MTAT.03.083 – Systems Modelling Petri nets Assignment (5 points)

Submission instructions

- *Due on Friday 19 December 2014 at 10am EET.*
- *Submit using the Submit button in the course Web page.*
- *The assignment has to be completed in teams of two members. Please write the name of your team-mate in the "Comments" field of the submission form.*
- *The submission should include one Petri net per question. The Petri nets should be encoded in PNML format (the format supported by Woped). The PNML files should be packaged in a single "zip", "7z", or "rar" file.*
- *The submitted Petri nets will be assessed in terms of two criteria: "correctness" and "simplicity and understandability". Please make sure that you use meaningful names for the places and transitions in the net to increase its understandability. You may include an additional file (in plain text format, PDF or Word) to explain the meaning of transitions and places in your nets. This explanatory document is optional.*

Automated Factory Line

We consider a segment of a factory with two conveyor belts, two machines, one robot and one buffer. Raw parts arrive through a first conveyor belt, called the *raw line*. The robot moves each part from the *raw line* into machine M1. Machine M1 immediately starts processing the raw part. Eventually, the machine will finish processing the part and the robot may then move the processed part into the buffer. Eventually, the robot moves the part from the buffer into machine M2. Machine M2 will start processing it. When machine M2 finishes processing the part, the robot will then move that part from machine M2 into a second conveyor belt (called the *finished line*).

Figure 1 illustrates the factory line in the state where the raw line holds 2 parts, M1 and M2 hold one part each, the buffer holds two parts, and the finished line holds one part.

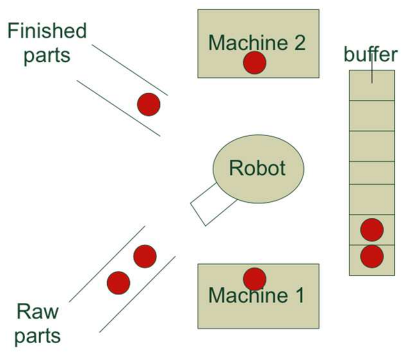

Figure 1: Factory Line Structure

M1 can hold at most one part at a time, and the same applies for M2. The robot can only move one part a time. When machine 2 is free, the robot can move a part directly from machine 1 into machine 2 instead of moving the part to the buffer.

The conveyor belts can hold any number of parts but the buffer can hold at most 7 parts. When the buffer is full, the robot will not put a part into machine 1, even if machine 1 is empty. This constraint is intended to avoid the situation where machine M1 finishes processing a part and the robot is not able to take away the processed part from M1.

This segment of factory line (in its “empty” state) is modelled as a Petri net in Figure 2.

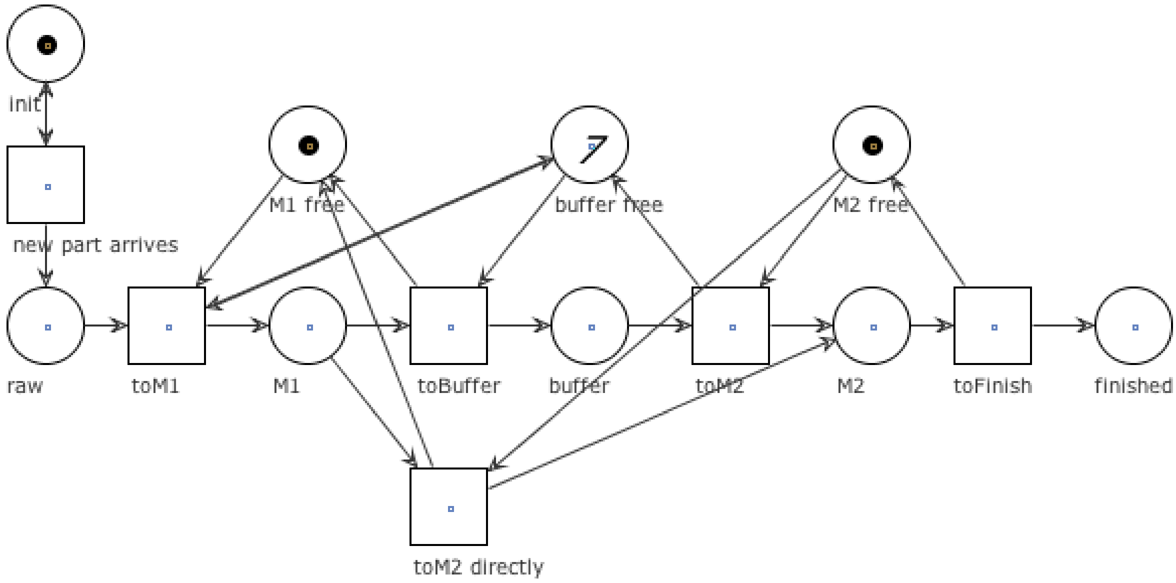

Figure 2: Petri net of the system in its initial (empty) state.

Tasks

Task 1. [2 points]

From time to time, it happens that one of the machines breaks down. In this case the machine moves into a “broken” state and an alarm is triggered so that an operator fixes the problem. If the machine breaks down while it is processing a part, the operator discards this part. If the machine breaks while it holds an already processed part, the robot moves this processed part into the buffer (in the case of M1) or into the finished line (in the case of M2). Once the machine is empty, the operator eventually repairs it and restarts the machine. While one of the machines is broken, the other one may continue to work.

Modify the above Petri net from in order to capture the possibility of machine break-downs.

Task 2. [1 point]

The factory line has been experiencing slow production times due to machine M1 being too slow. The production engineers have decided to replace machine M1 with a larger machine (called “M1L”) with two separate slots. This new machine can process two items concurrently (but it can also process one item at a time). Machine M2 remains unchanged and still has a capacity of one part only. The robot still has capacity for transporting only one part at a time. When M1L is empty, the robot will first place a raw part onto one of the slots of M1L. It may then place a second raw part into the other slot. When M1L breaks down, the operator discards the unprocessed part(s) inside M1L (if any) and the robot moves any already-processed part(s) out of M1L. Once M1L is empty, the operator may repair it and restart it.

Modify the Petri net from the previous task in order to capture the replacement of M1 with a larger machine.

Task 3. [2 points]

Sensors are added in the finished line in order to measure the size and weight of the finished parts. If the sensor detects that one of the parts does not fit certain requirements, a robotic arm attached to the finished line is triggered. The robotic arm removes the defective part from the finished line and drops it into a bin. If two consecutive parts are found to be defective, a red light in the raw line is turned on and the robot stops taking new parts from the raw line. Eventually, a technician checks the factory line, perform some adjustments and restarts the line. When the line is restarted, the red light is turned off and the robot can start taking parts from the raw line again.

Acknowledgments: This exercise is inspired by a similar by exercise by R. Wattenhofer, ETH Zürich.