MODULARIZATION BY T-INVARIANTS

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ABSTRACT DEPENDENT TRANSITION SETS (ADT-SETS)

- **Let X denote the set of all (non-trivial) minimal T-invariants x of a given PN.**

- **dependency relation**

  Two transitions i, j depend on each other,

  if they always appear together in all minimal T-invariants $\mathbf{x}$, i.e.

$$\forall(x \in X) \; : \; supp(x)(i) \; = \; supp(x)(j)$$

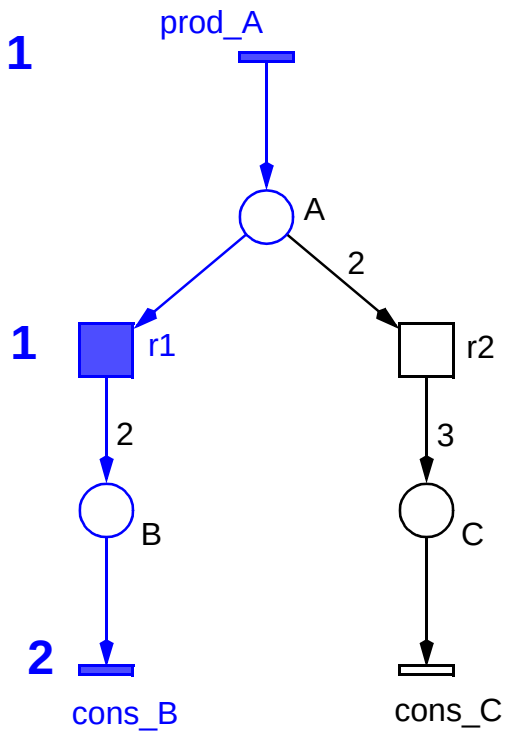
- **equivalence relation in the transition set, leading to a partition of T**
  - -> *reflexive*
  - -> *symmetric*
  - -> *transitive*

- **the equivalence classes A represent maximal ADT-sets**

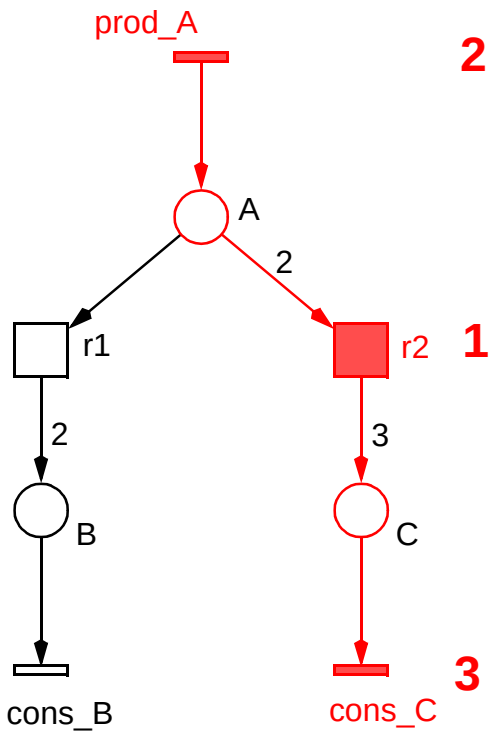
$$\forall(x \in X): A \subseteq supp(x) \vee A \cap supp(x) \; = \; \varnothing$$

