

The Simulation Experiment Description Markup Language

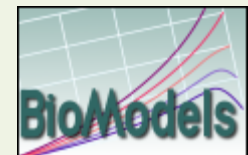
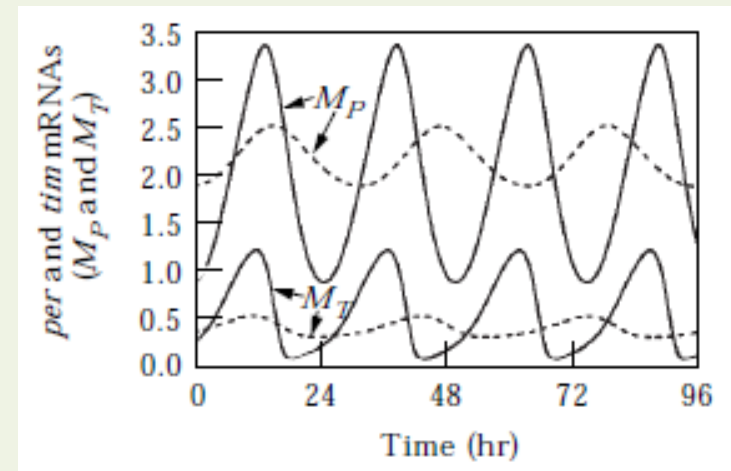
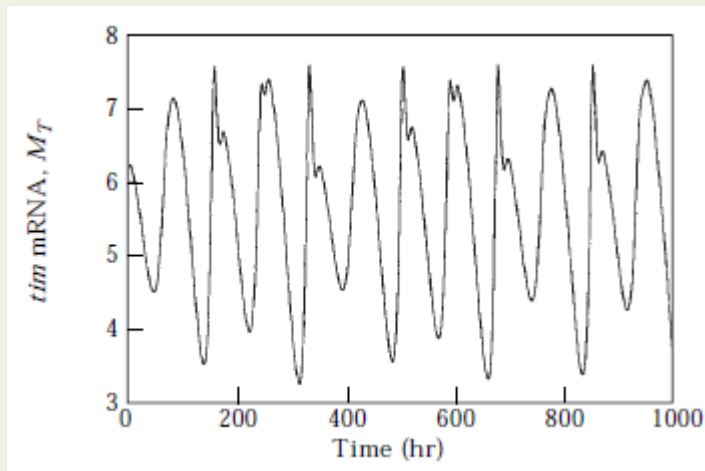
Frank T. Bergmann
HARMONY, NY

MOTIVATION

Motivation

Chaos and Birhythmicity in a Model for Circadian Oscillations of the PER and TIM Proteins in *Drosophila*

JEAN-CHRISTOPHE LELOUP AND ALBERT GOLDBETER*

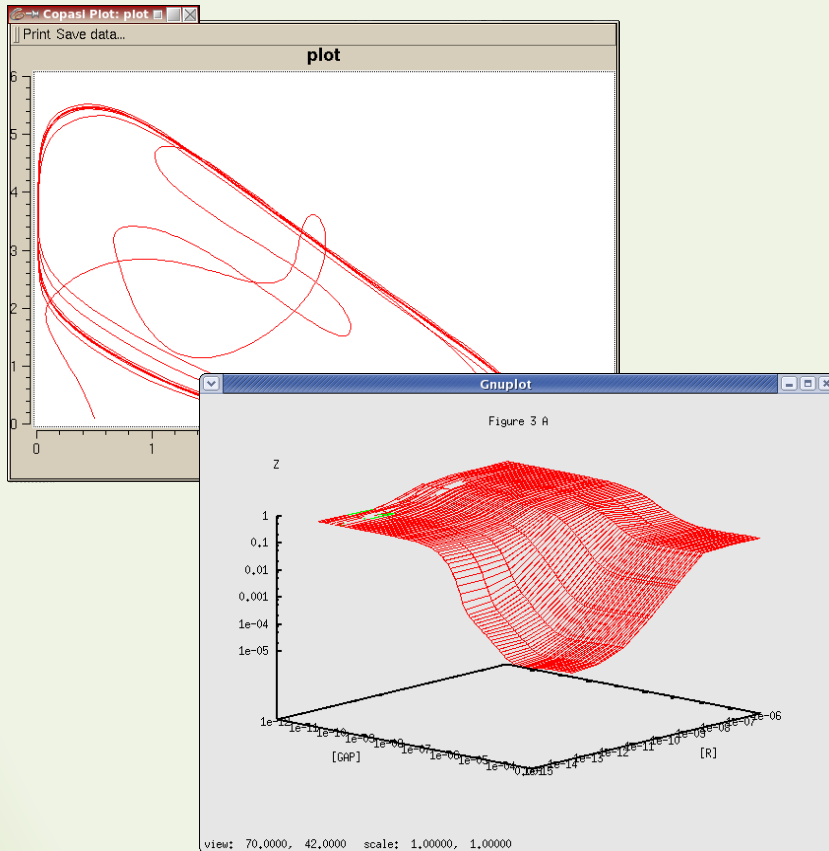


J. theor. Biol. (1999) **198**, 445-459

Article No. jtbi.1999.0924, available online at <http://www.idealibrary.com>

Motivation

BM 22



BM 86

- Changes in model parameterization
- Use of a number of different models in one experiment
- Choice of correct simulation algorithm
- Post-processing of the result data, e.g. normalization, logarithmic scale ...

