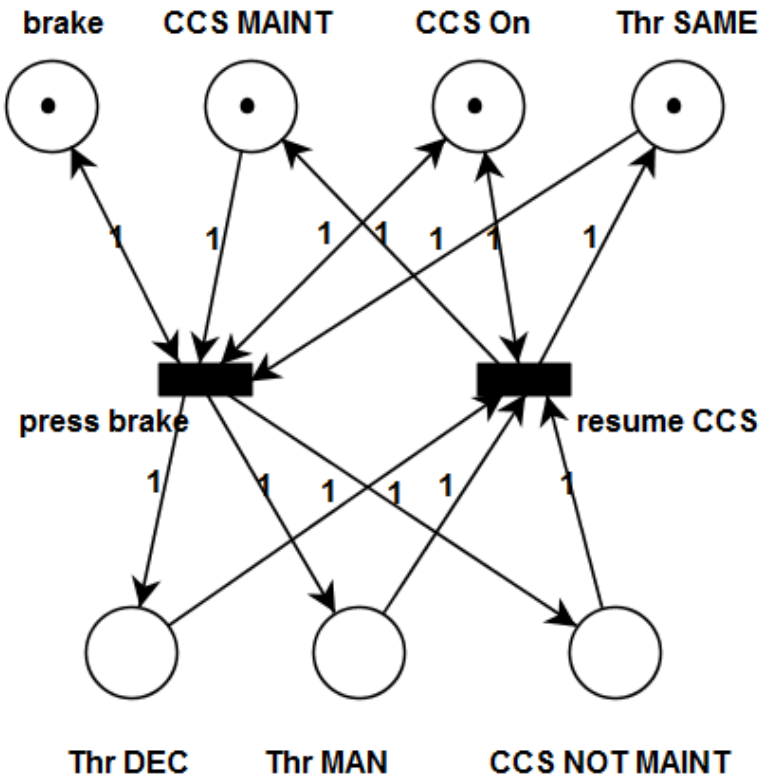
inputs / states	I1 Engine ON	I2 Engine OFF	I3 CCS ON	I4 CCS OFF	I5 pulses above freq	I6 pulses below freq	I7 pulses at freq	I8 acceler down	I9 brake	I10 increase speed for CCS	I11 decrease speed for CCS	I12 resume CCS control
S1	S2	–	–	–	–	–	–	–	–	–	–	–
S2	–	S1	S3	–	–	–	–	–	–	–	–	–
S3	–	–	–	S2	S5	S4	–	S4	S7	S4	S5	–
S4	–	–	–	S2	S5	–	S3	–	S7	S3	S3	–
S5	–	–	–	S2	–	–	S3	S4	S7	S3	S3	–
S6	–	S1	–	S2	–	–	–	–	S7	–	–	S3
S7	–	S1	–	S2	–	–	–	S6	–	–	–	S3