ADT-SETS, EX1

r1: A -> 2 B
r2: 2 A -> 3 C



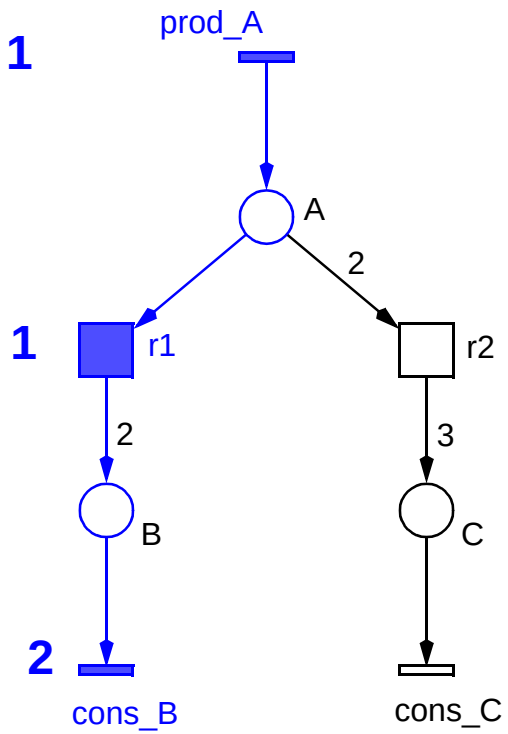
T-INVARIANT 1



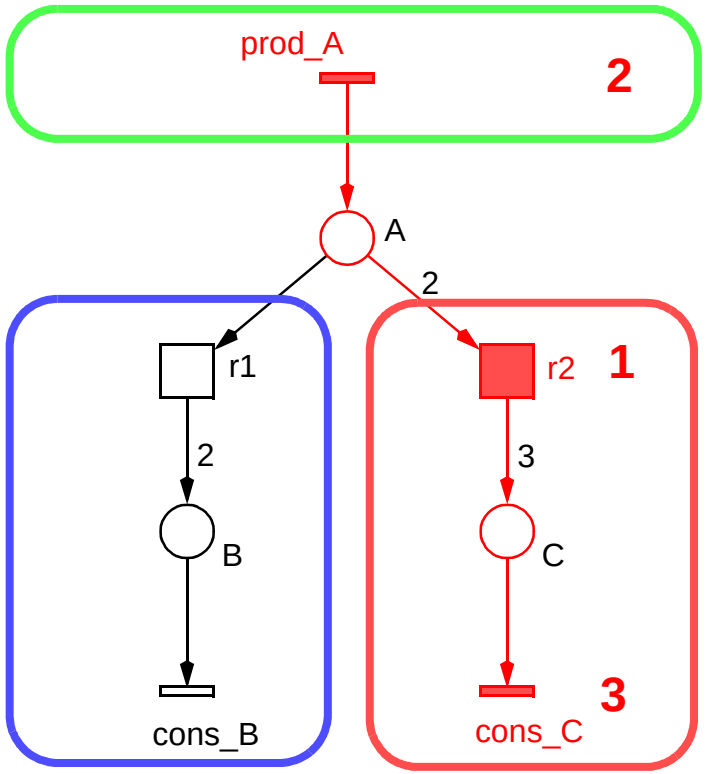
T-INVARIANT 2

ADT-SETS, EX1

r1: A -> 2 B
r2: 2 A -> 3 C



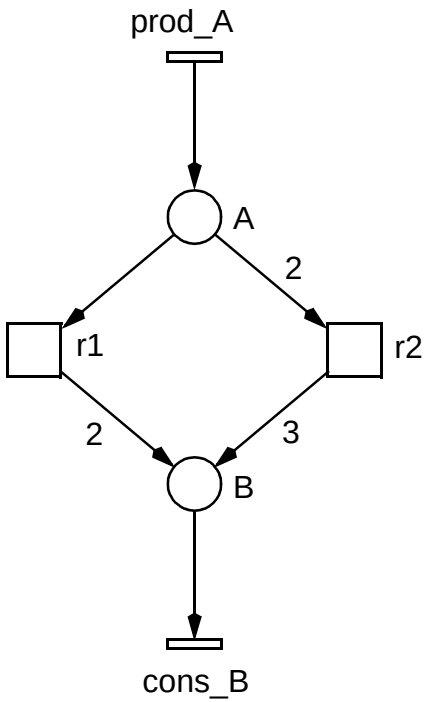
T-INVARIANT 1



T-INVARIANT 2

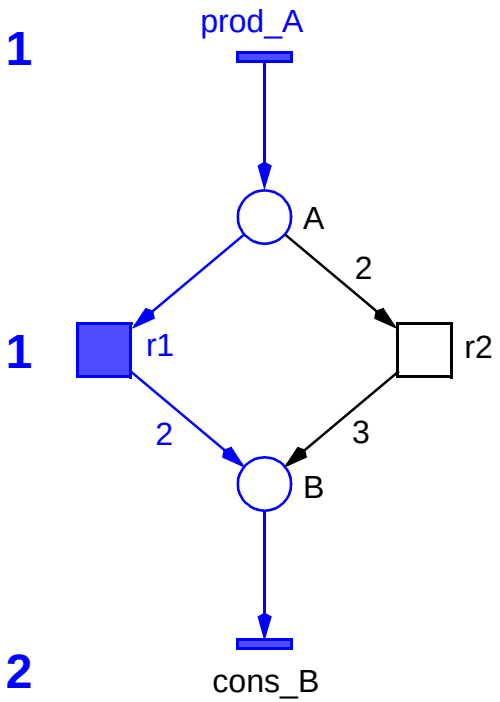
ADT-SETS, EX2

r1: A -> 2 B
r2: 2 A -> 3 B

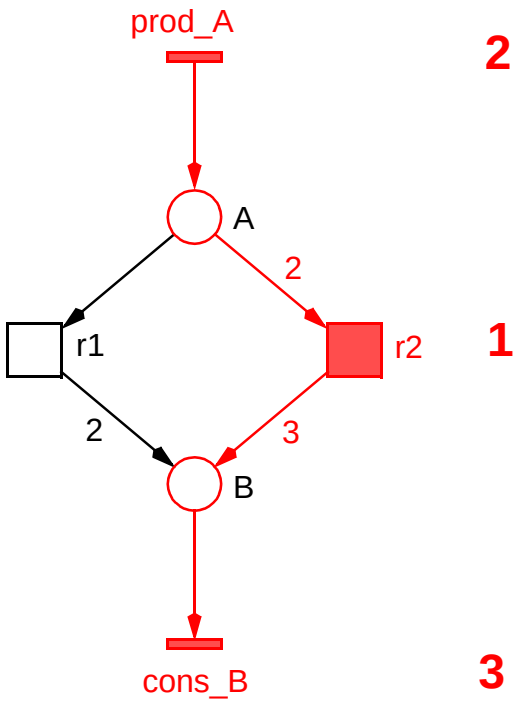


ADT-SETS, EX2

r1: A -> 2 B
r2: 2 A -> 3 B



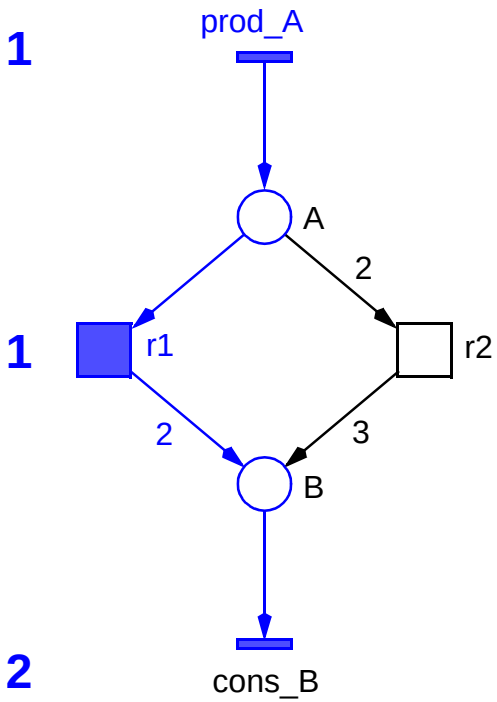
T-INVARIANT 1



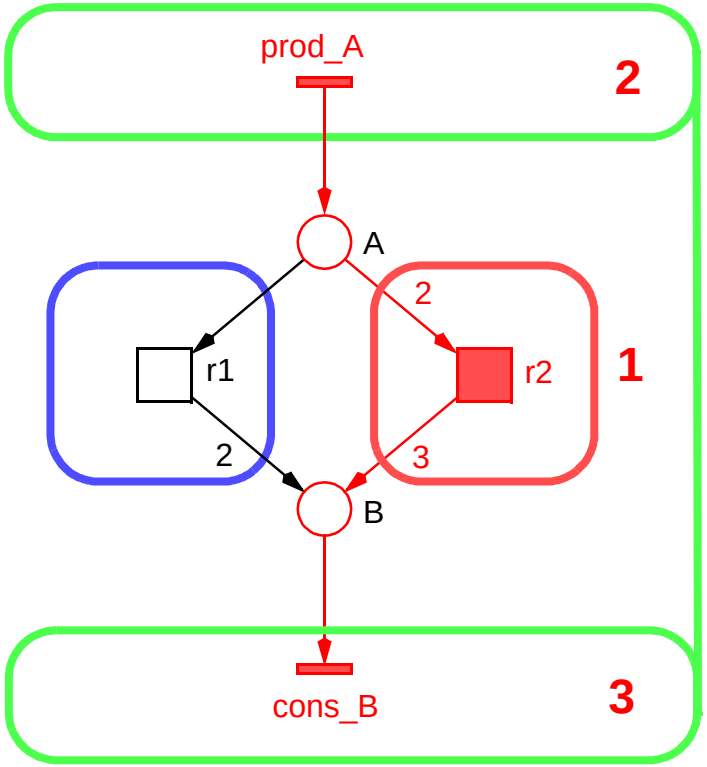
T-INVARIANT 2

ADT-SETS, EX2

r1: A -> 2 B
r2: 2 A -> 3 B



T-INVARIANT 1



T-INVARIANT 2

ADT-SETS, INTERPRETATION

- **maximal ADT-sets**
  - -> *disjunctive subnets*
  - -> *not necessarily connected*

minimal T-invariants

- -> *overlapping subnets*
- -> *connected*

- **interpretation**
  - -> *structural decomposition into rather small subnets*
  - -> *smallest biologically meaningful functional units*
  - -> *building blocks*

- **variations**
  - -> *with / without trivial T-invariants*
  - -> *whole / partial set of T-invariants*

