Using Inhibitors to Achieve Universality of Sequential P Systems

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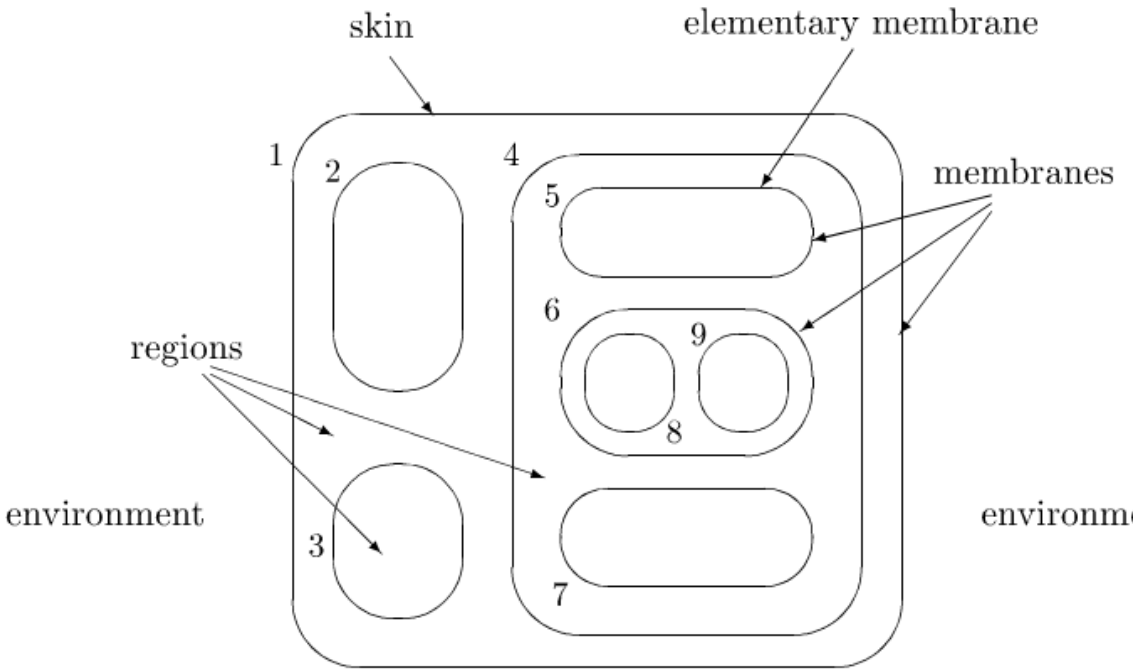
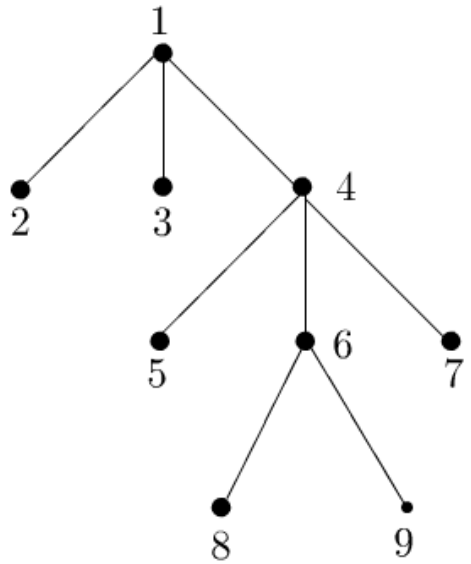
1. Overview of P systems
   - P systems
   - Variants
2. Sequential P systems with inhibitors
   - Accepting case
   - Generating case

Membrane structure





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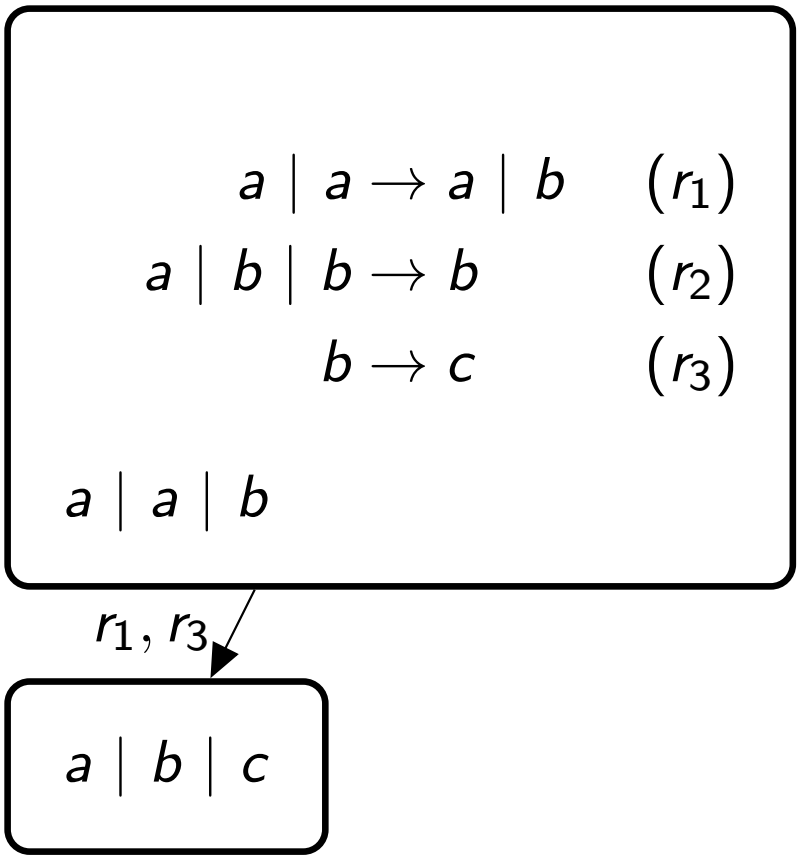

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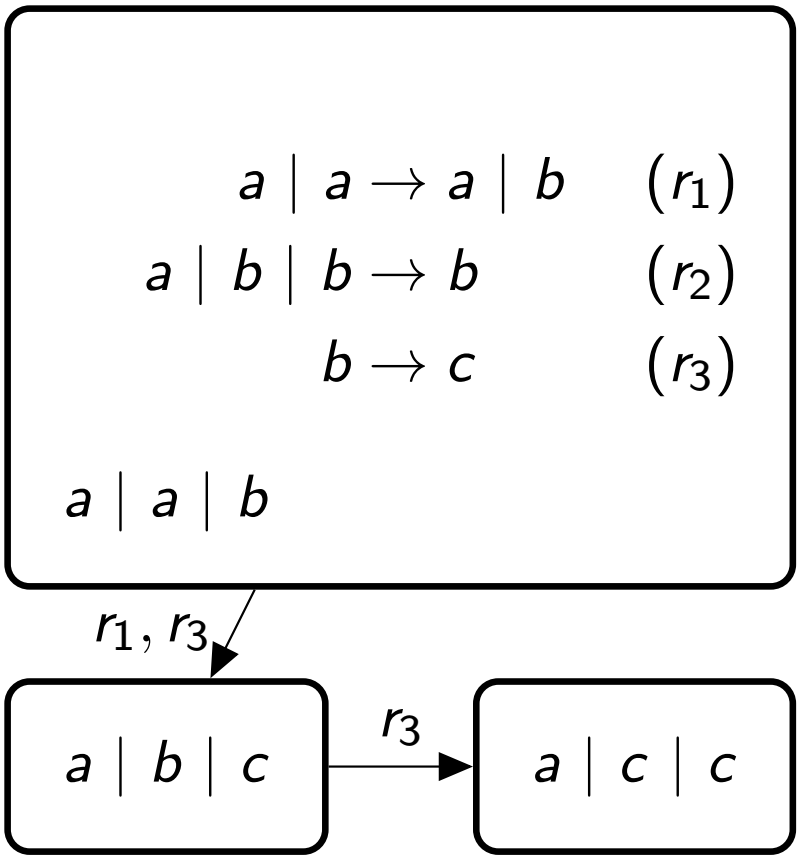