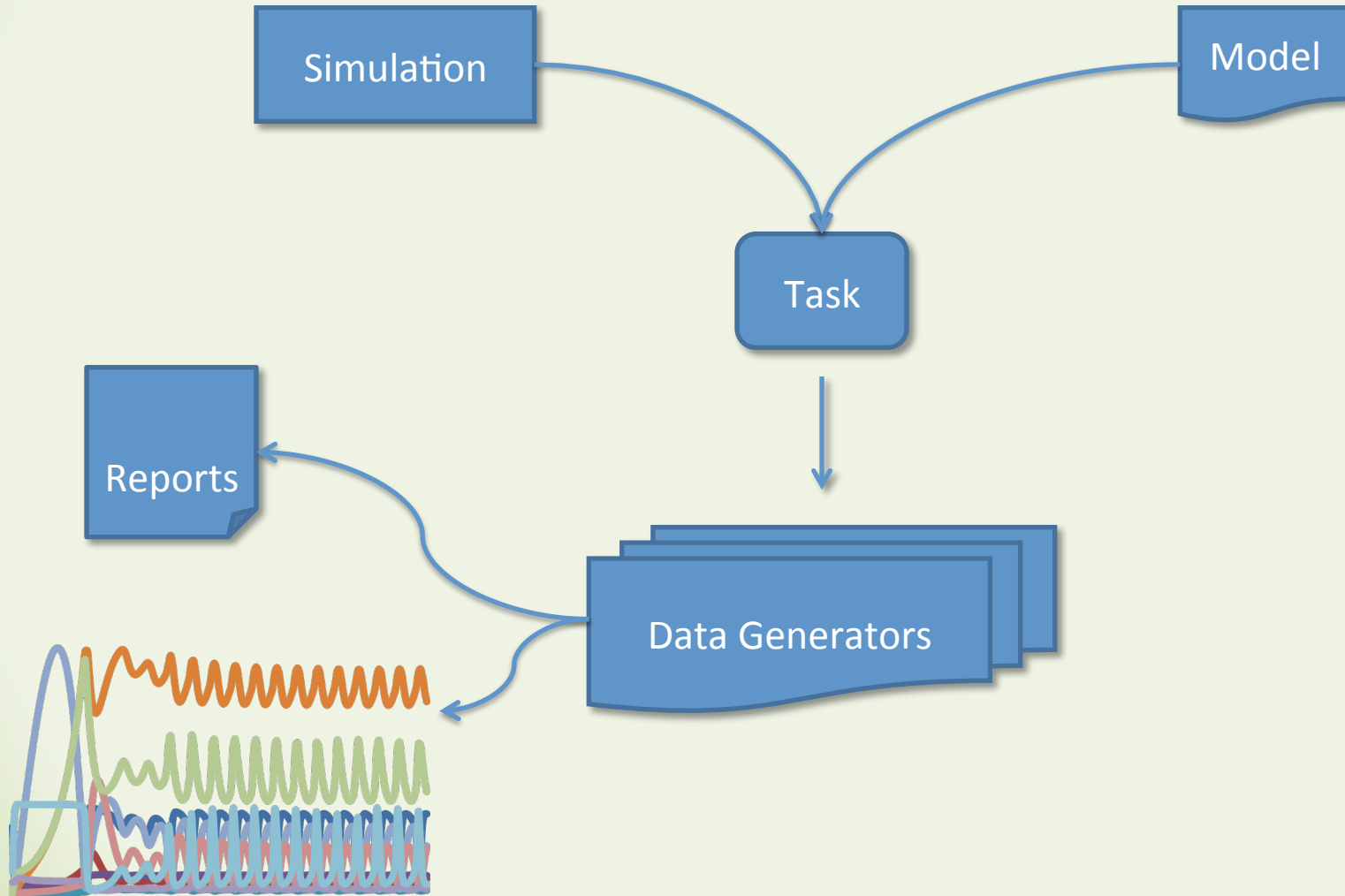
HOW DOES SED-ML HELP?