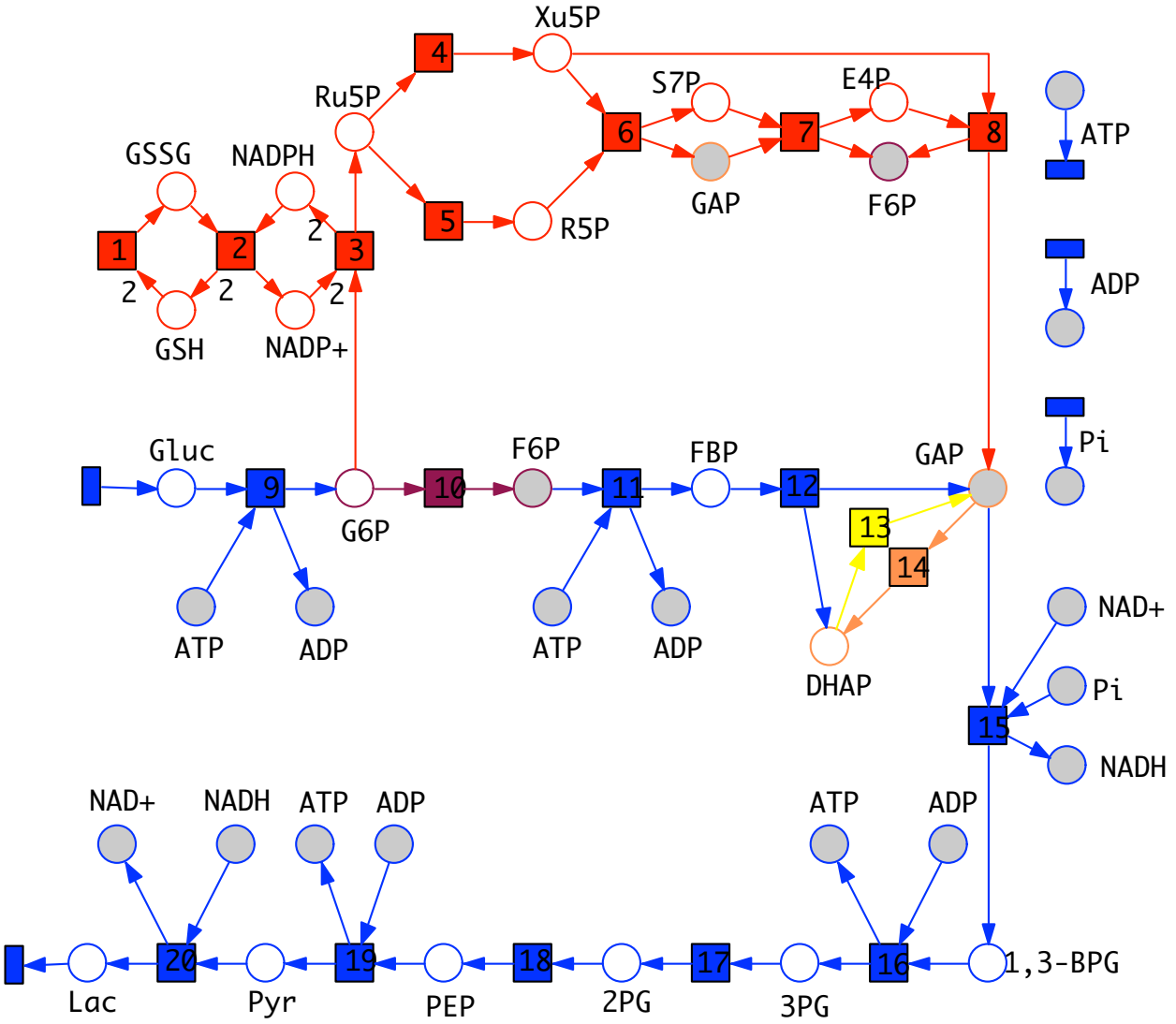
} *not necessarily maximal ADT-sets*

- **classification of all transitions based on the T-invariants' support**

ADT-SETS, APPLICATION

- **maximal ADT-sets**
  - -> *not necessarily connected*
- **further decomposition into connected ADT-sets**
  - -> *possibly according to primary compounds, only, i.e. neglecting connections by auxiliary compounds*
  - -> *non-maximal ADT-sets*
- **coarse network structure, definition**
  - -> *macro transitions* - *abstract from connected ADT-sets*
  - -> *places* - *interface between functional units*
  - -> *(minimal) path* - *(minimal) T-invariant*
- **coarse network structure, what for?**
  - -> *set of T-invariants gets structured*
  - -> *better understanding of the net behaviour*

Ex1 - Glycolysis and Pentose Phosphate Pathway



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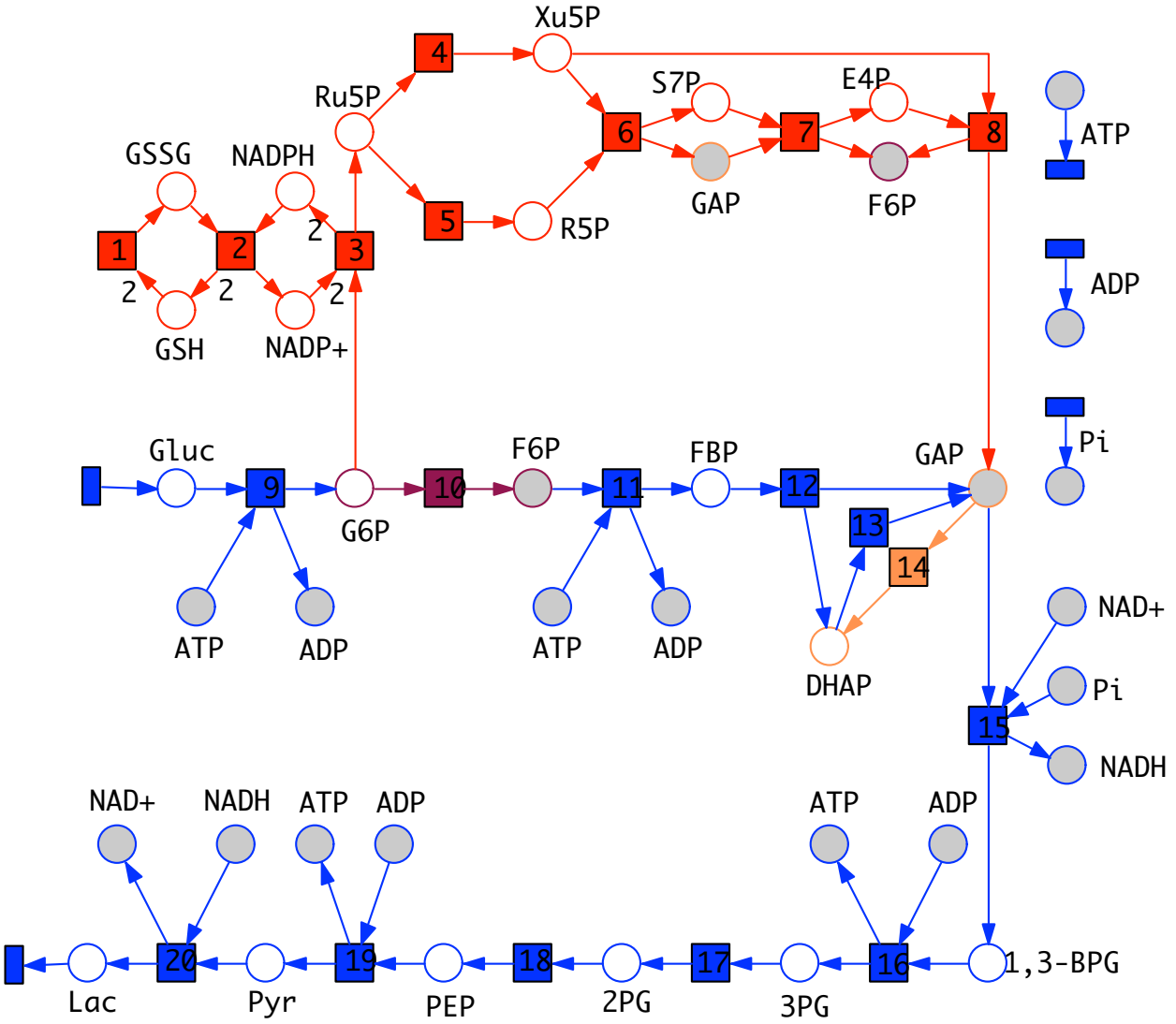