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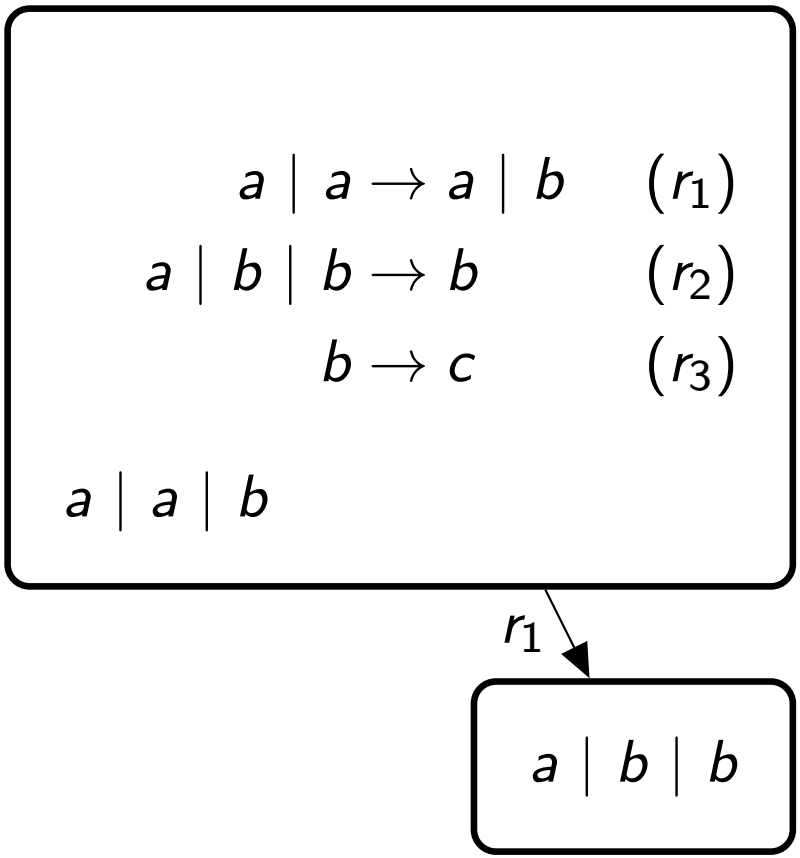

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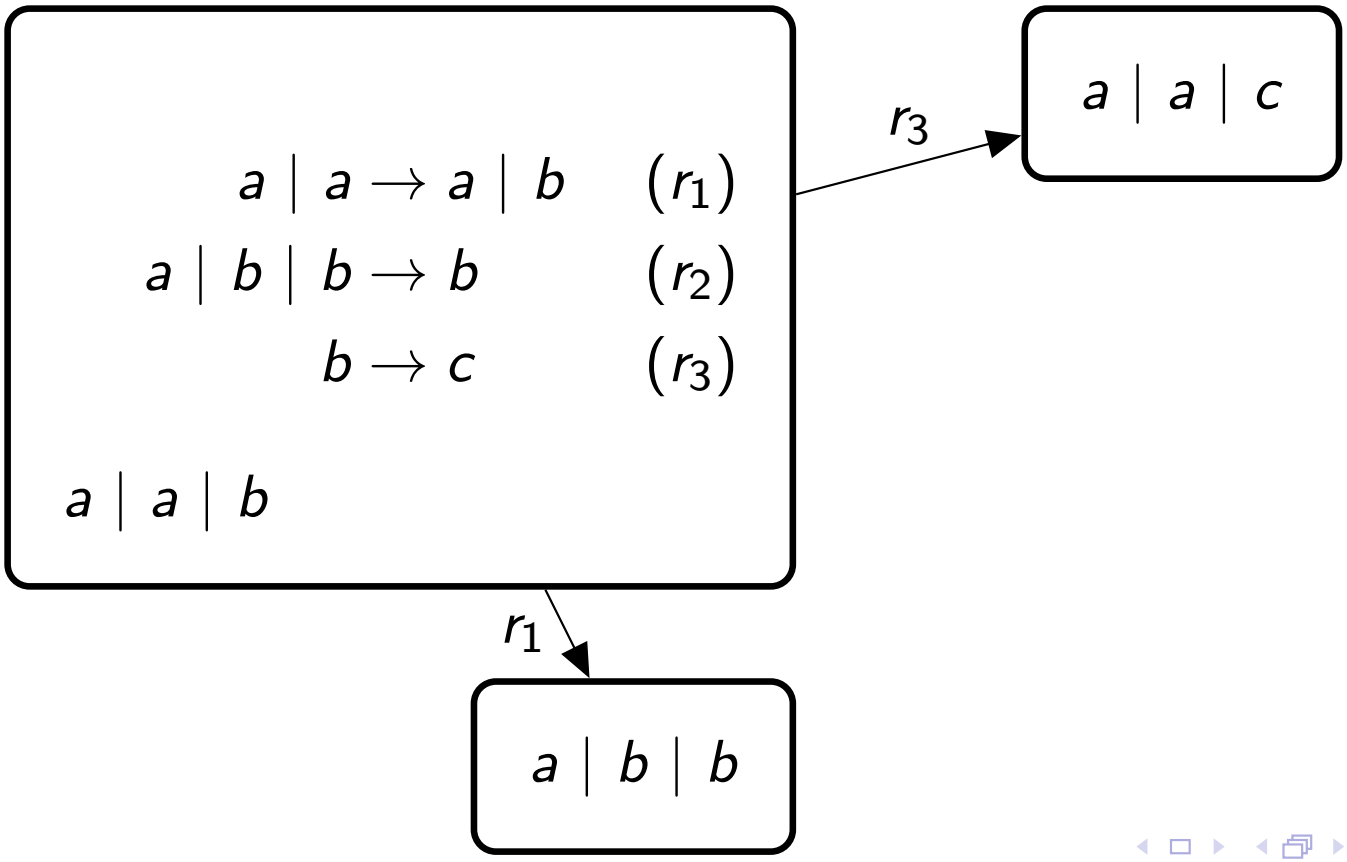

