Reachability for Dynamic Parametric Processes

Helmut Seidl, Anca Muscholl, Igor Walukiewicz

TU München, U. Bordeaux

Dagstuhl, Nov. 25, 2016

Reachability for Dynamic Parametric Processes w/o Weak Memory

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Dynamic Process

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root()  {
        spawn(p);
                switch (x) {
                  case 2 :   result = #;
                }
}
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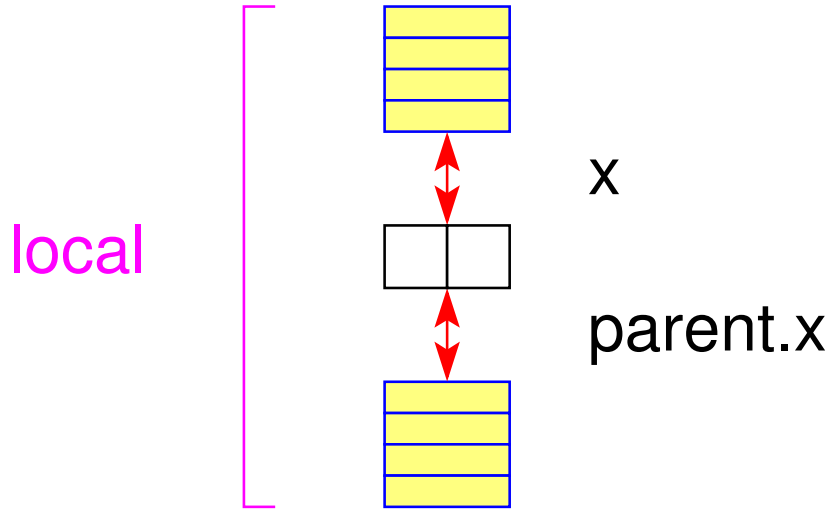
- access to data

Data Access



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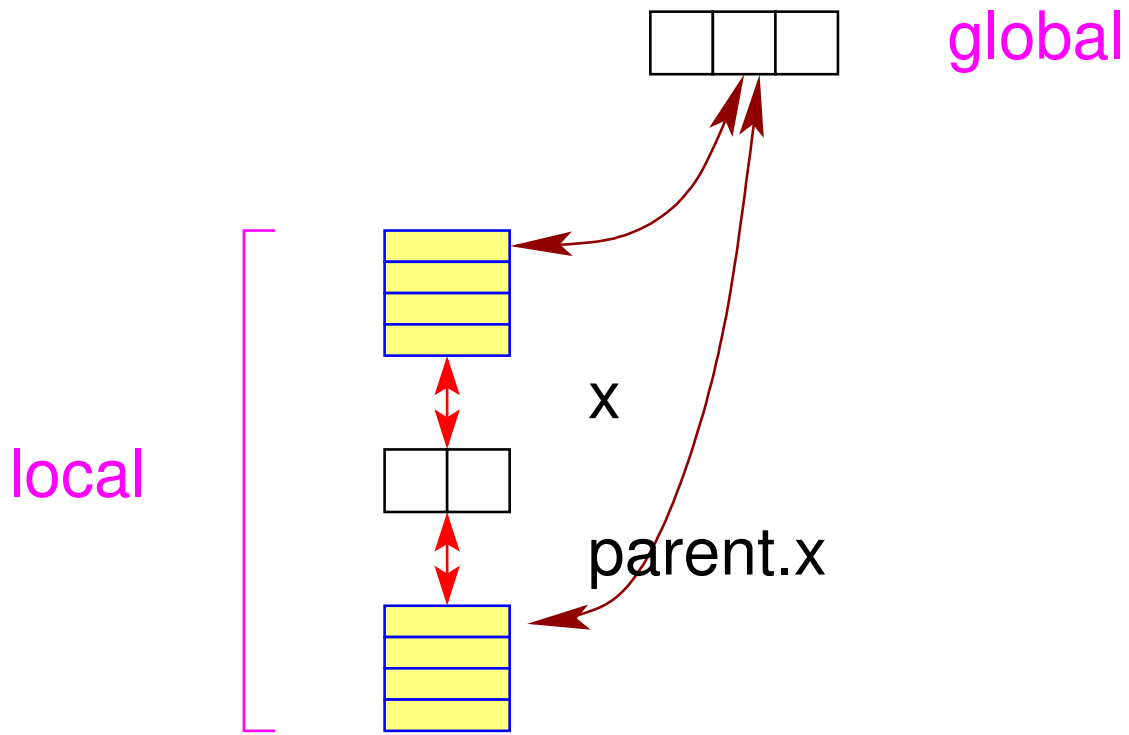