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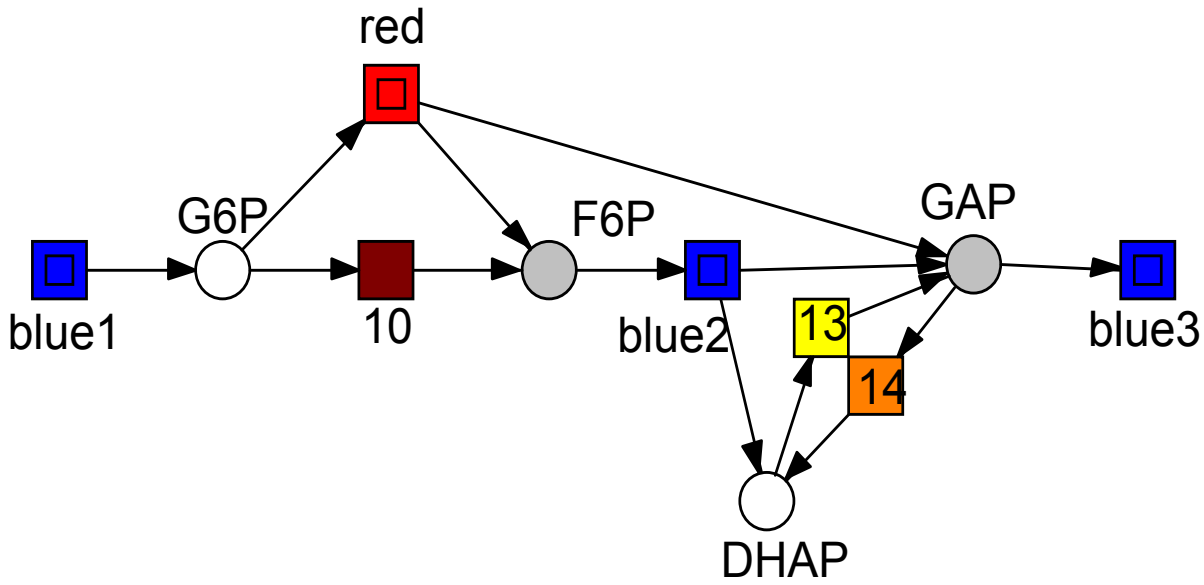