Repeatable simulation experiments

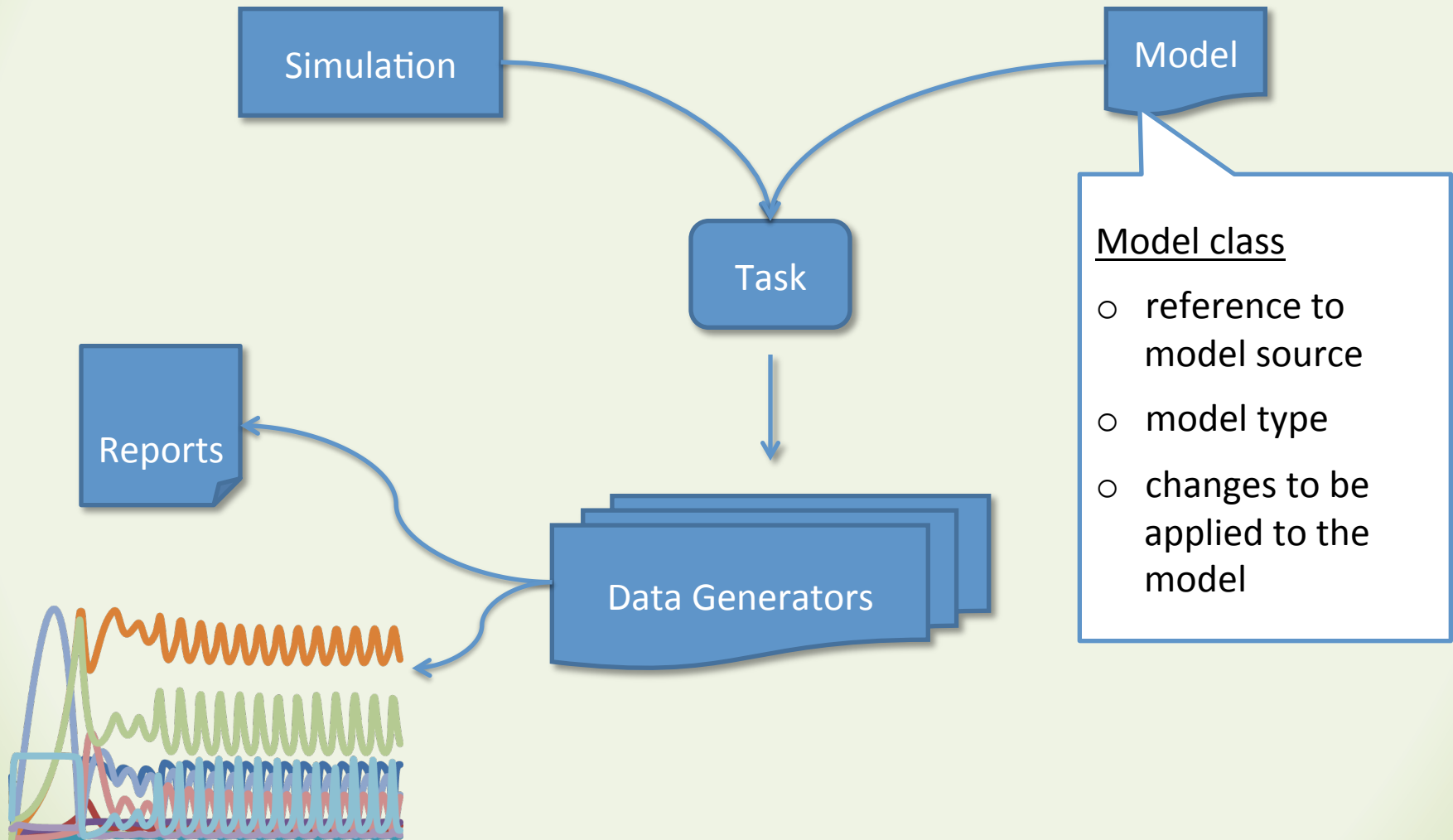
Simulation Experiment Description – Markup Language (SED-ML):

Is a language that aims to standardize the exchange of simulation experiments, independently from the model description language and the simulation tool.