CCS model: accelerator, brake and resume





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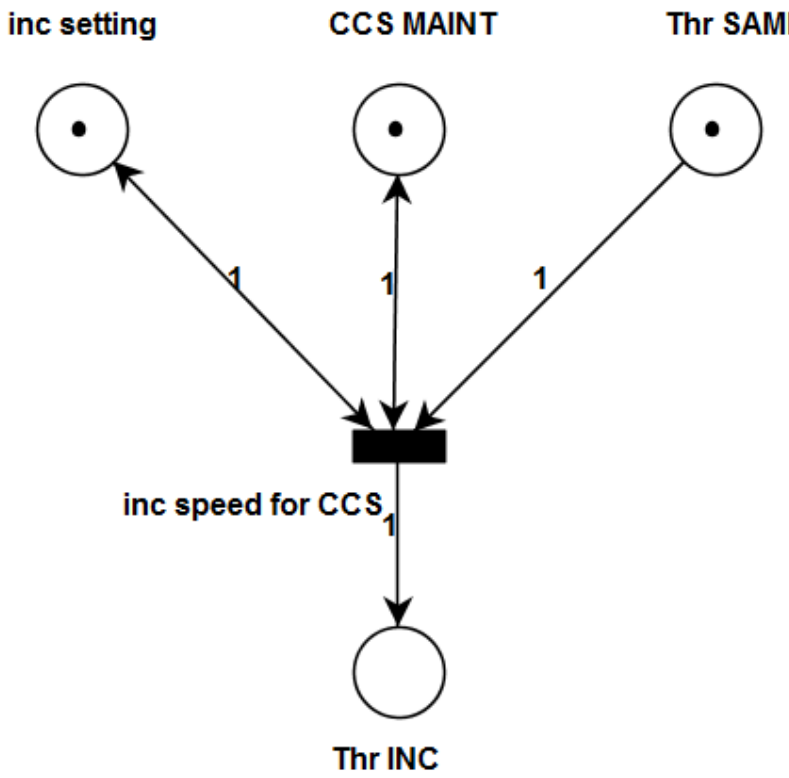
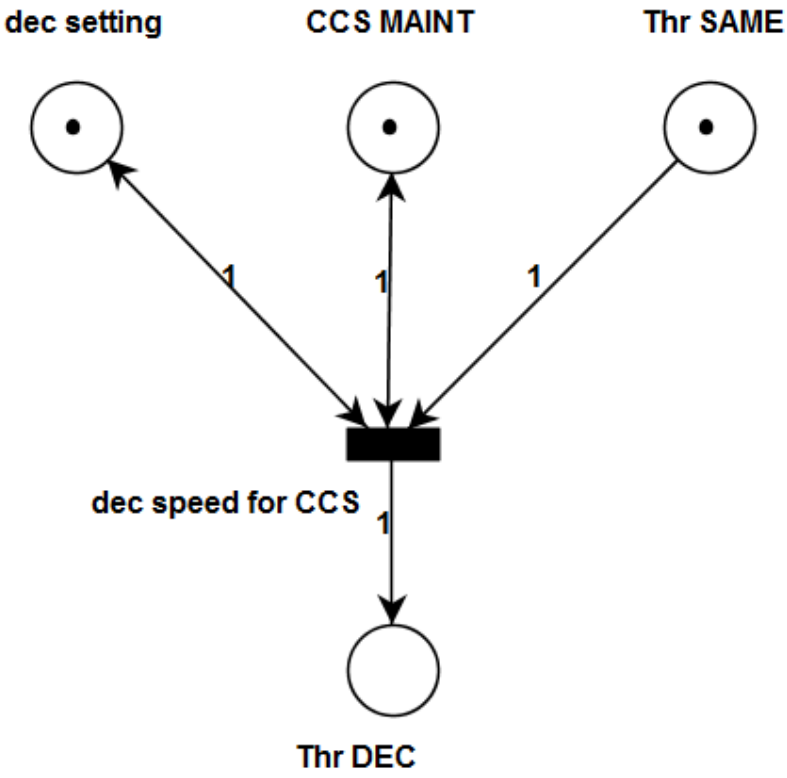
inputs / states	I1 Engine ON	I2 Engine OFF	I3 CCS ON	I4 CCS OFF	I5 pulses above freq	I6 pulses below freq	I7 pulses at freq	I8 acceler down	I9 brake	I10 increase speed for CCS	I11 decrease speed for CCS	I12 resume CCS control
S1	S2	–	–	–	–	–	–	–	–	–	–	–
S2	–	S1	S3	–	–	–	–	–	–	–	–	–
S3	–	–	–	S2	S5	S4	–	S4	S7	S4	S5	–
S4	–	–	–	S2	S5	–	S3	–	S7	S3	S3	–
S5	–	–	–	S2	–	–	S3	S4	S7	S3	S3	–
S6	–	S1	–	S2	–	–	–	–	S7	–	–	S3
S7	–	S1	–	S2	–	–	–	S6	–	–	–	S3

CCS model: increase/decrease desired speed





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CCS model

- group work
- grade will be individual (equal for each team member)
- Remember that both .xml file and .png file should be submitted by 16:50 in lab
- Get confirmation that I received the email before the lab ends