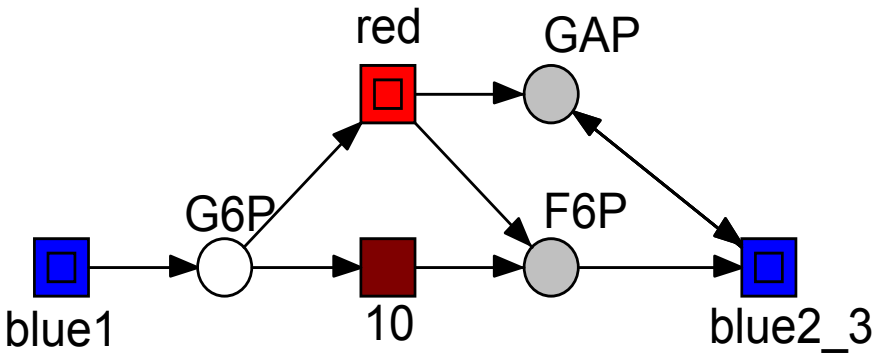

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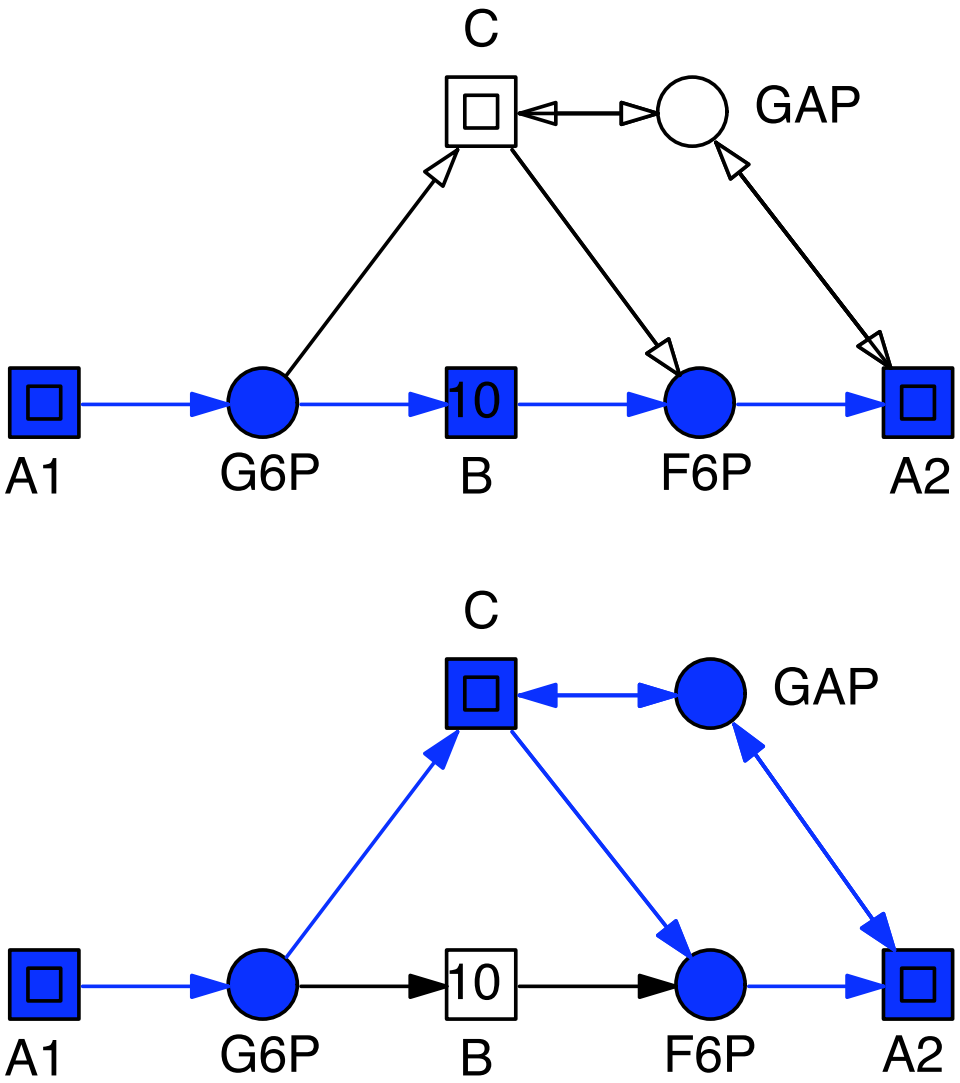
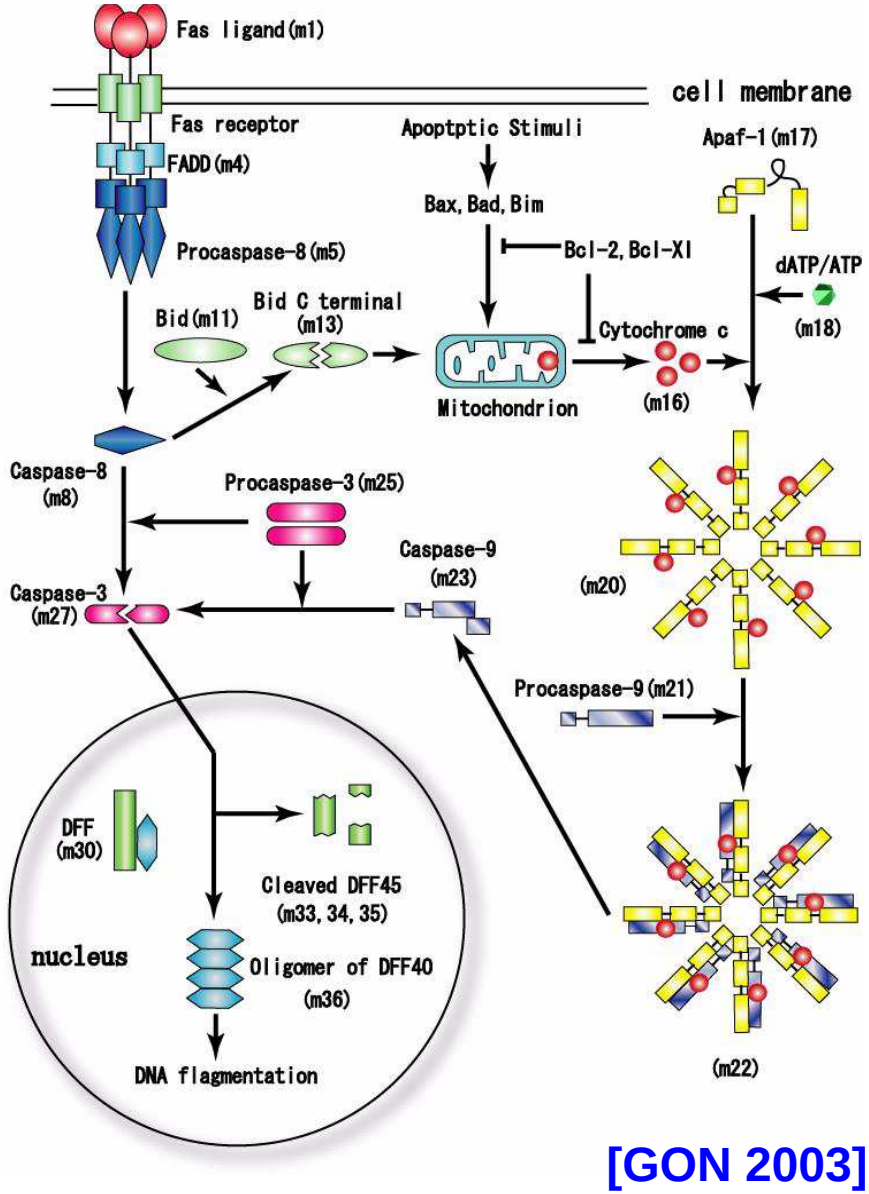


EX2 - APOPTOSIS IN MAMMALIAN CELLS



[GON 2003]