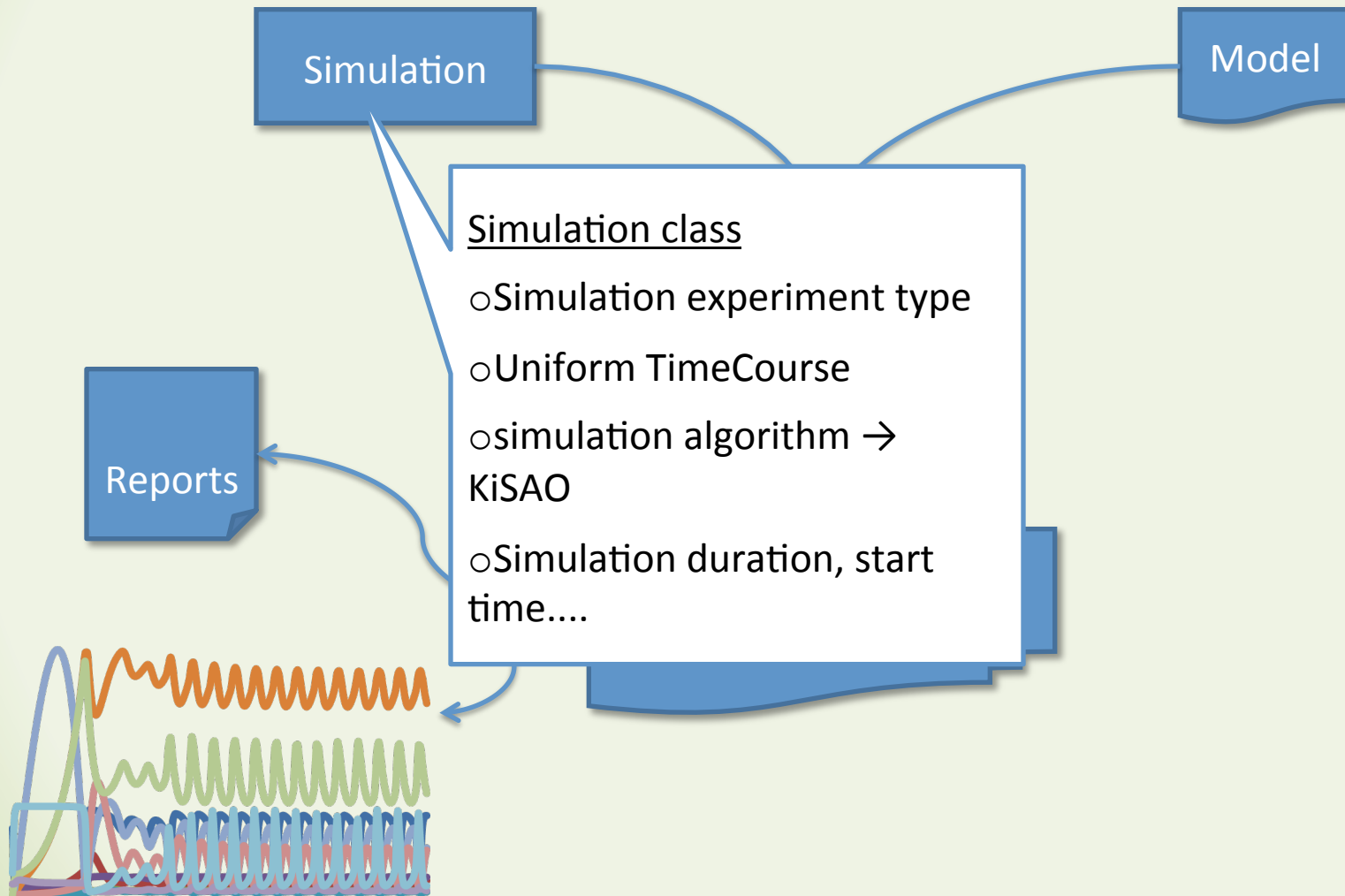
Repeatable simulation experiments



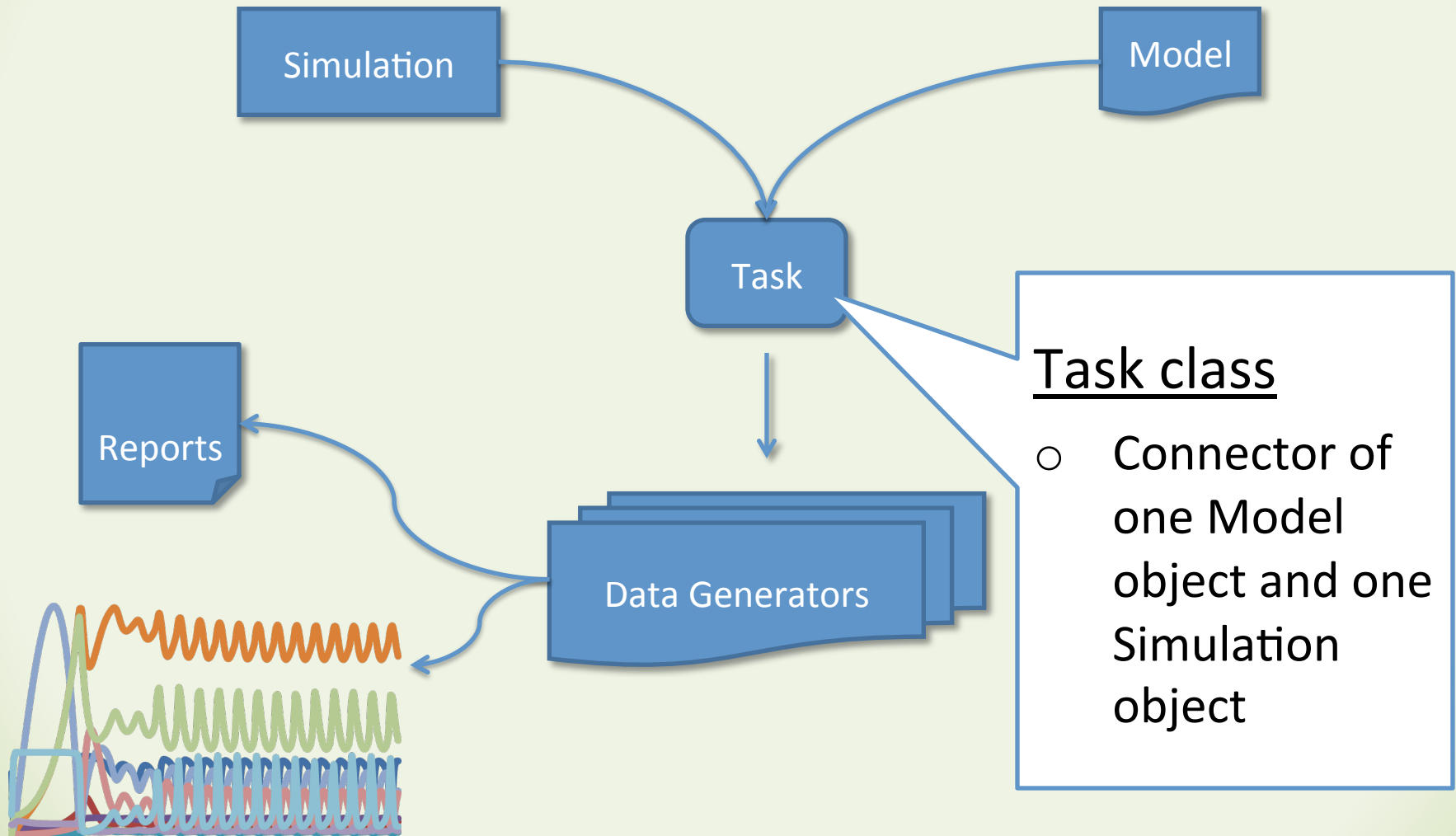
Repeatable simulation experiments



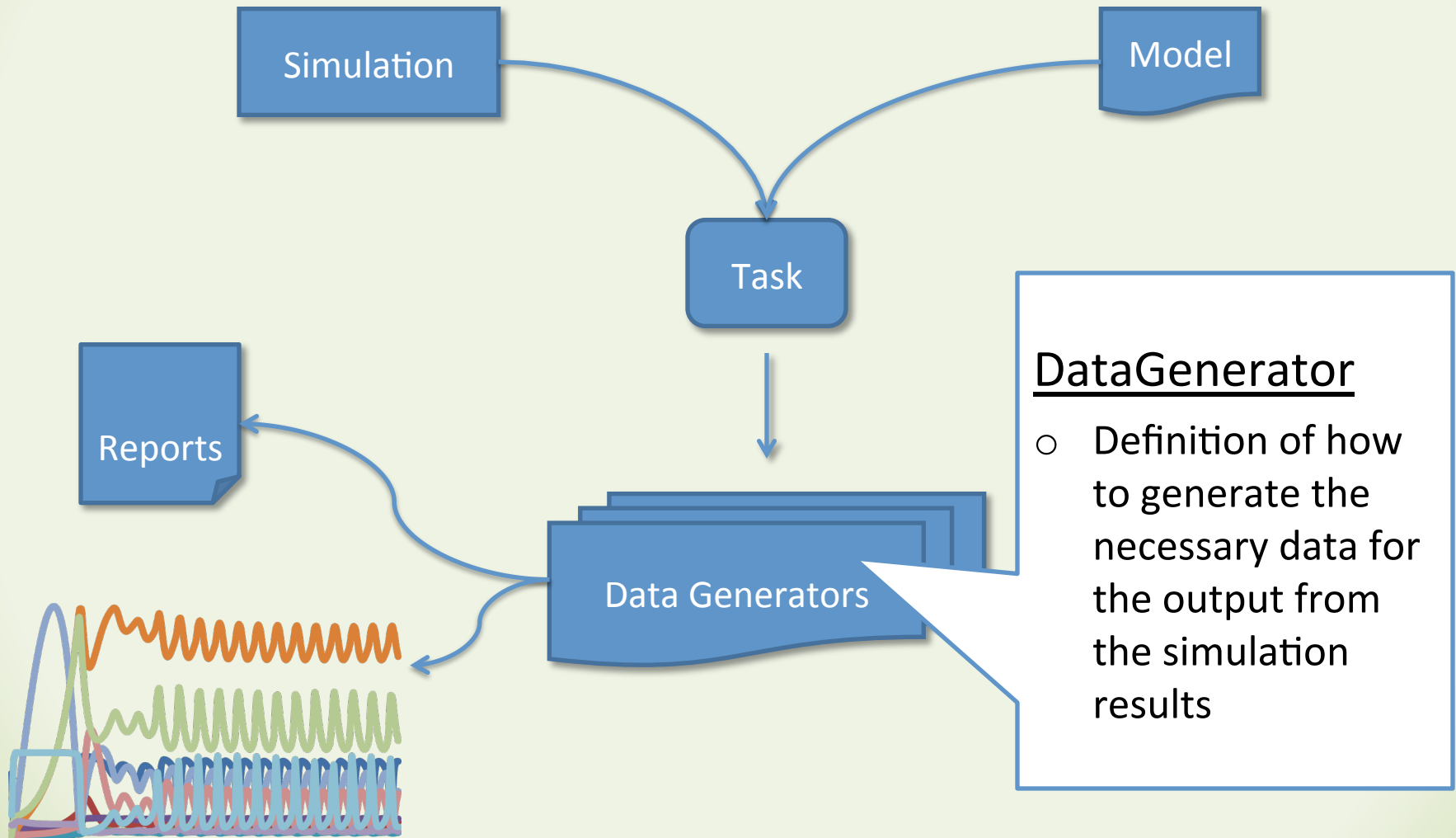
Repeatable simulation experiments



Repeatable simulation experiments



Repeatable simulation experiments



SED-ML Main Concepts



- No storage of simulation results
- SBRML
- No description of the layout of the output curves

SED-ML L1 V1 Released!

- final version available from

<http://sed-ml.org>

Simulation Experiment Description Markup Language (SED-ML) : Level 1 Version 1

March 25, 2011

Editors

Dagmar Waltemath	<i>University of Rostock, Germany</i>
Frank T. Bergmann	<i>University of Washington, Seattle, USA</i>
Richard Adams	<i>University of Edinburgh, UK</i>
Nicolas Le Novère	<i>European Bioinformatics Institute, UK</i>

The latest release of the Level 1 Version 1 specification is available at
<http://sed-ml.org/>

To discuss any aspect of the current SED-ML specification as well as language details, please send your messages to the mailing list
