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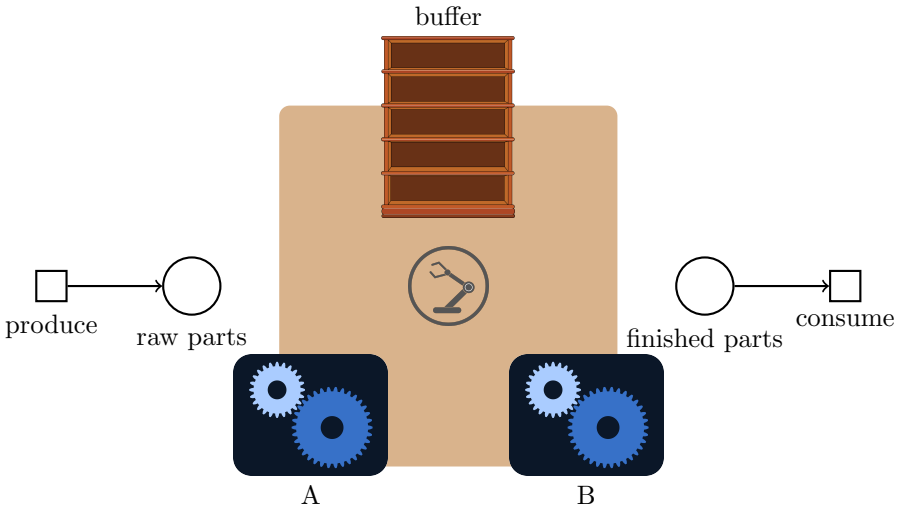
Petri nets — Exercise sheet 1

Due 30.04.2019

Exercise 1.1 (adapted from [1, ex. 2.20])
Consider a simple production system in which raw parts are first processed by a machine A, stored into a buffer, and then processed by a machine B. The parts are moved around using a single robot arm R. The buffer can contain at most five items at a time, and machines A and B can only handle one item at a time.



Model this production system as a Petri net by extending the partial model shown above. The actions of machines A and B are not atomic: they have a beginning and an end. On the other hand, the action of the robot arm can be considered as atomic. There is no need to distinguish between particular buffer places, or between particular items to be processed.

Exercise 1.2
Consider Lamport's 1-bit mutual exclusion algorithm:

First process

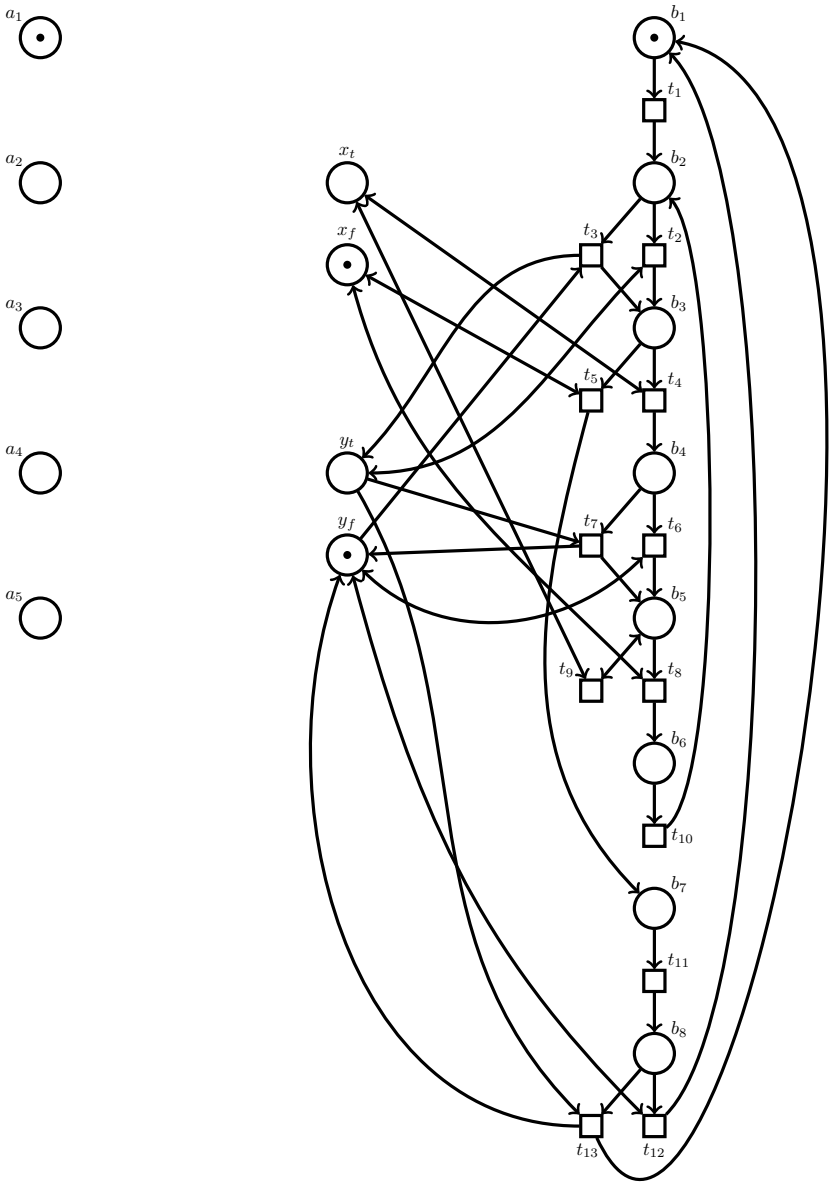
```
1.  while True:
2.    x = True
3.    while y: pass
4.    # critical section
5.    x = False
```