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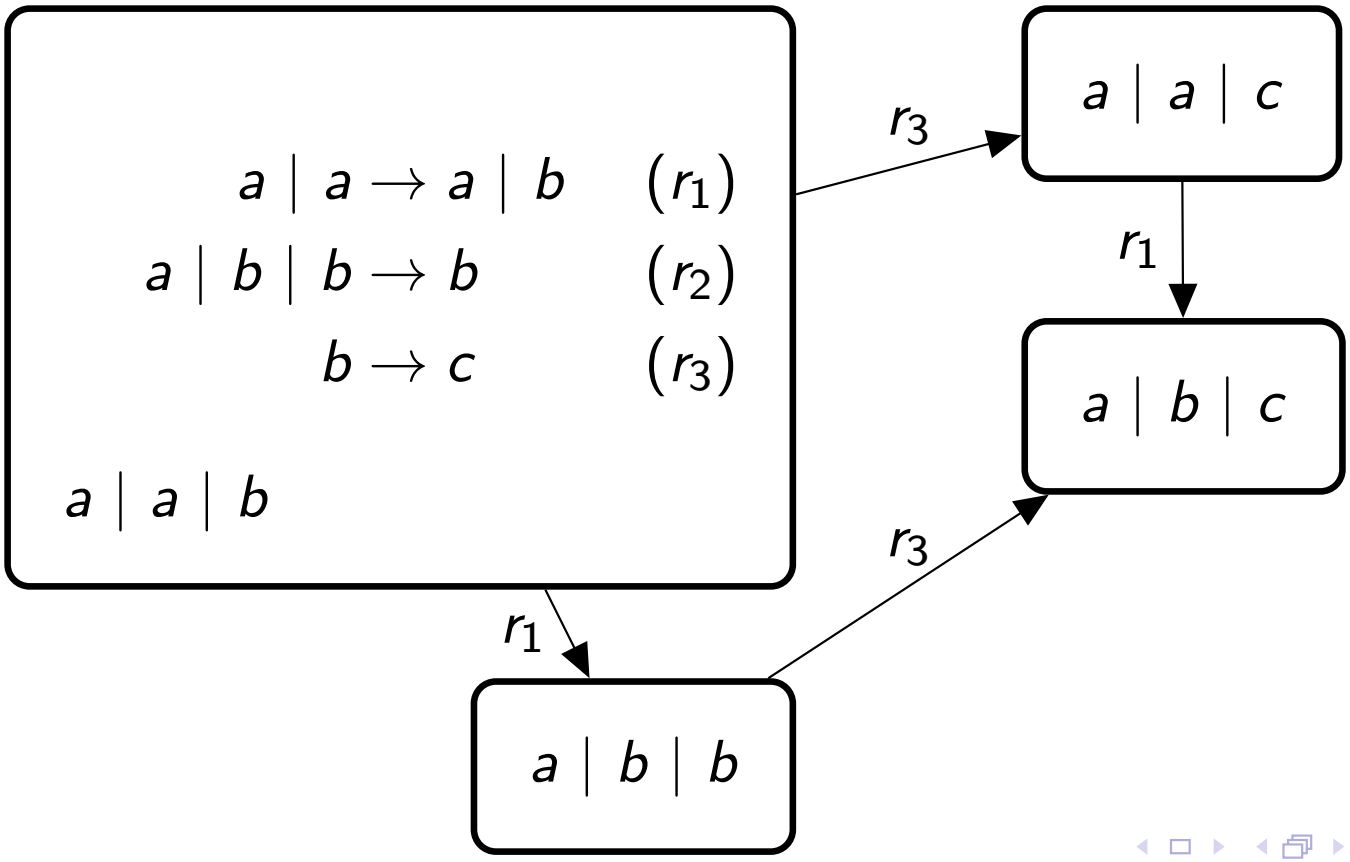

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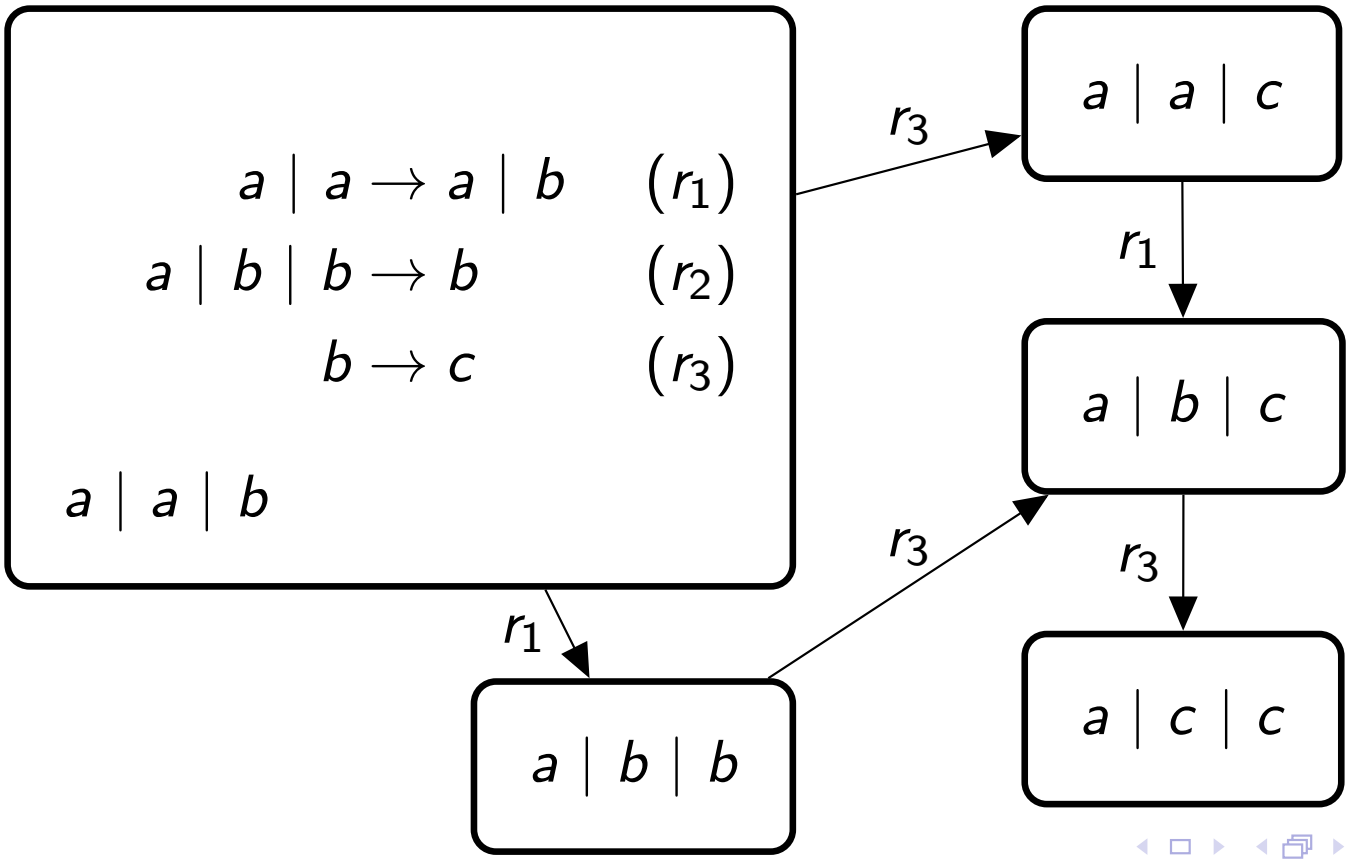