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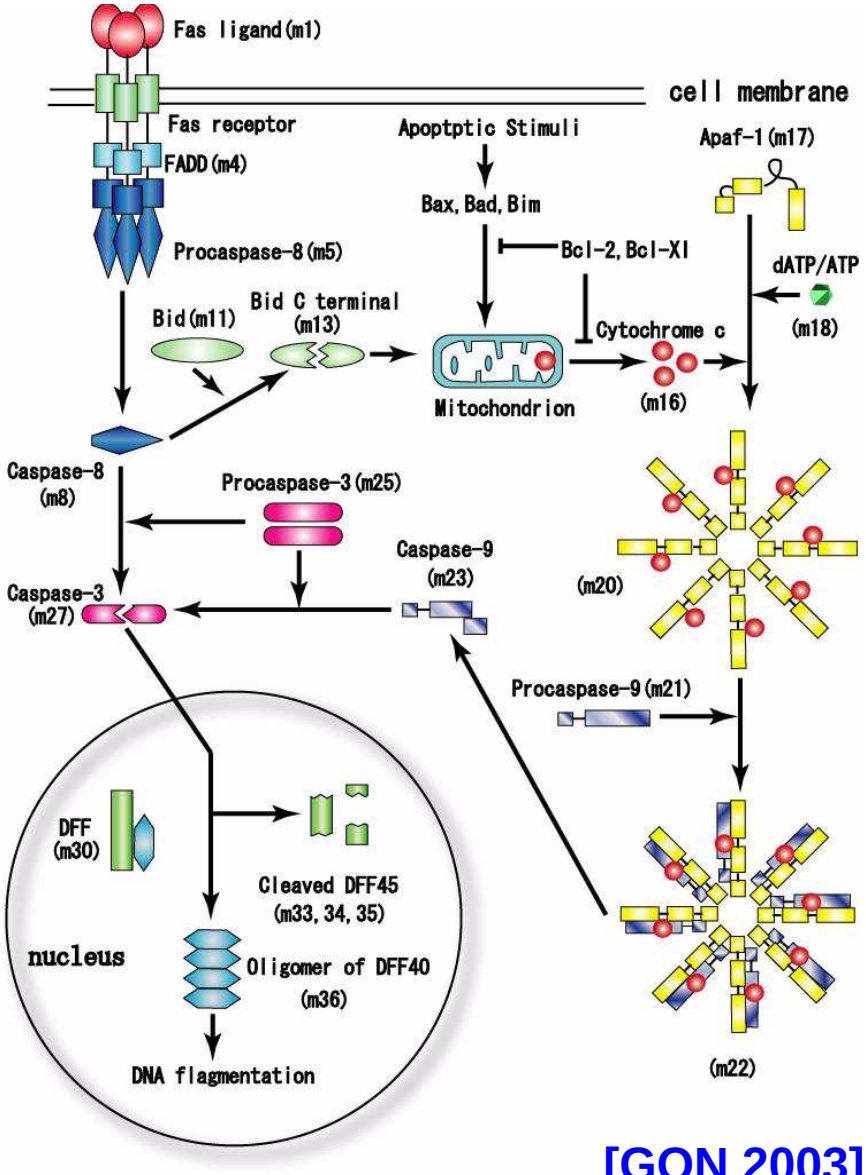
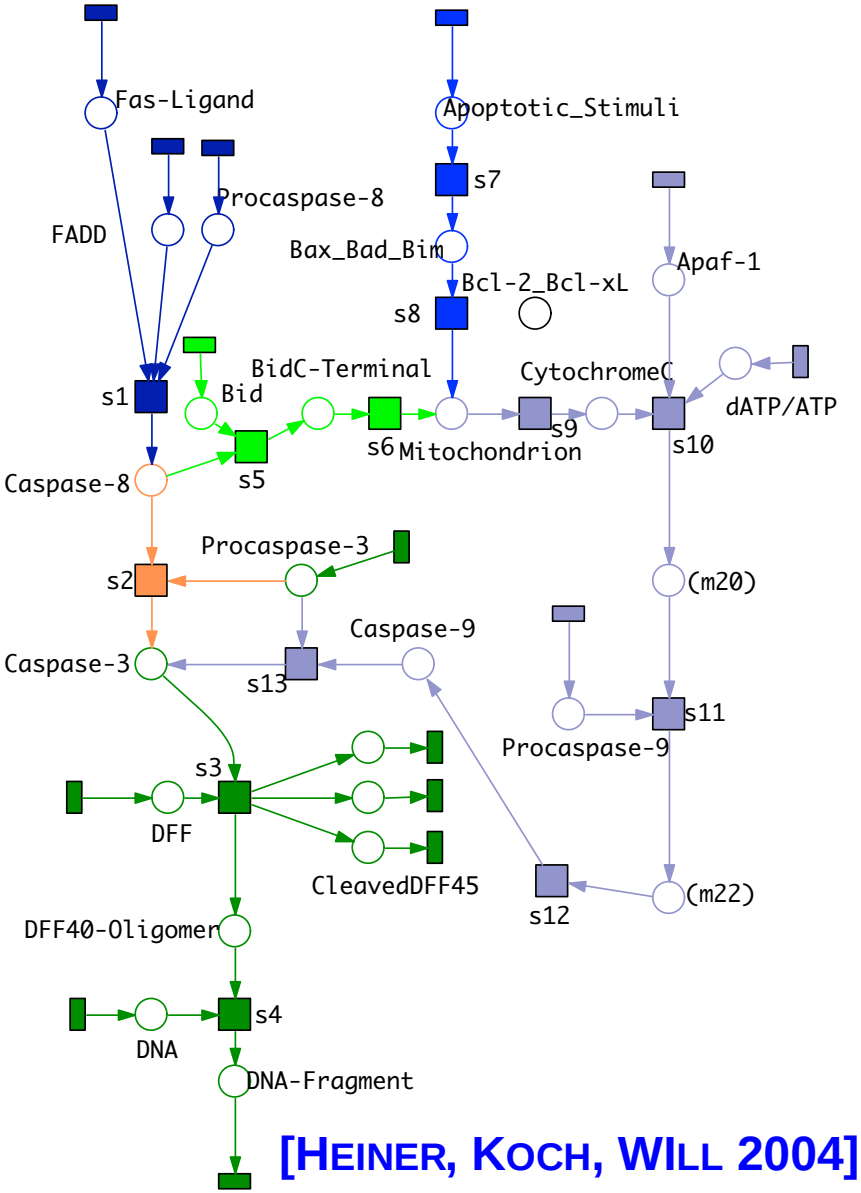


[GON 2003]



[HEINER, KOCH, WILL 2004]