Dynamic Process (cont.)

```
p()  {
     switch (parent.x) {
      case 0 :  spawn(p);
                if (*)  parent.x = 1
                else switch (x) {
                       case 1 :  parent.x = 1; break;
                       case 2 :  break;
                     }
                break;
      case 1 :  spawn(p);
                if (*)  parent.x = 0
                else switch (x) {
                       case 1 :  parent.x = 2; break;
                       case 2 :  parent.x = 2; break;
                     }
     }
}
```

Bad News

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- arbitrary locking — Kahlon et al. 2005

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Restricting locking disciplines helps! Kahlon et al. 2005

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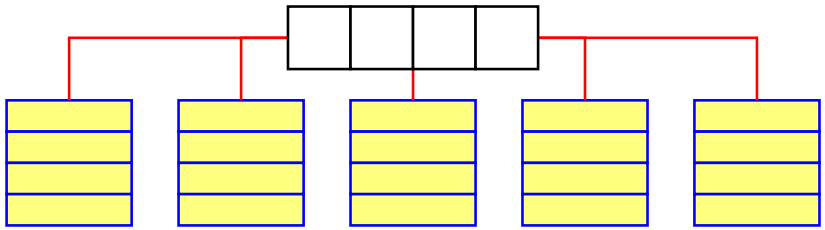

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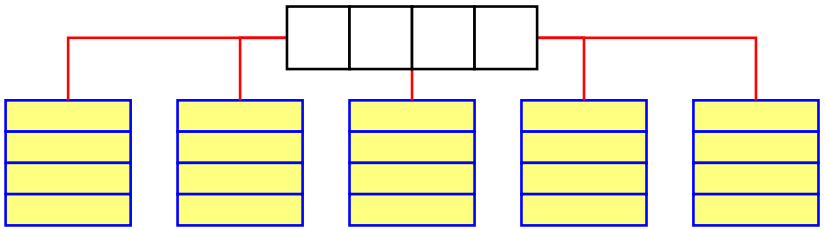
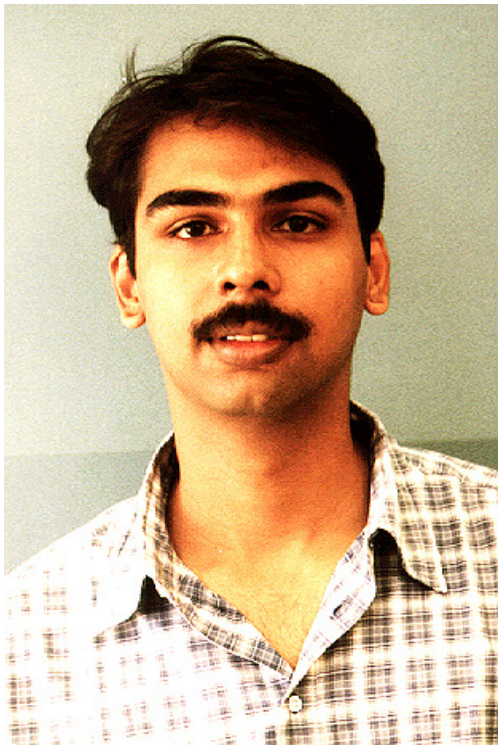
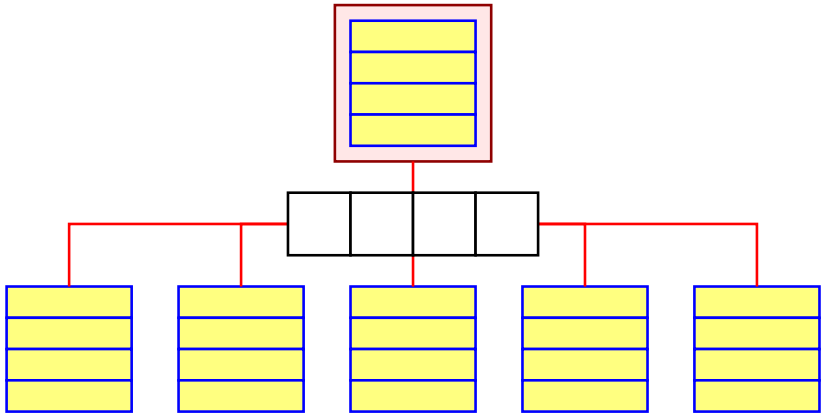




