

Exercise 1:

1a)

An element in the incidence matrix gives the change in the token amount, if a transition fires. A read arc indicates that no token will be consumed. Thus, in the incidence matrix, a zero would occur, although there is an arc in the underlying Petri net graph.

All loop structures, are also properly reflected in the incidence matrix, because they are structurally corresponding to read arc.

For examples, see the file `excl/figure1a.pdf`.

1b)

If we apply the matrix transposition to the incidence matrix of a Petri net, i.e. if we exchange rows and columns, places would become transitions and transitions would become places. Thus, the T-invariants would become P-invariants, and the P-invariants would become T-invariants. The solutions of the equation systems would be the same, but the interpretation would be different.

1c)

The MCT-sets for the open model with and without trivial T-invariants are in the files `figure7.6_with_triv.mct` and `figure7.6_without_triv.mct`.

Comparing both files, we see that in the case including trivial T-invariants we get most MCT-sets (1, 2, 3, 5, 6, 7, 8, 9, 10) consisting of only one transition. Except one MCT-set (`t5.Phosphoglucose_isomerase`), which is part in both result files, for all other MCT-sets with one element, this transition is part of trivial T-invariants.

Always, if we have metabolic systems with trivial t-invariants, describing forward and backward reactions, the number of MCT-sets, which contain only transition, will increase.

Exercise 2:

2)

The open Petri net model is modelled in the file `carbon_open.spped`.

2a) and 2b)

The structural properties and invariants are given in `carbon_open.ina`, and the MCT-sets in `carbon_open_with_triv.mct`.

Interpretation of:

P-invariants: The first p-invariant covers all carbon-containing compound, whereas the second t-invariant all oxygen-containing compounds.

T-invariants: The first t-invariant is a trivial one, reflecting the third stoichiometric equation.

The second t-invariant describes reaction 1), the third t-invariant reaction 2), the fourth t-invariant the combined reactions 2) and 3a), and the fifth t-invariant the combined reactions 1) and 3b). All t-invariants describe the basic system behaviour.

MCT-sets: The MCT-sets with and without trivial t-invariants are provided in the files `carbon_open_with_triv.mct` and `carbon_open_without_triv.mct`, respectively.

2c)

The closed Petri net model is modelled in `carbon_closed.spped`.

2d)

The MCT-sets with and without trivial t-invariant are stored in the files `carbon_closed_with_triv.mct` and `carbon_closed_without_triv.mct`, respectively. The MCT-sets are not very significant, because the system is really small.

2e)

The reachability graph for the open system cannot be constructed because the net is unbounded, i.e., there are places that can get an infinite number of tokens. Thus, the reachability graph becomes also infinite.

The reachability graph for the closed system is provided in the file `carbon_closed.gra`. It consists of six states.

For the analysis results see file `carbon_closed.ina`. The net is live, reversible, and exhibits dynamic conflicts.

T-invariant one is not realizable in that initial marking, because there are no tokens on places CO and CO₂, which are necessary for firing of transitions r3a) or r3b).

T-invariants two, three, and four are realizable in that initial marking.

2f)

The if-condition in both propositions is the same, i.e. for all states, where the places, C and O₂, each carry two tokens. Whereas the first expression means that, then, for all paths a state would be reached, where the place, CO, carries two tokens, the second expression says that, then, there would exist a path to a state, where the place, CO, carries two tokens.

Exercise 3:

3)

The Petri net model is provided in `figure_exc3.spped`.

The analysis with p- and t-invariants can be found in file `figure_exc3.ina`.

The MCT-sets with and without trivial t-invariant are stored in the files `figure_exc3_with_triv.mct` and `figure_exc3_without_triv.mct`, respectively.

Exercise 4:

4) Please ask Monika.Heiner@informatik.tu-cottbus.de.

Exercise 5:

5)

The corresponding continuous Petri net is in file `figure5.spcontped` and the discrete Petri net with converted test edges in file `figure5.spped`. The analysis results are summarized in file `figure5.ina`. The net exhibits no invariants.