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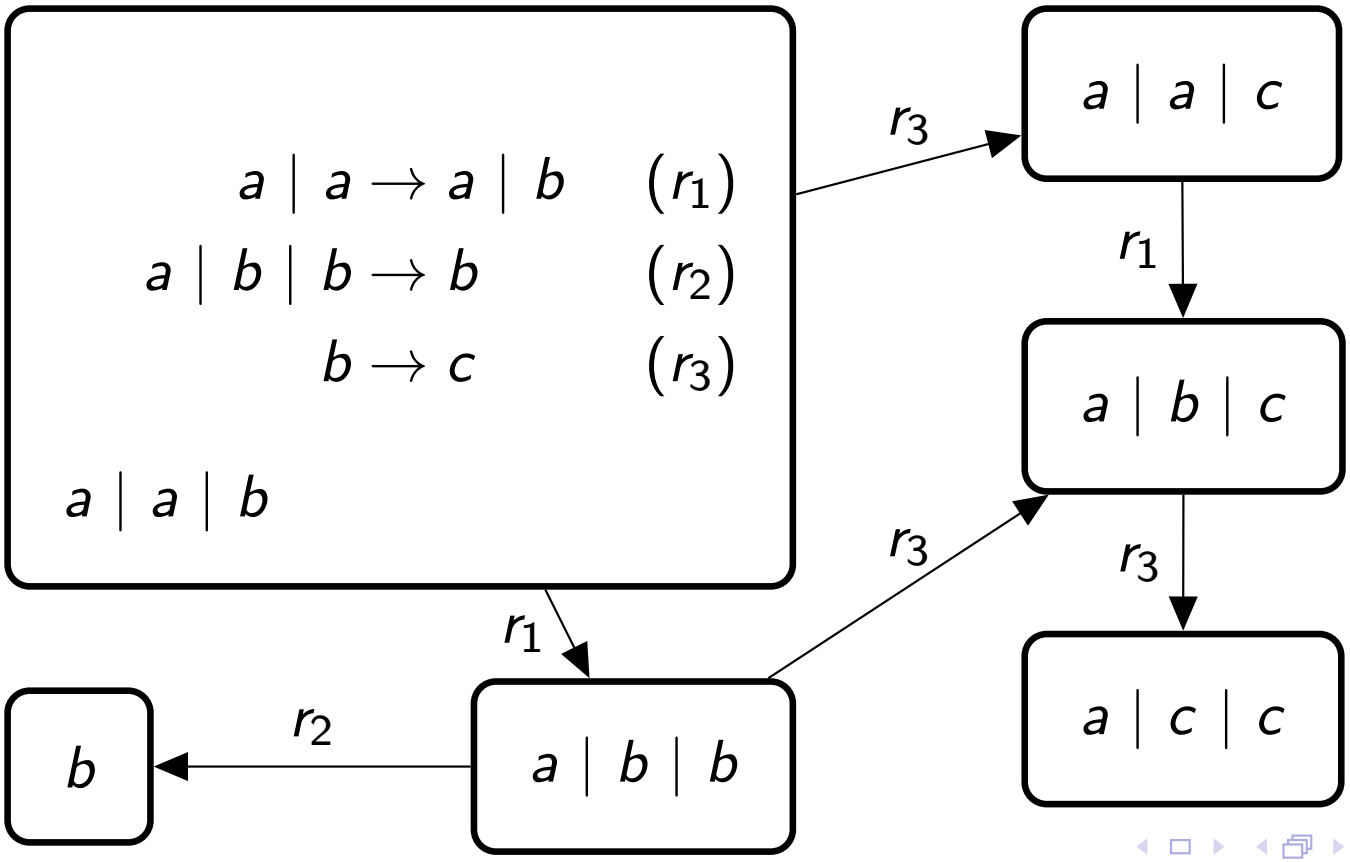

Language of a P system

- The result of the computation is a multiset of objects, which is present in a specific membrane at a halting configuration
- The language generated by a P system is a set of results of all possible conputations.

Variants of rules

- cooperative ($a \mid b \mid b \rightarrow b$) (universal [Păun, 1998])

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- catalytic ($a \mid b \to a \mid c \mid d$)
  - catalytic with 2 catalysts (universal [Freund et al., 2005])
  - with 1 catalyst (open problem)
  - with 1 catalyst and inhibitors (universal [Ionescu and Sburlan, 2004])

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- are equal to VASS $\Rightarrow$ not universal [Ibarra et al., 2005]
- with priorities are universal [Ibarra et al., 2005]
- with unbounded membrane creation are universal [Ibarra et al., 2005]

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- with unbounded membrane creation are universal [Ibarra et al., 2005]
- **with inhibitors [Kováč, 2014]**

Overview of the simulation for the accepting case

- Simulation of a register machine
- Contents of register j is represented by the multiplicity of the object a_j
- SUB instruction is simulated by inhibitors

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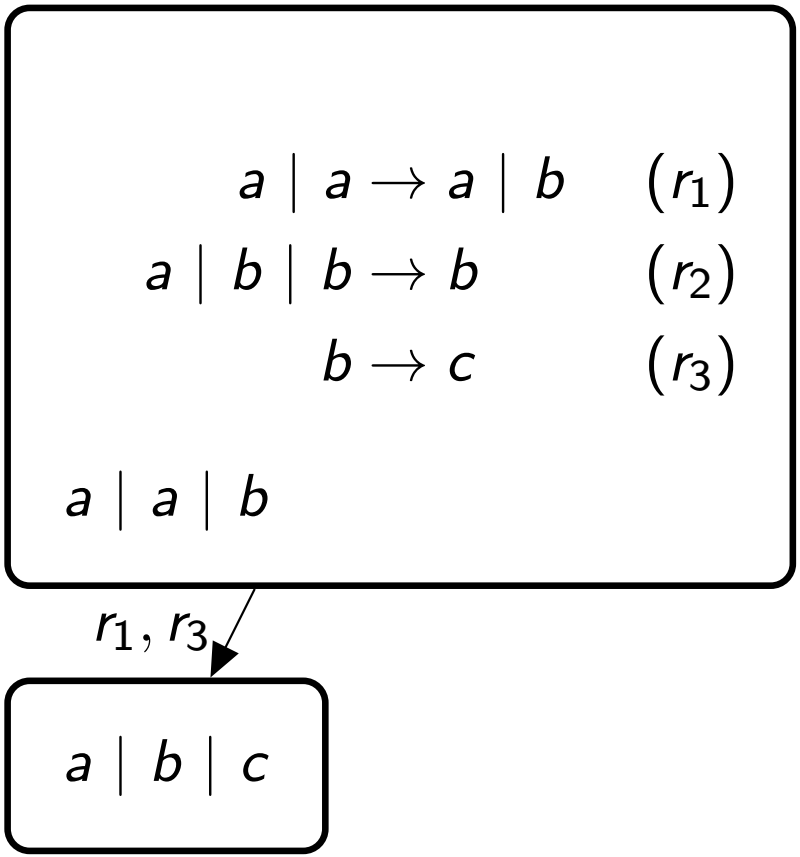

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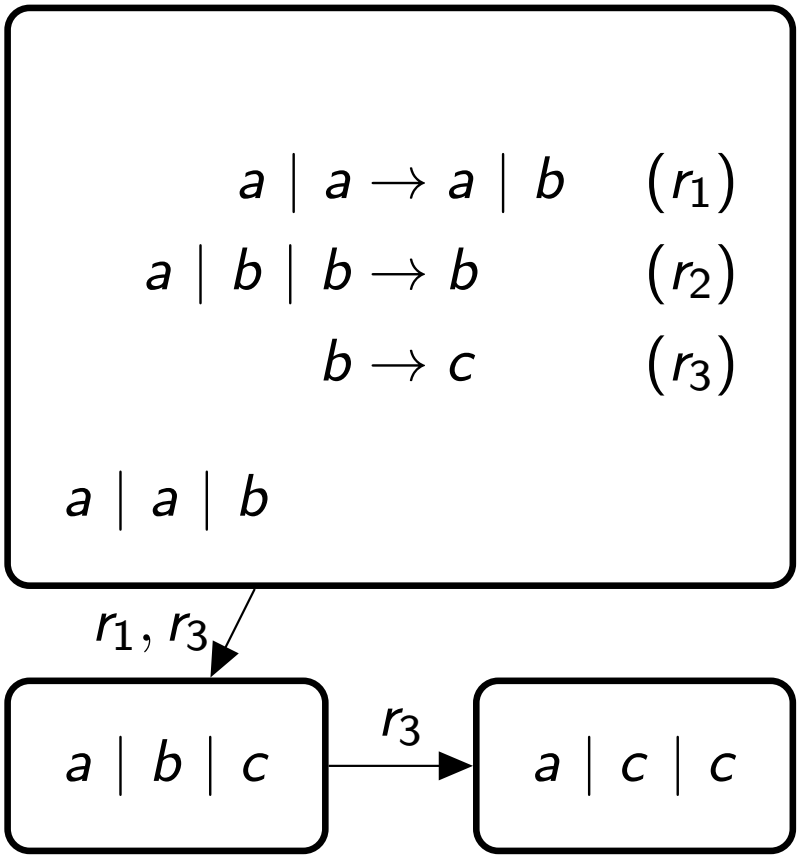