Second process

```
1.  while True:
2.    y = True
3.    if x then:
4.      y = False
5.      while x: pass
6.      goto 2
7.    # critical section
8.    y = False
```

The algorithm can be modeled by a Petri net $\mathcal{N}$ where each program location (i.e. line of code of a process) is associated to a place, and where the shared binary variables `x` and `y` are associated to two places each. In

more details, $\mathcal{N} = (P, T, F)$ where $P = \{a_1, \ldots, a_5, b_1, \ldots, b_8, x_t, x_f, y_t, y_f\}$. A token in a_i (resp. b_i) indicates that the first (resp. second) process is at line i; a token in x_t (resp. y_t) indicates that `x` (resp. `y`) has value `True`; and a token in x_f (resp. y_f) indicates that `x` (resp. `y`) has value `False`. The initial marking of $\mathcal{N}$ is $M_0 = \{a_1, b_1, x_f, y_f\}$. We give a partial Petri net that only models the second process:



(a) Complete the above Petri net $\mathcal{N}$ so that it also models the first process. You should not add new places, only transitions and arcs. Note that `pass` is a "no operation", i.e. an operation without any effect.

(b) Complete the given `APT` file for $\mathcal{N}$ accordingly, and verify whether

(i) $(\mathcal{N}, M_0)$ is bounded;

(ii) $(\mathcal{N}, M_0)$ is live.

(c) Complete the given `LoLA` file for $\mathcal{N}$ accordingly, and verify whether

(i) $(\mathcal{N}, M_0)$ is deadlock-free;

(ii) a process can be at multiple program locations at the same time;

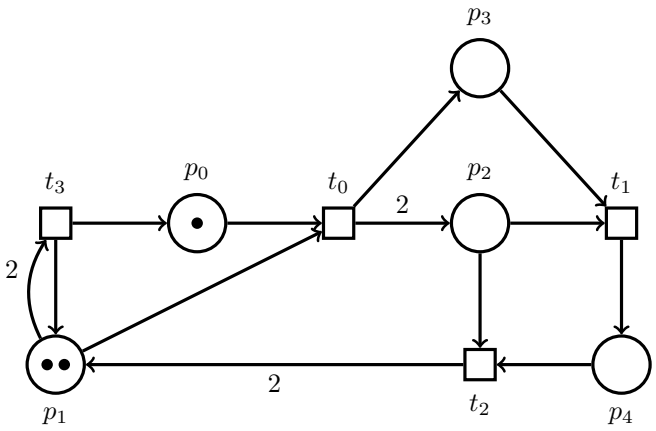
(iii) whether both processes can reach their critical sections simultaneously.

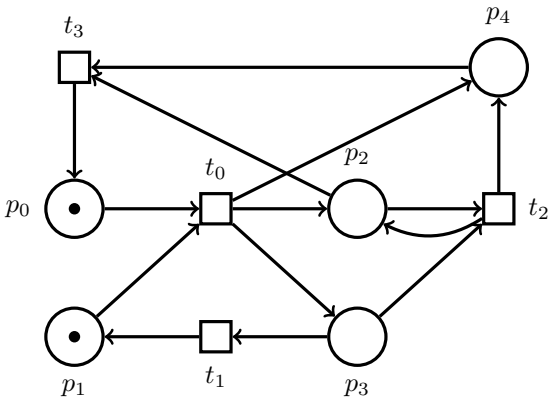
Exercise 1.3
For each Petri net $(\mathcal{N}, M_0)$ below:

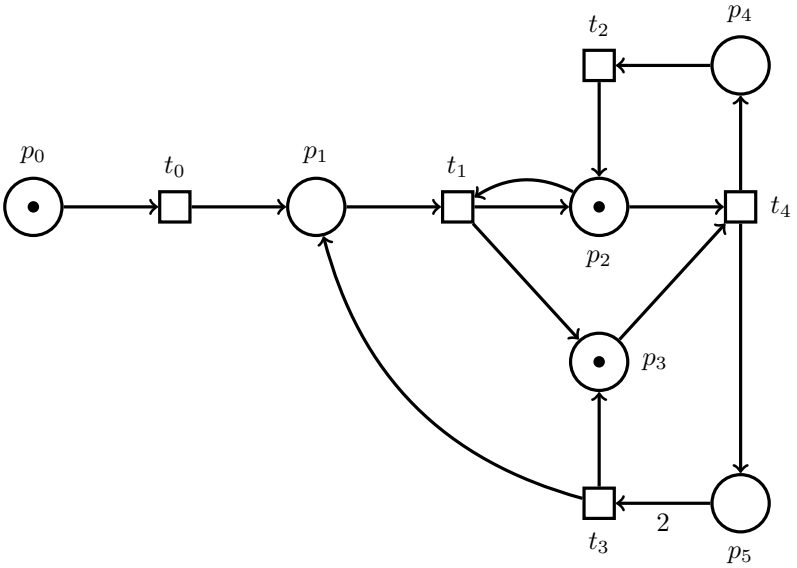
(a) construct the reachability graph of $(\mathcal{N}, M_0)$.

(b) say whether $(\mathcal{N}, M_0)$ is bounded, deadlock-free and/or live. If it is bounded, give the smallest k such that it is k-bounded. Justify your answers.

(c) give the subnet $\mathcal{N}' = (P', T', F')$ of $\mathcal{N}$ such that $P' = \{p_0, p_1, p_2, p_4\}$ and $T' = T$.







References

[1] Wil van der Aalst, Massimiliano de Leoni, Boudewijn van Dongen, and Christian Stahl. Course business information systems: Exercises. Available at `http://wwwis.win.tue.nl/~wvdaalst/old/courses/BIScourse/exercise-bundle-BIS-2015.pdf`, 2015.