Technische Universität München (I7)
Prof. J. Esparza / P. Meyer

Summer term 2016
Thursday 14^{th} April, 2016

Petri nets – Homework 1

Discussed on Thursday 21^{st} April, 2016.

For questions regarding the exercises, please send an email to meyerphi@in.tum.de or just drop by at room 03.11.042.

Exercise 1.1 Alcohol burning

Model the chemical reaction $C_2H_5OH + 3\,O_2 \longrightarrow 2\,CO_2 + 3\,H_2O$ as a Petri net. Use weighted arcs as needed.

Assume that there are two steps: first each molecule is disassembled into its atoms and then these atoms are assembled into other molecules. The net should have places for each of the molecules, and the marking where there are two tokens in the place CO_2 and three tokens in the place H_2O should be reachable if and only if there are at least one token in the place C_2H_5OH and three tokens in the place O_2 in the initial marking.

Acknowledgement: Exercise taken from www.workflowcourse.com

Exercise 1.2 Manufacturing process

In a "just-in-time" manufacturing system, items can be ordered to be produced, which is signaled by an "order" event. An order is acknowledged by a "receive" event, and then manufactured by a "produce" event. After that, the item is checked by quality control and can either be ready to be sent (event "positive") or be discarded (event "negative"). In the positive case, the item is sent (event "send") to the customer. In the negative case, a replacement item is scheduled to be produced.

An item can be in any of the states "ordered", "received", "produced", "to_be_sent", "sent" "discarded". Suppose that there are initially two orders.

(a) Model the system as a Petri net, where there are transitions for each event and places for each possible state of an item. You may have additional places and transitions. Do not use weighted arcs.

(b) Now adapt your model such that there is at most one item in the "produced" state at any time, and further items have to wait for that item to be quality checked before they are produced.

Exercise 1.3 Nets and subnets

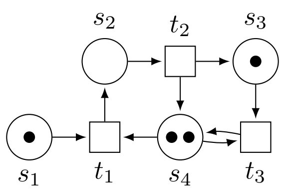
Consider the net $N = (S, T, F)$ defined by $S = \{s_1, s_2\}$, $T = \{t_1, t_2\}$ and $F = \{(s_1, t_1), (t_1, s_2), (s_2, t_1), (s_2, t_2), (t_2, s_2), (t_2, s_1)\}$.

(a) Draw the net N.

(b) Is the net $N' = (S', T', F')$ defined by $S' = \{s_2\}$, $T' = \{t_2\}$ and $F' = \{(s_2, t_2), (t_2, s_2), (t_2, s_1)\}$ a subnet of N?

Exercise 1.4 Reachable markings

Consider the following Petri net:



(a) Give the preset and postset of each place and each transition.

(b) Which transitions are enabled at M_0?

(c) Construct the reachability graph of the Petri net.

(d) Does the number of reachable markings increase or decrease if we remove i) place s_1 and its adjacent arcs ii) place s_2 and its adjacent arcs?

Acknowledgment: Exercise designed by Wil van der Aalst et al. (TU Eindhoven).

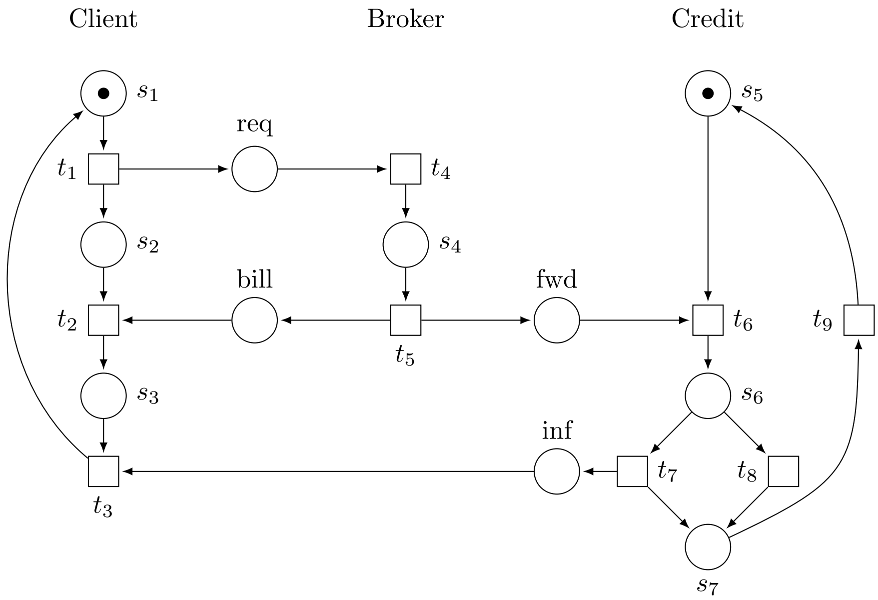
Exercise 1.5 Model analysis (with tools)

For the Petri net below modelling a bank contract, check if the following properties hold. You may use tools such as **PIPE**, **APT** or **Lola** to check the properties. The input files for the net are given in appropriate format on the homepage. You may then use the tools with the integrated modules to check properties or construct the reachability graph.

(a) **Boundedness**: Is the Petri net bounded, i.e., for every place s, is there a number $b \geq 0$ such that $M(s) \leq b$ for every reachable marking M?

(b) **Liveness**: Is the net live, i.e., for every reachable marking M and every transition t, is there a marking M' reachable from M that enables t?

(c) **Deadlock freedom**: Is the Petri net deadlock-free, i.e., is there a reachable marking M that enables no transitions?



Exercise 1.6 Exchange Lemma

Let u and v be transitions of a net satisfying ${}^\bullet u \cap v^\bullet = \emptyset$. Show: If $M \xrightarrow{vu} M'$ then $M \xrightarrow{uv} M'$.