sed-ml-discuss@lists.sourceforge.net.

To get subscribed to the mailing list, please write to the same address
sed-ml-discuss@lists.sourceforge.net.

To contact the authors of the SED-ML specification, please write to
sed-ml-editors@lists.sourceforge.net



SED-ML

```
<?xml version="1.0" encoding="UTF-8"?>
<!-- Written by libSedML v1.1.4092.21172 see http://libsedml.sf.net -->
- <sedML xmlns="http://www.biomodels.net/sed-ml">
  - <listOfSimulations>
    - <uniformTimeCourse numberOfPoints="1000" outputEndTime="380" outputStartTime="0" initialTime="0" id="simulation1">
      <algorithm kisaoID="KISAO:0000019"/>
    </uniformTimeCourse>
  </listOfSimulations>
  - <listOfModels>
    <model language="urn:sedml:language:sbml" id="model1" source="urn:miriam:biomodels.db:BIOMD0000000021" name="Circadian Oscillations"/>
    - <model language="urn:sedml:language:sbml" id="model2" source="model1" name="Circadian Chaos">
      - <listOfChanges>
        <changeAttribute newValue="0.28" target="/sbml:sbml/sbml:model/sbml:listOfParameters/sbml:parameter[@id="V_mT"]/@value"/>
        <changeAttribute newValue="4.8" target="/sbml:sbml/sbml:model/sbml:listOfParameters/sbml:parameter[@id="V_dT"]/@value"/>
      </listOfChanges>
    </model>
  </listOfModels>
  - <listOfTasks>
    <task id="task1" simulationReference="simulation1" modelReference="model1"/>
    <task id="task2" simulationReference="simulation1" modelReference="model2"/>
  </listOfTasks>
  - <listOfDataGenerators>
    - <dataGenerator id="time" name="time">
      - <listOfVariables>
        <variable id="t" symbol="urn:sedml:symbol:time" taskReference="task1"/>
      </listOfVariables>
      - <math xmlns="http://www.w3.org/1998/Math/MathML">
        <ci> t </ci>
      </math>
    </dataGenerator>
    - <dataGenerator id="tim1" name="tim mRNA">
      - <listOfVariables>
        <variable id="v1" target="/sbml:sbml/sbml:model/sbml:listOfSpecies/sbml:species[@id='Mt']" taskReference="task1"/>
      </listOfVariables>
      - <math xmlns="http://www.w3.org/1998/Math/MathML">
        <ci> v1 </ci>
      </math>
    </dataGenerator>
  </listOfDataGenerators>
</sedML>
```