More Good News

Parametric contributors + one master

Hague 2011
Esparza et al. 2015



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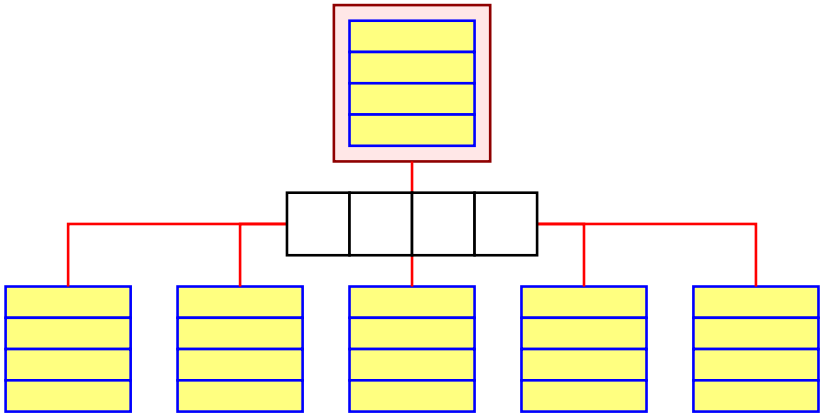

Dynamic Processes

no data, no locking

Bouajjani et al. 2005

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Our Model of Processes

- recursion
- dynamic parametric creation of child processes
- asynchronous execution (no test-and-set)

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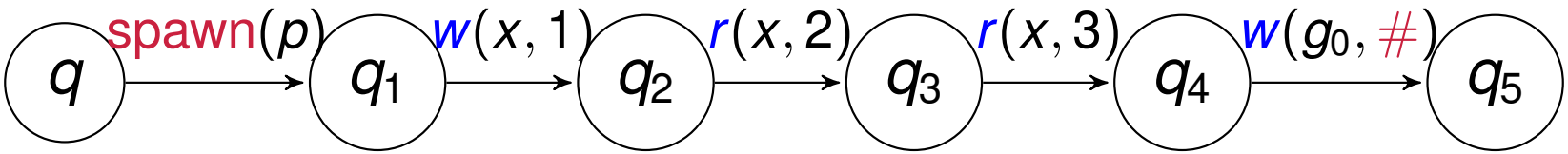
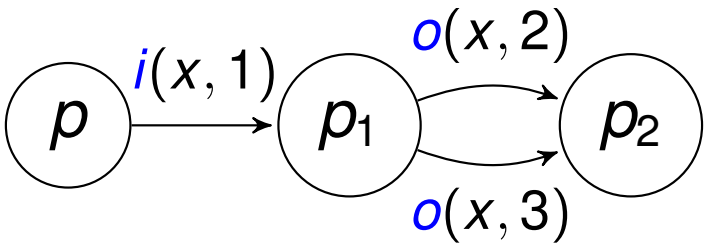
Dynamic parametric processes

Dynamic Process





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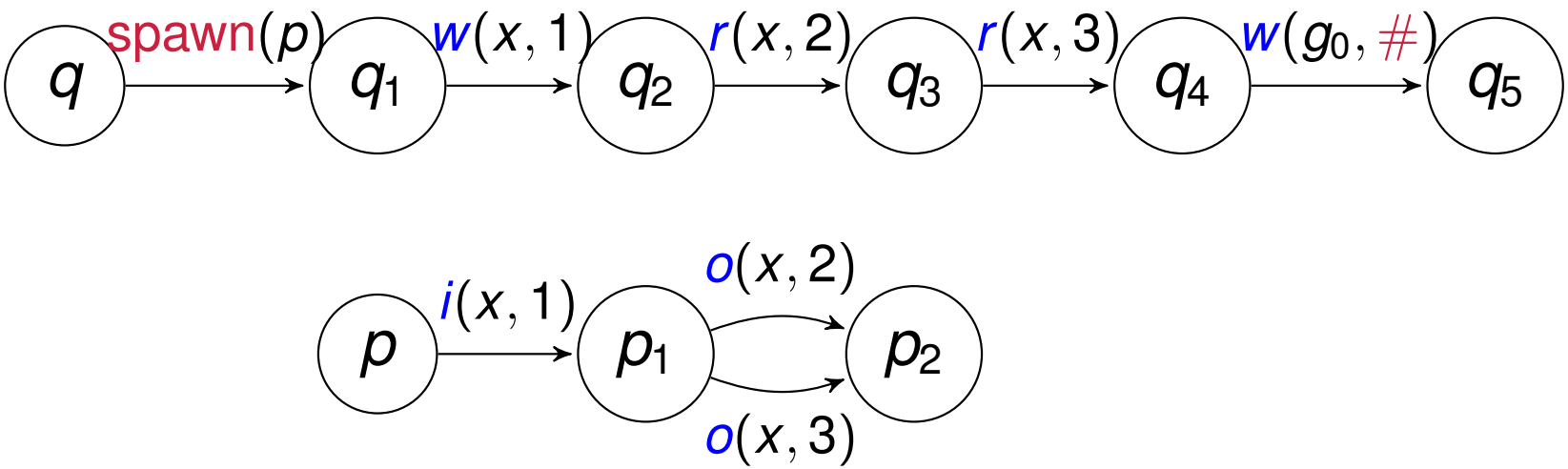