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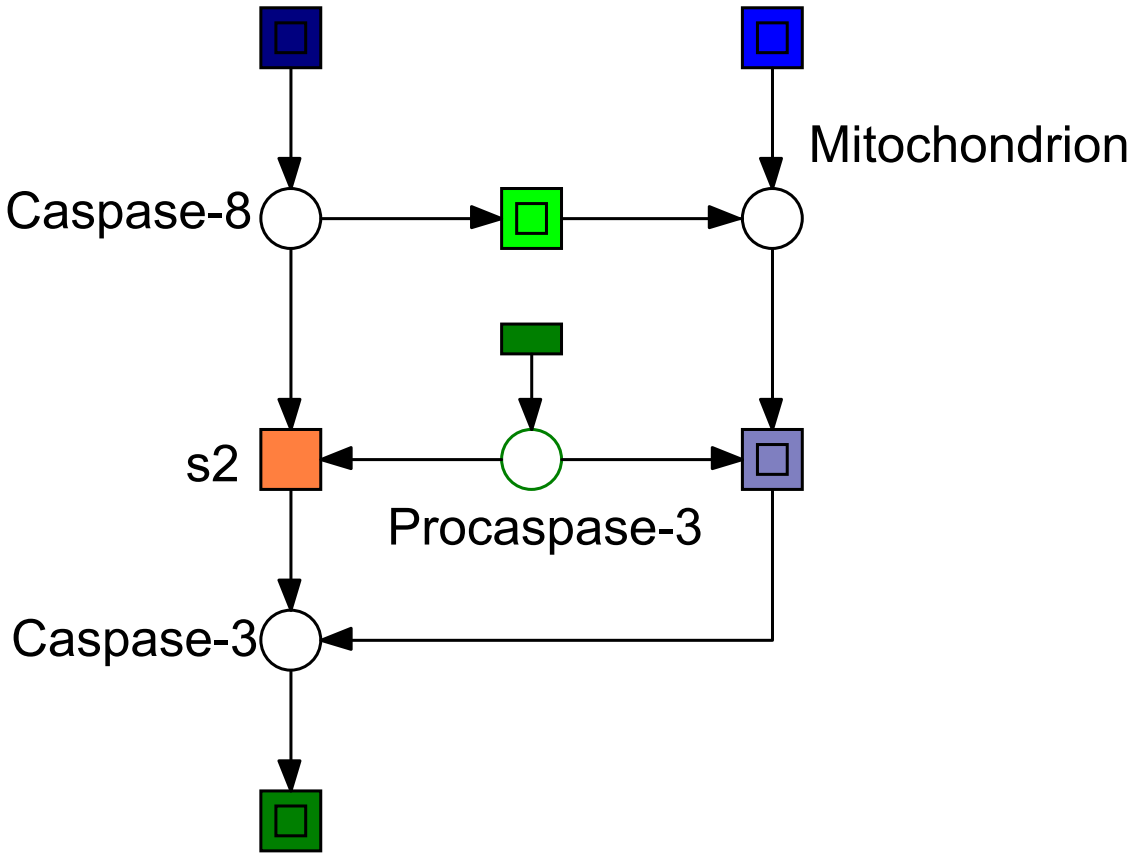

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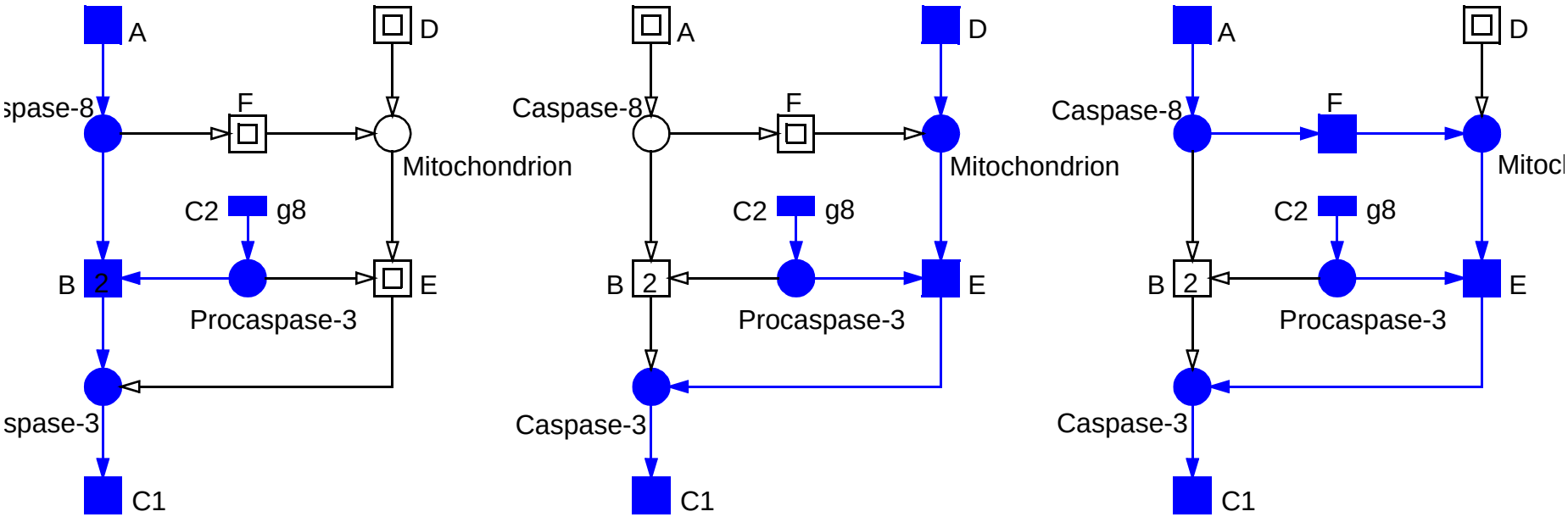

Ex3 - Carbon Metabolism in Potato Tuber

[Koch, Junker, Heiner 2005]

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[Koch, Junker, Heiner 2005]

ADT-sets without trivial T-invariants