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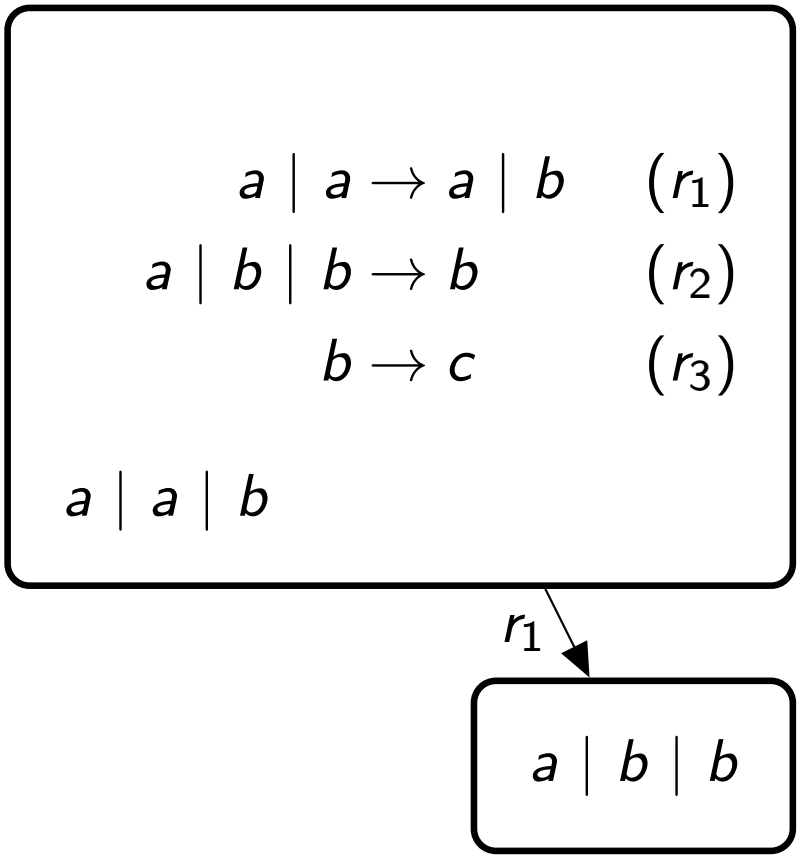

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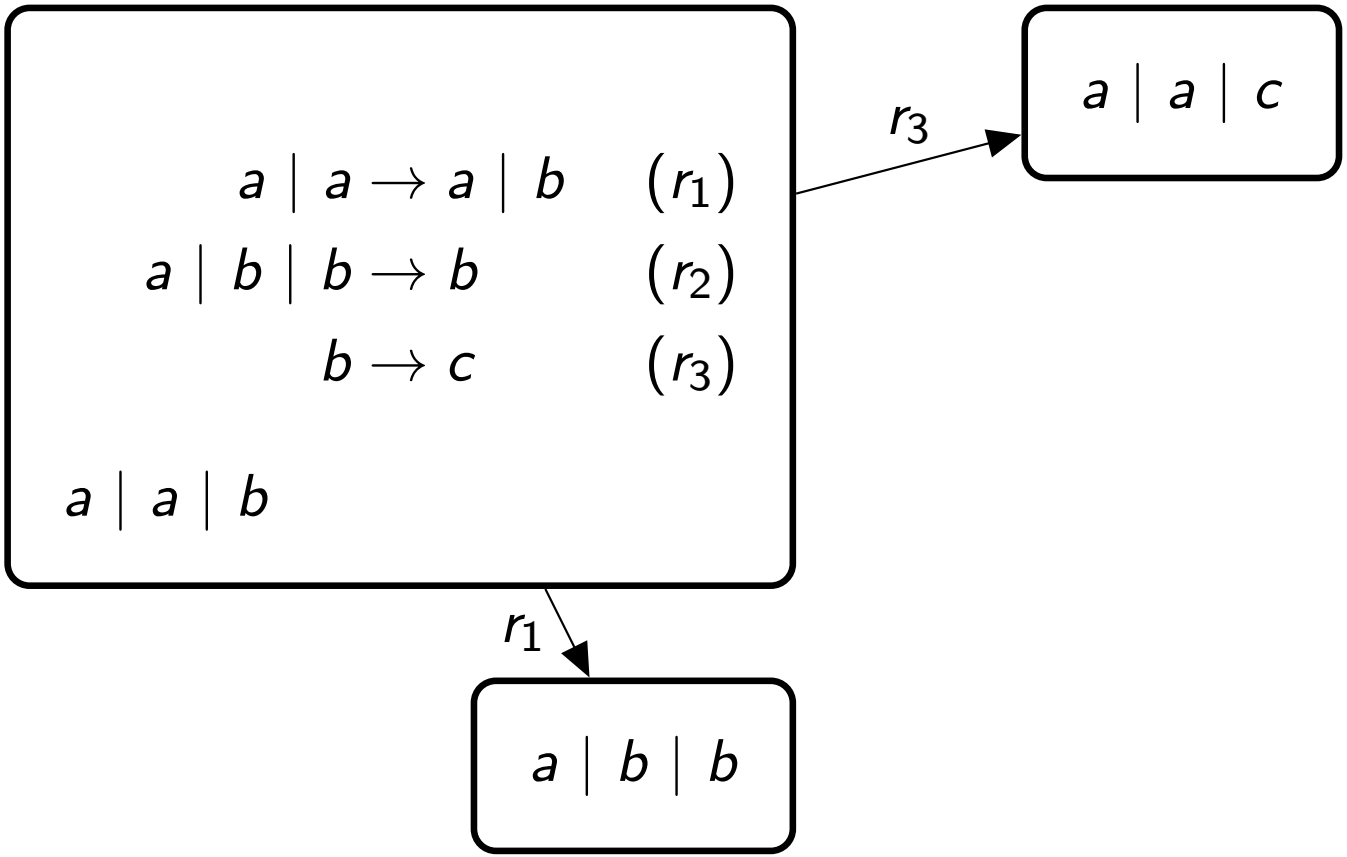