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- r, w access own variable x;
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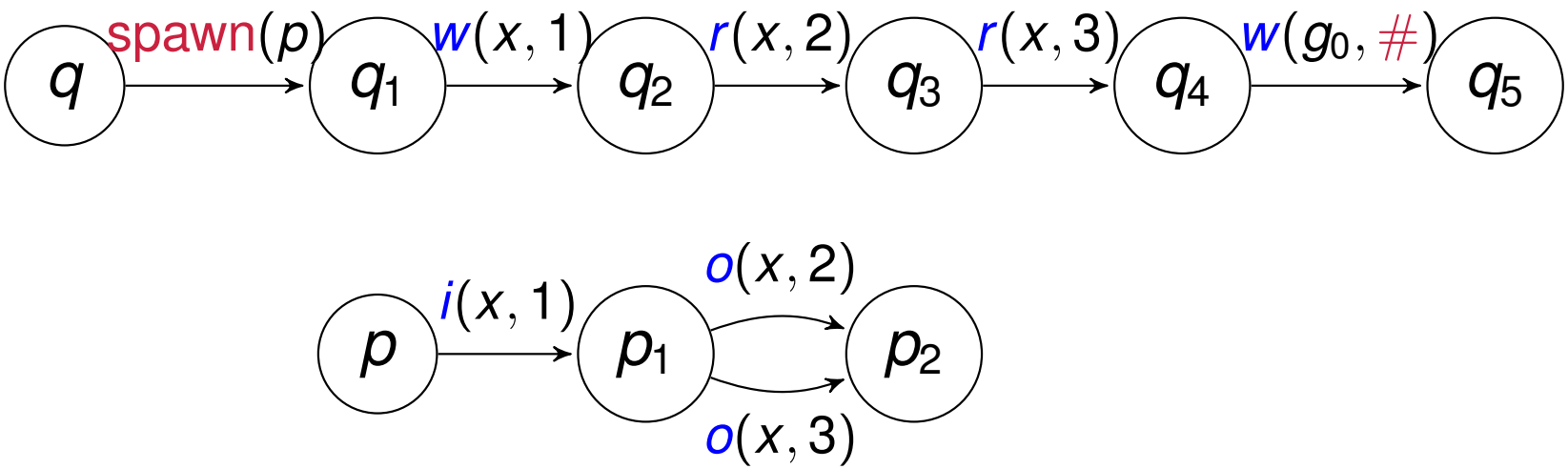

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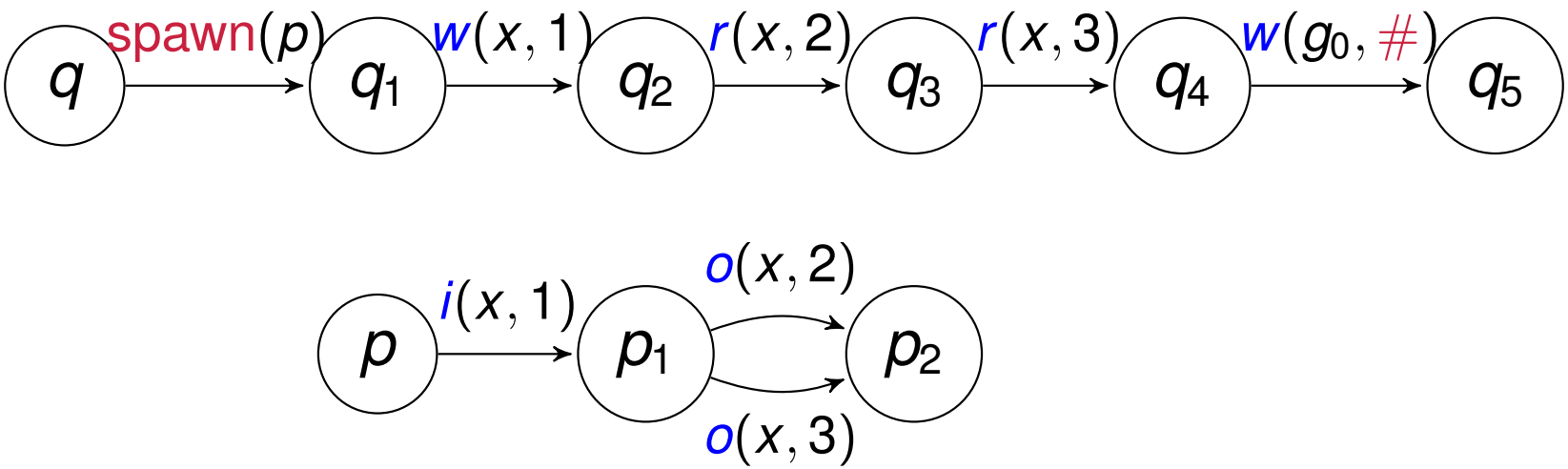