SED-ML

```

<?xml version="1.0" encoding="UTF-8"?>
<!-- Written by libSedML v1.1.4092.21172 see http://libsedml.sf.net -->
- <sedML xmlns="http://www.biomodels.net/sed-ml">
  - <listOfSimulations>
    - <uniformTimeCourse numberOfPoints="1000" outputEndTime="380" outputStartTime="0" initialTime="0" id="simulation1">
      <algorithm kisaoID="KISAO:0000019"/>
    </uniformTimeCourse>
  </listOfSimulations>
  - <listOfModels>
    <model language="urn:sedml:language:sbml" id="model1" source="urn:miriam:biomodels.db:BIOMD0000000021" name="Circadian Oscillations"/>
    - <model language="urn:sedml:language:sbml" id="model2" source="model1" name="Circadian Chaos">
      <listOfChanges>
        <changeAttribute newValue="0.28" target="/sbml:sbml/sbml:model/sbml:listOfParameters/sbml:parameter[@id="V_mt"]/@value"/>
        <changeAttribute newValue="4.8" target="/sbml:sbml/sbml:model/sbml:listOfParameters/sbml:parameter[@id="V_dT"]/@value"/>
      </listOfChanges>
    </model>
  </listOfModels>
  - <listOfTasks>
    - <dataGenerators>
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        - <listOfVariables>
          <variable id="t" symbol="urn:sedml:symbol:time" taskReference="task1"/>
        </listOfVariables>
        - <math xmlns="http://www.w3.org/1998/Math/MathML">
          <ci> t </ci>
        </math>
      </dataGenerator>
      - <dataGenerator id="tim1" name="tim mRNA">
        - <listOfVariables>
          <variable id="v1" target="/sbml:sbml/sbml:model/sbml:listOfSpecies/sbml:species[@id='Mt']" taskReference="task1"/>
        </listOfVariables>
        - <math xmlns="http://www.w3.org/1998/Math/MathML">
          <ci> v1 </ci>
        </math>
      </dataGenerator>
    </listOfDataGenerators>
  </listOfTasks>
</sedML>

```

```
"1.0" encoding="UTF-8"?>
libSedML v1.1.4092.21172 see http://libsedml.sf.net -->
"http://www.biomodels.net/sed-ml">
ulations>
mTimeCourse numberOfPoints="1000" outputEndTime="380" outputStartTime="0" initialTime="0" id="simulation1">
gorithm kisaoID="KISAO:0000019"/>
mTimeCourse>
ulations>
ls>
language="urn:sedml:language:sbml" id="model1" source="urn:miriam:biomodels.db:BIOMD0000000021" name="Circadian
ulations"/>
language="urn:sedml:language:sbml" id="model2" source="model1" name="Circadian Chaos">
OfChanges>
<changeAttribute newValue="0.28" target="/sbml:sbml/sbml:model/sbml:listOfParameters/sbml:parameter[@id="V_m
<changeAttribute newValue="4.8" target="/sbml:sbml/sbml:model/sbml:listOfParameters/sbml:parameter[@id="V_dT
tOfChanges>
```

```
language="urn:sedml:language:sbml"
name="Circadian Oscillations"/>
language="urn:sedml:language:sbml"
```


