Pint, a static analyzer for dynamics of Automata Networks
Loïc Paulevé

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Input Model

- Asynchronous Automata Networks [1]
  a \[0,1,2\]
  b \[0,1\]
  c \[0,1,2\]
  a 0 \rightarrow 1 \text{ when } b=0
  a 0 \rightarrow 2 \text{ when } c=0
  a 2 \rightarrow 1
  b 1 \rightarrow 0 \text{ when } a=0
  b 0 \rightarrow 1 \text{ when } a=2 \text{ and } c=1
  c 0 \rightarrow 1 \text{ when } b=0
  c 1 \rightarrow 2 \text{ when } a=1 \text{ and } b=0
  c 2 \rightarrow 0 \text{ when } b=1

\text{initial state} a=0,b=1,c=0

- Encoding of Boolean networks and multi-valued.
- Import from SBML-qual/GINsim using LogicalModel
  https://github.com/colomoto/logicalmodel
  $\text{logicalmodel sbml:an model.sbml model.an}$
- Other formats: SBGN-PD [2], Biocham, CellNetAnalyzer

Technologies

- Abstract interpretation: traces abstraction causality analysis (Local Causality Graphs) formal over-/under-approximations of reachability
- Answer-Set Programming (ASP)
- Logic programming for enumeration problems (NP)
- Implemented with OCaml programming language
- Free software: CeCILL licence

Applications to Biological Networks

- Gene regulatory networks; signalling pathways; etc.
- Tractable on very large networks (100-10,000 comp.)

- Identification of cut sets for goal (mutations)

<table>
<thead>
<tr>
<th>Model</th>
<th>local ts</th>
<th>nb states</th>
<th>pD (21,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCell-d (101)</td>
<td>384</td>
<td>2.7 10^2</td>
<td>1</td>
</tr>
<tr>
<td>RBE2F (370)</td>
<td>286</td>
<td>194</td>
<td>1</td>
</tr>
<tr>
<td>MAPK (309)</td>
<td>194</td>
<td>194</td>
<td>1</td>
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<tr>
<td>PIF (21,000)</td>
<td>194</td>
<td>194</td>
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</tbody>
</table>

- Identification of bifurcations for goal

<table>
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<th>goal</th>
<th>bmi</th>
<th>time</th>
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<td>48s</td>
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- Goal-oriented reduction: make life easier for model-checking

<table>
<thead>
<tr>
<th>Model</th>
<th>local ts</th>
<th>nb states</th>
<th>Verification of goal reachability</th>
<th>Verification of cut set</th>
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In all cases, reductions took less than 0.1s. Properties are equivalent in the reduced models.

For more information:

[1] Paulevé, Goal-Oriented Reduction of Automata Networks at CMSB 2016

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