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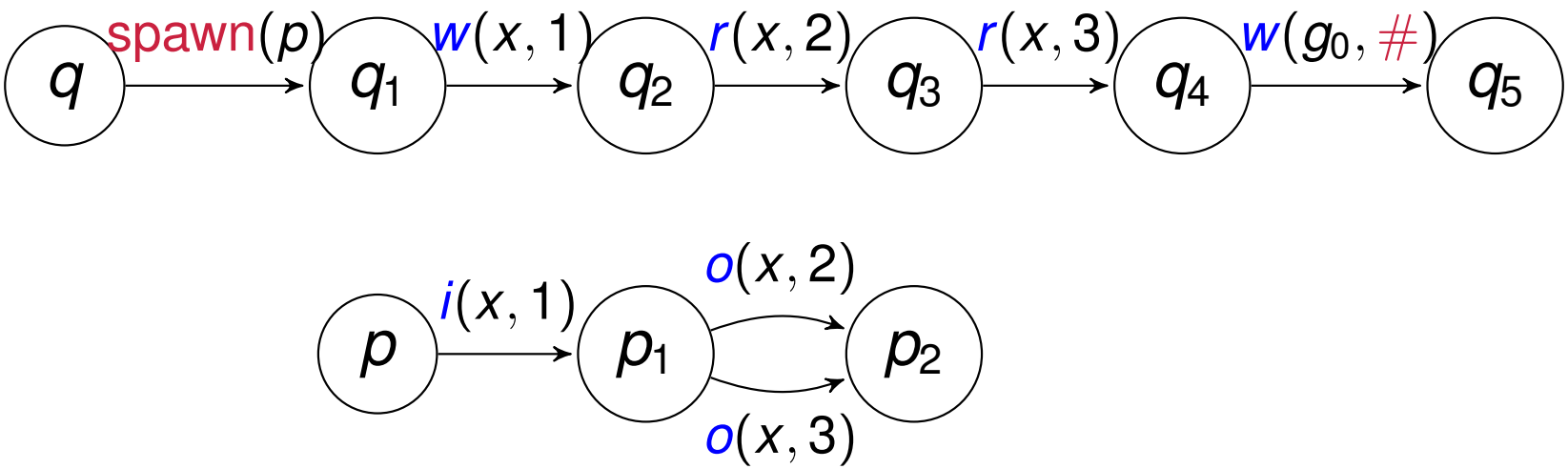
Reachability: may # ever be written? **No**

Dynamic Parametric Process



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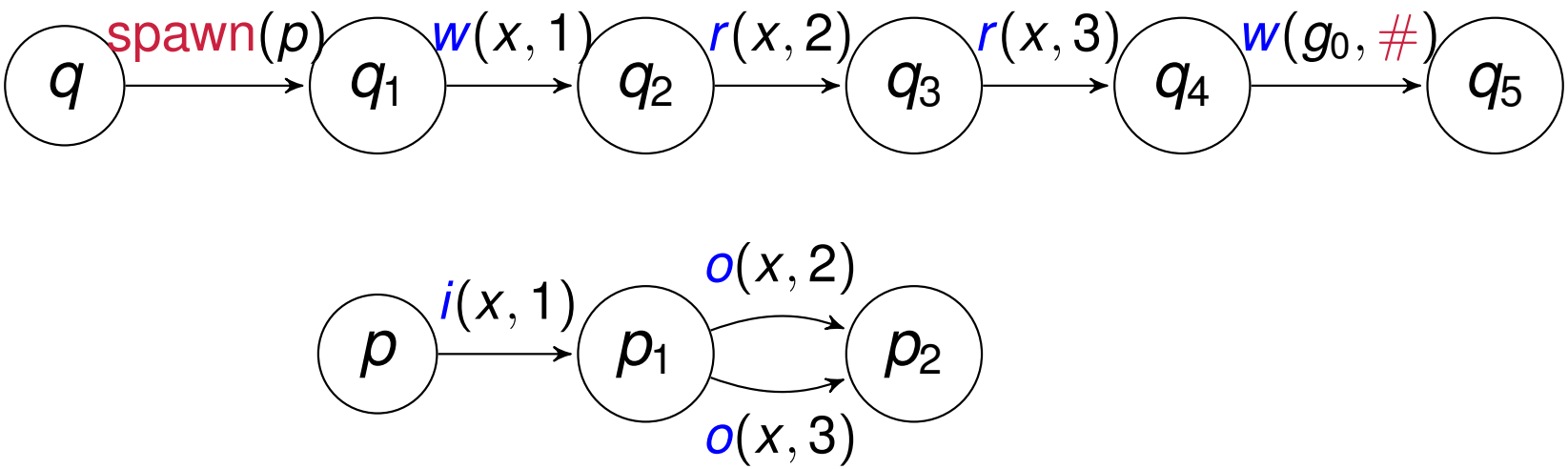