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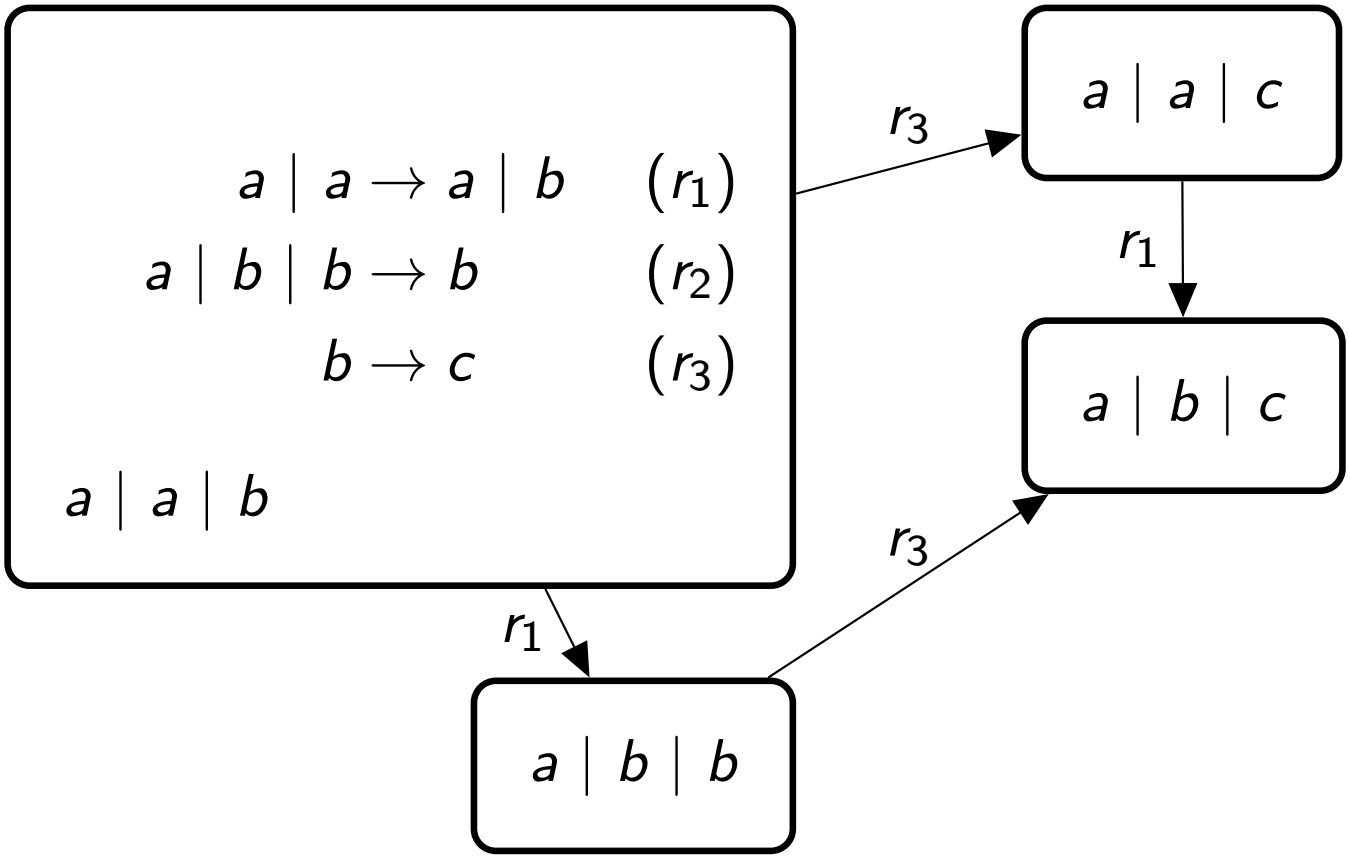

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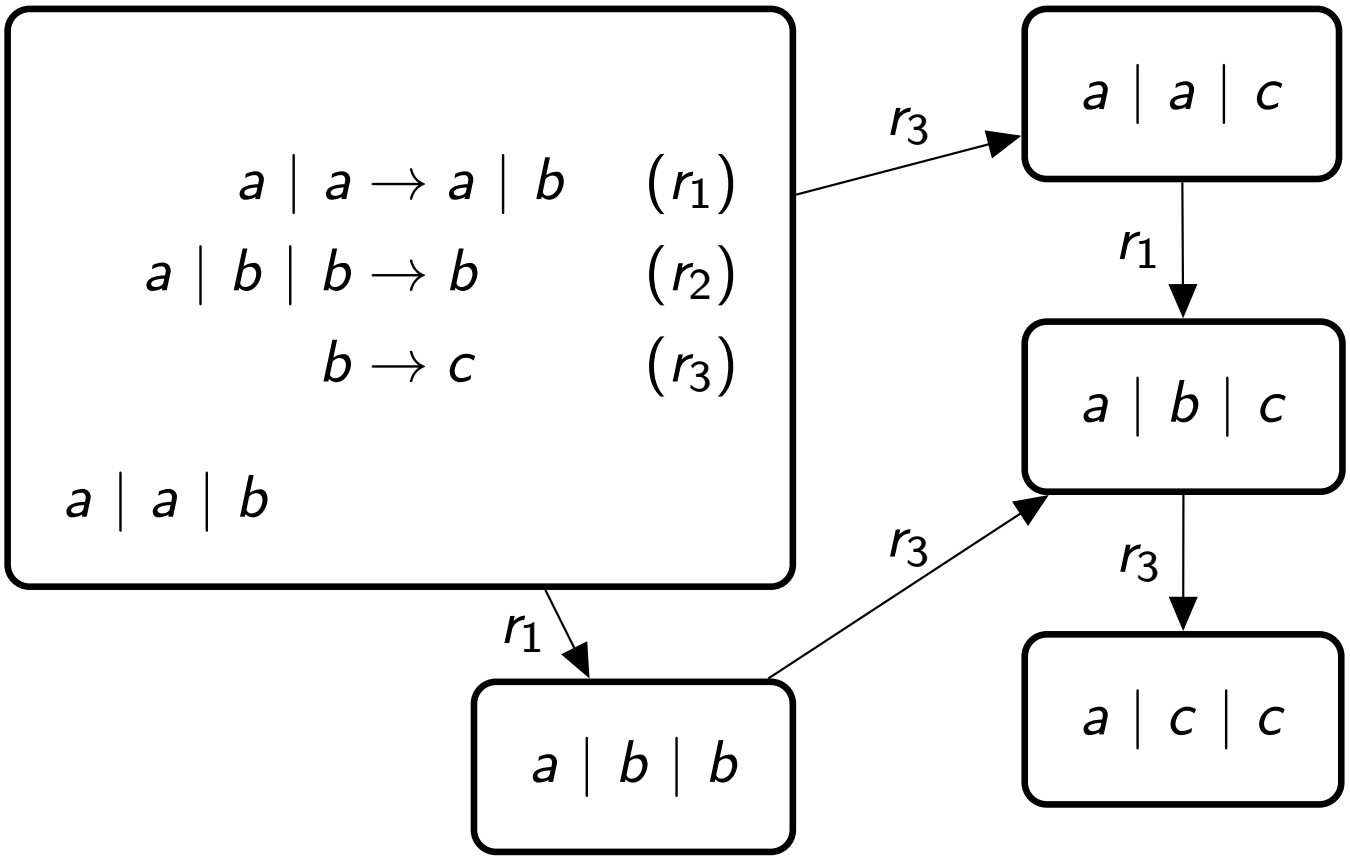