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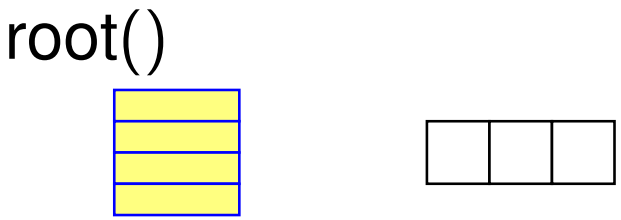
A Run



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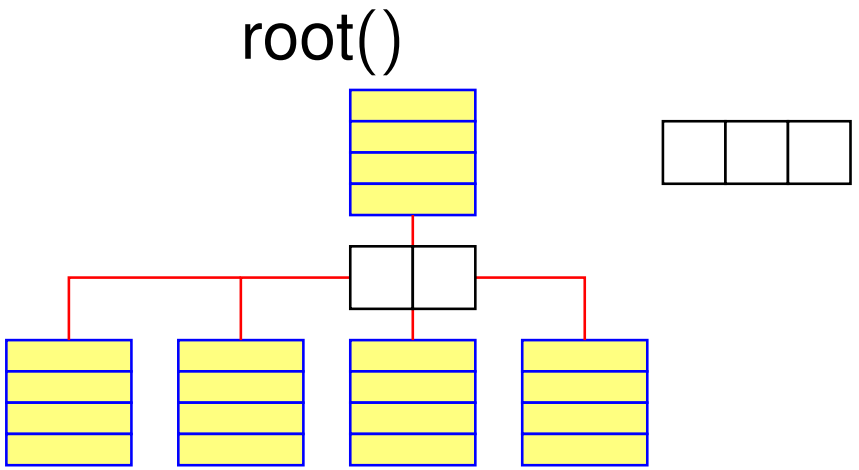

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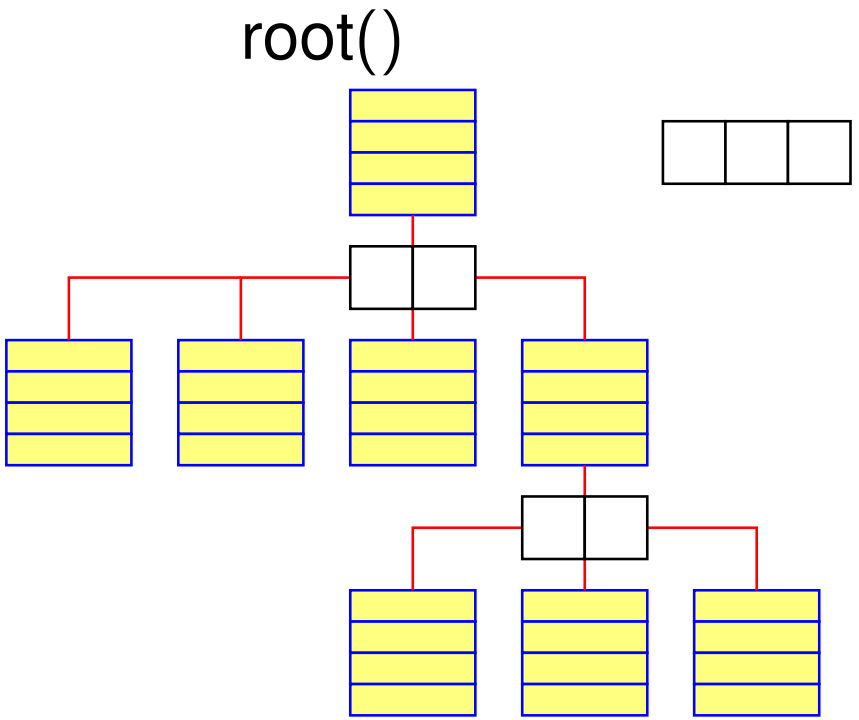

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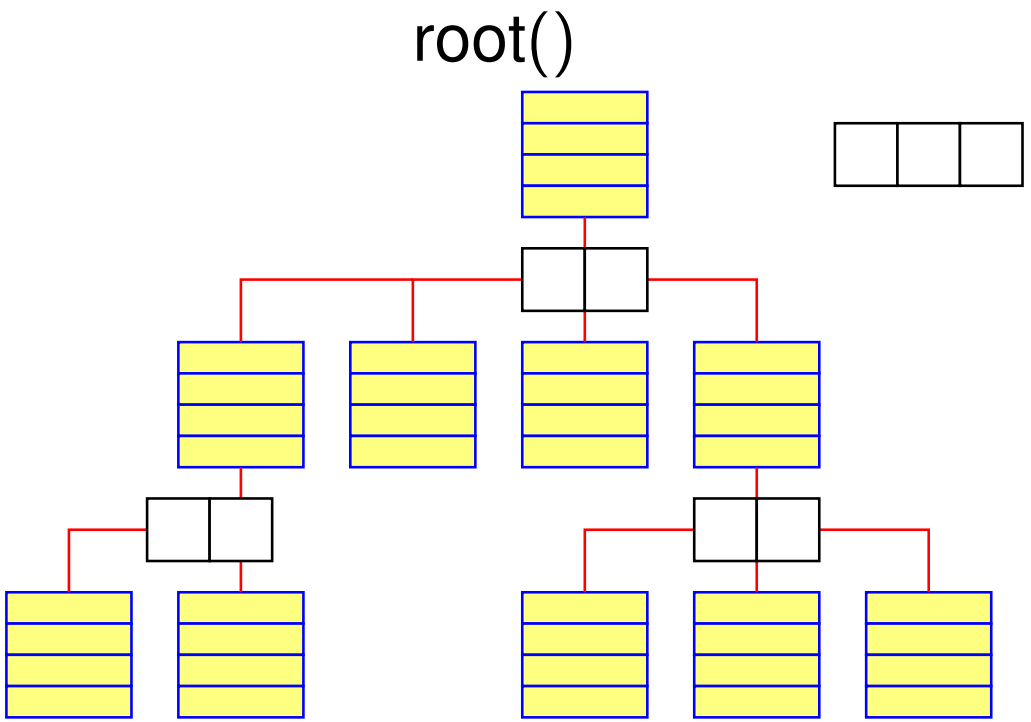

Our Results

Theorem 1

Reachability for dynamic processes is decidable.

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In absence of locals, reachability is PSPACE complete.

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Theorem 3

For generalized futures, reachability is DEXPTIME complete.

Abstraction 1: Set Semantics

Multiset Configuration

$$\langle p, ABBC, \{x \mapsto 1, y \mapsto 2\}, \{5 \cdot t_1, 2 \cdot t_2, 17 \cdot t_3\}\rangle$$

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$$\langle p, ABBC, \{x \mapsto 1, y \mapsto 2\}, \{\mathrm{set}(t_1), \mathrm{set}(t_2), \mathrm{set}(t_3)\}\rangle$$

Abstraction 1: Set Semantics

Intuition

Child actions may be repeated arbitrarily.

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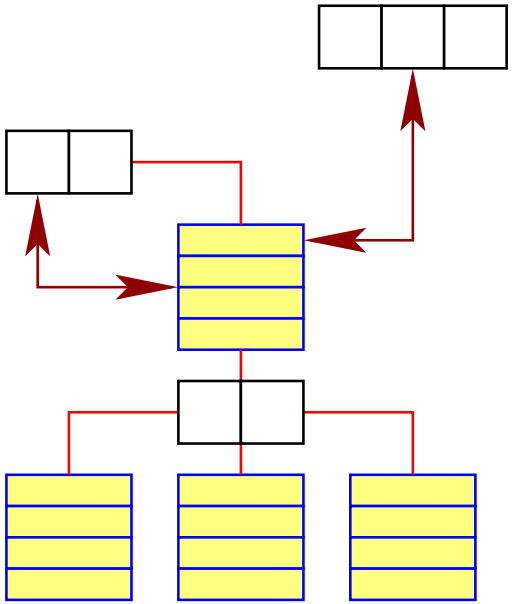
Proposition