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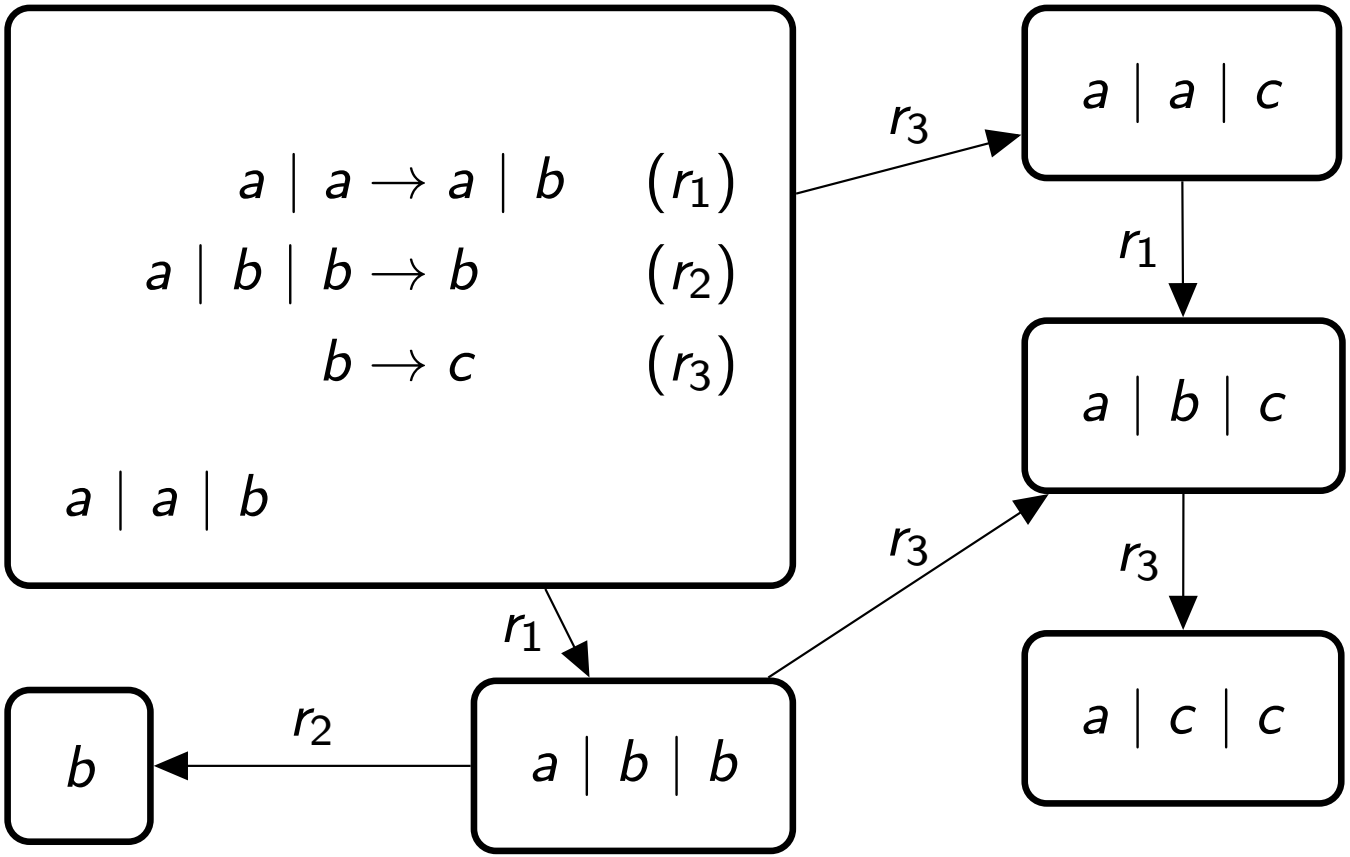

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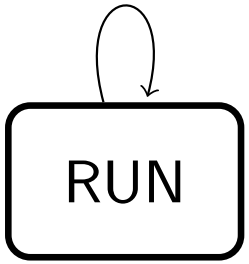
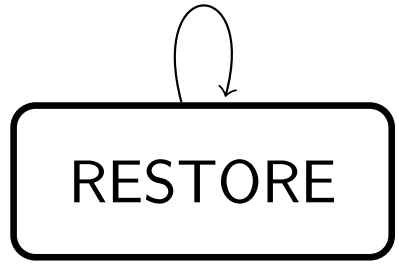
- $RESTORE \mid a' \rightarrow RESTORE \mid a$
- $RESTORE \mid b' \rightarrow RESTORE \mid b$
- $RESTORE \mid c' \rightarrow RESTORE \mid c$

Switching the phases

applying rules



restoring objects



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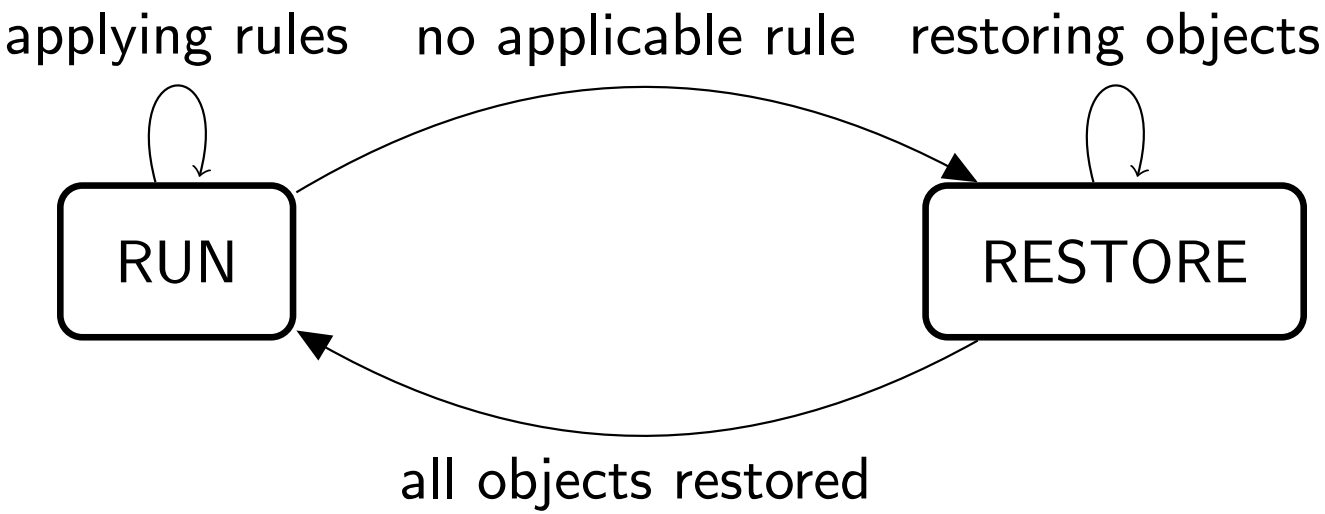

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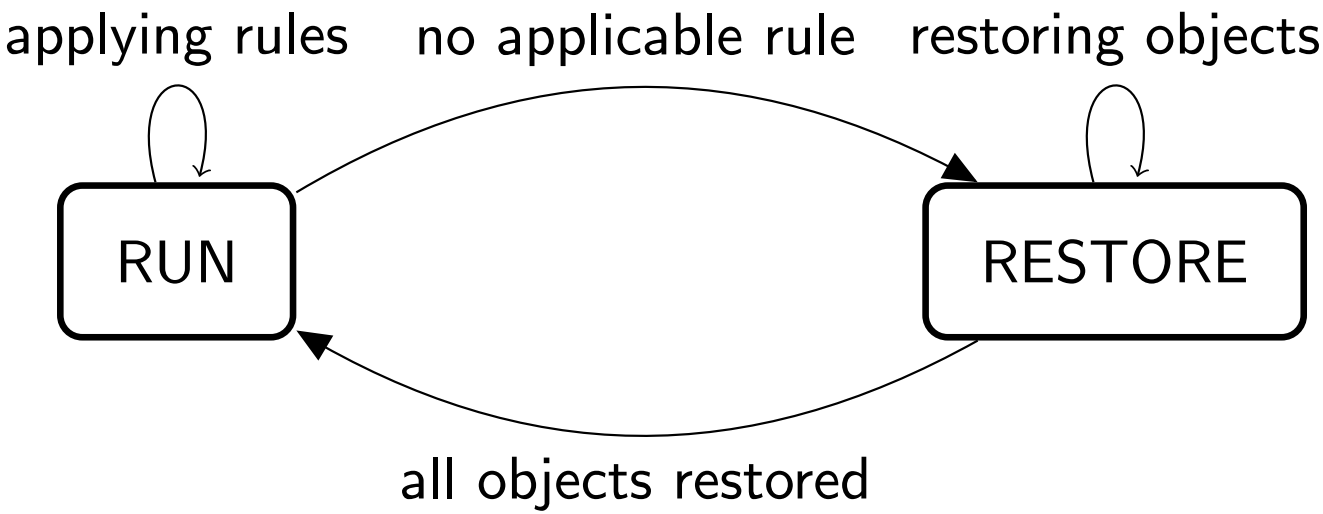