Multset Reachability $\equiv$ Set Reachability

External Behavior



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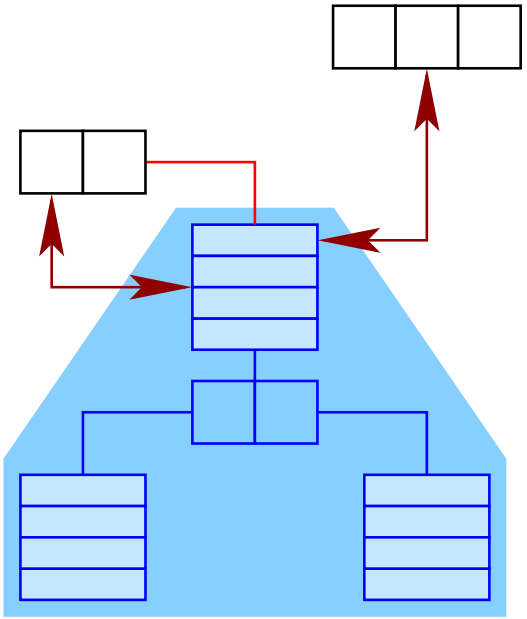

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Abstraction 2: Hypotheses

Hypothesis

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$\Longleftrightarrow$ all external behaviors of child processes.

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Abstraction

Set of child processes $\mapsto$ Set of external behaviors

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Abstraction 3: Lifted Hypotheses

Arbitrarily insert earlier actions ...

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- $\mathrm{core}(H)$ is finite.

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- Stop when $\mathrm{core}(\mathrm{Ext}_k) = \mathrm{core}(\mathrm{Ext}_{k-1})$.

Wrap-up

Theorem 1

Reachability for dynamic parametric processes is decidable.

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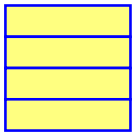
The same holds true for higher-level dynamic processes.

Extension to Weak Memory

PSO



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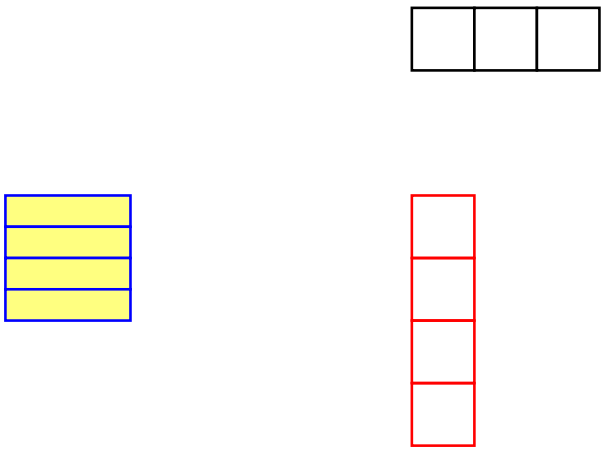

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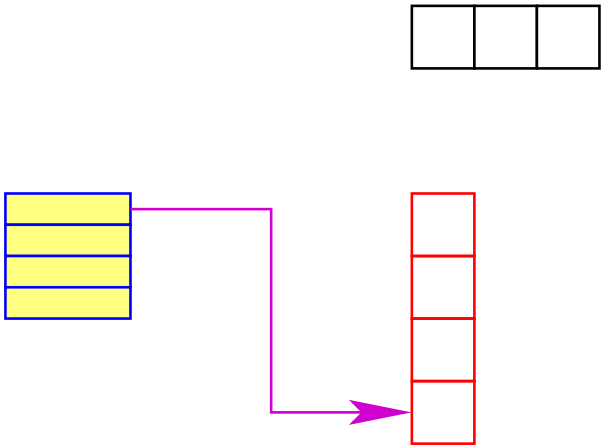

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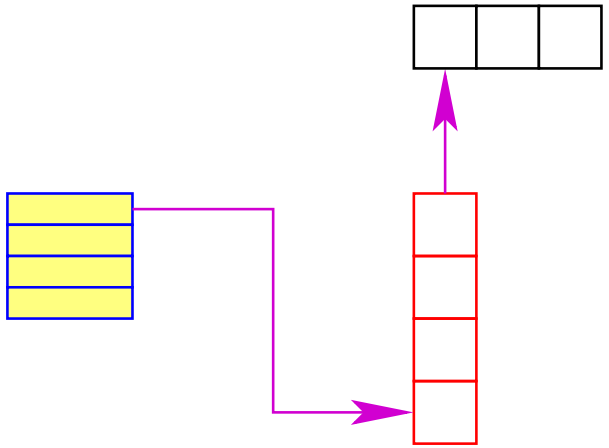

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Conjecture: Reachability is decidable

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- How to parameterize model / results with various kinds of WMs ?

Thank you!