- $RUN \mid UNUSABLE_1 \mid UNUSABLE_2 \mid UNUSABLE_3 \rightarrow RESTORE$

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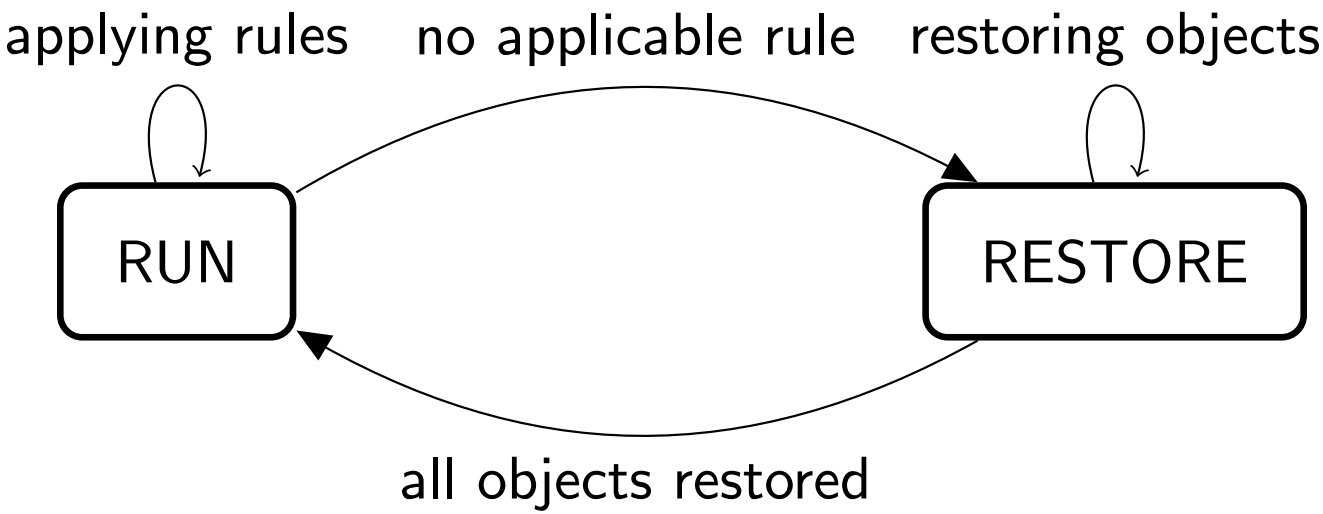

- $RUN \mid UNUSABLE_1 \mid UNUSABLE_2 \mid UNUSABLE_3 \rightarrow RESTORE$
- $RESTORE \rightarrow RUN \mid_{\neg a' b' c'}$

Creating UNUSABLE objects (simple case)

- $(3) : b \rightarrow c$
- $RUN \rightarrow RUN \mid UNUSABLE_3 \mid_{\neg b, UNUSABLE_3}$

Creating UNUSABLE objects (complicated case)

- $(1) : a \mid a \rightarrow a \mid b$
- $RUN \rightarrow RUN \mid UNUSABLE_1 \mid_{\neg a, UNUSABLE_1}$
- Wrong for exactly 1 occurence of a

Promoting objects

- $RUN \mid a \rightarrow RUN \mid \dot{a} \mid_{\neg \dot{a}}$
- $RUN \mid b \rightarrow RUN \mid \dot{b} \mid_{\neg \dot{b}}$
- $RUN \mid c \rightarrow RUN \mid \dot{c} \mid_{\neg \dot{c}}$
- At most 1 object can be promoted.

Using promoted objects

- $RUN \mid a \mid \dot{a} \rightarrow a' \mid b'$
- $RUN \mid \dot{a} \mid b \mid b \rightarrow b'$
- $RUN \mid \dot{a} \mid \dot{b} \mid b \rightarrow b'$
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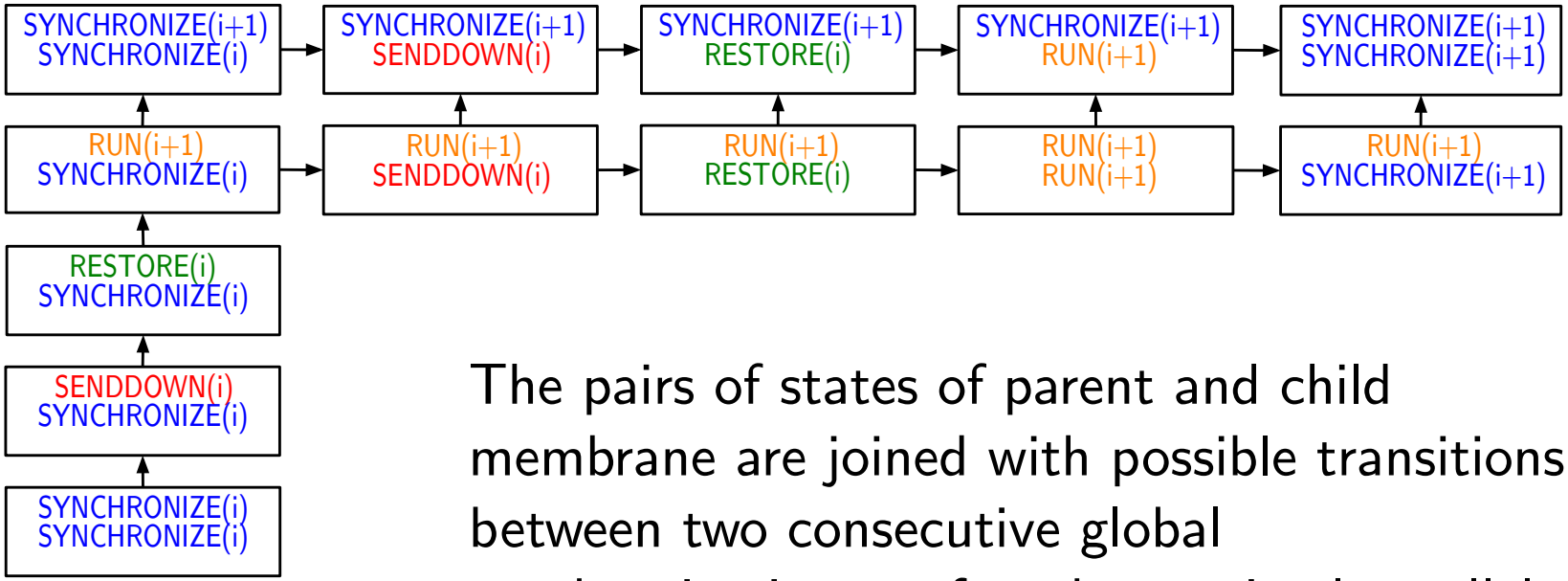
- $RUN \mid a \mid \dot{b} \mid b \rightarrow b'$
- $RUN \mid \dot{b} \rightarrow c'$
- $RUN \rightarrow RUN \mid UNUSABLE_3 \mid_{\neg b, \dot{b}, UNUSABLE_3}$
- $RUN \rightarrow RUN \mid UNUSABLE_1 \mid_{\neg a, UNUSABLE_1}$

Multiple different objects on the left side

- $(2) : a \mid b \mid b \rightarrow b$
- $RUN \rightarrow RUN \mid UNUSABLE_2 \mid_{\neg a, \dot{a}, UNUSABLE_2}$
- $RUN \rightarrow RUN \mid UNUSABLE_2 \mid_{\neg b, UNUSABLE_2}$

Thanks for your attention!

Parent and child membrane phases



The pairs of states of parent and child membrane are joined with possible transitions between two consecutive global synchronizations - after the maximal parallel steps i and i+1

Obr. : Possible pairs of states of parent and child membrane

Snapshot of all membrane states