SED-ML

```

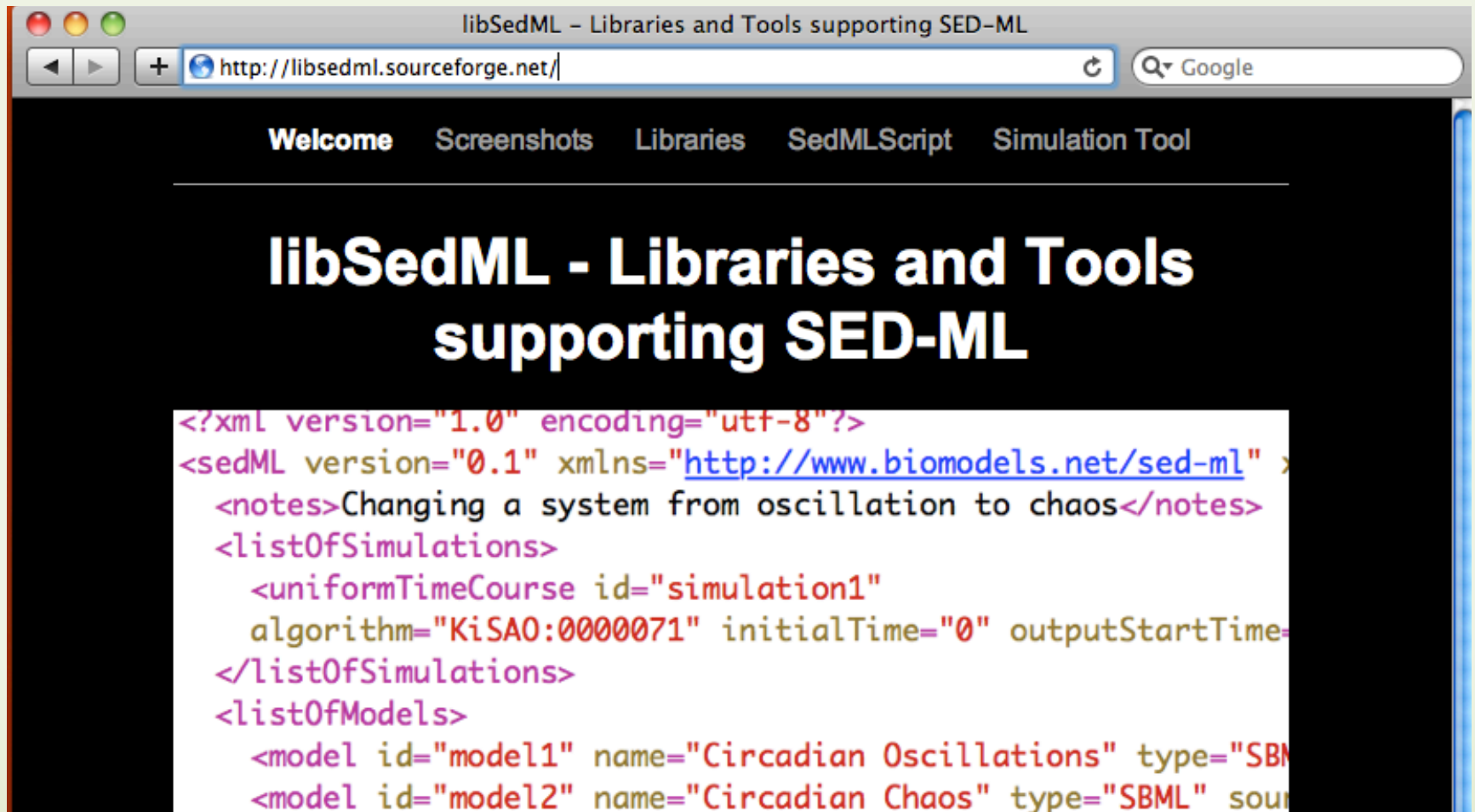
<?xml version="1.0" encoding="UTF-8"?>
<!-- Written by libSedML v1.1.4092.21172 see http://libsedml.sf.net -->
- <sedML xmlns="http://www.biomodels.net/sed-ml">
  - <listOfSimulations>
    - <uniformTimeCourse numberOfPoints="1000" outputEndTime="380" outputStartTime="0" initialTime="0" id="simulation1">
      <algorithm kisaoID="KISAO:0000019"/>
    </uniformTimeCourse>
  </listOfSimulations>
  - <listOfModels>
    <model language="urn:sedml:language:sbml" id="model1" source="urn:miriam:biomodels.db:BIOMD0000000021" name="Circadian Oscillations"/>
    - <model language="urn:sedml:language:sbml" id="model2" source="model1" name="Circadian Chaos">
      - <listOfChanges>
        <change id="V_mT" symbol="V_mT" value="1" taskReference="task1"/>
        <change id="V_dT" symbol="V_dT" value="1" taskReference="task1"/>
      </listOfChanges>
    </model>
  </listOfModels>
  - <listOfTasks>
    <task id="task1" simulationReference="simulation1" modelReference="model1"/>
    <task id="task2" simulationReference="simulation1" modelReference="model2"/>
  </listOfTasks>
  - <listOfDataGenerators>
    - <dataGenerator id="time" name="time">
      - <listOfVariables>
        <variable id="t" symbol="urn:sedml:symbol:time" taskReference="task1"/>
      </listOfVariables>
      - <math xmlns="http://www.w3.org/1998/Math/MathML">
        <ci> t </ci>
      </math>
    </dataGenerator>
    - <dataGenerator id="tim1" name="tim mRNA">
      - <listOfVariables>
        <variable id="v1" target="/sbml:sbml/sbml:model/sbml:listOfSpecies/sbml:species[@id='Mt']" taskReference="task1"/>
      </listOfVariables>
      - <math xmlns="http://www.w3.org/1998/Math/MathML">
        <ci> v1 </ci>
      </math>
    </dataGenerator>
  </listOfDataGenerators>
</sedML>

```

symbol="urn:sedml:symbol:time"

IMPLEMENTATION

<http://libsedml.sf.net>



Implementation

SED-ML Script Editor

```
SED-ML Script Editor
AddTimeCourseSimulation('timecourse1', 'KISAO:0000019', 0, 0, 10, 1000)
AddModel('model1', 'model1.xml')
AddTask('task1', 'timecourse1', 'model1')
AddColumn('time1', [['time', 'task1', 'time']])
AddColumn('S11', [['S1', 'task1', 'S1']])
AddColumn('S21', [['S2', 'task1', 'S2']])
AddPlot('plot1', '', [['time1', 'S11'], ['time1', 'S21']]);
```



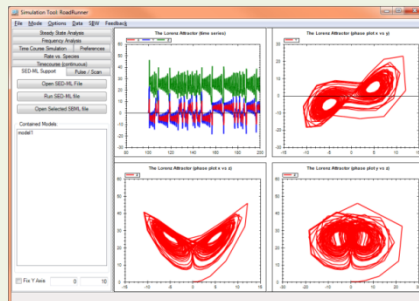
libSedMLScript



libSedML



libSedMLRunner



Simulation Tool



RoadRunner

JSim

iBioSim

Implementation

```
<?xml version="1.0" encoding="UTF-8" ?>
<!-- Written by libSedML v1.14.0 -->
<sedML xmlns="http://www.sed-ml.org" >
  <listOfSimulations>
    <uniformTimeCourse simulationID="1" >
      <algorithm kisaoID="1" >
        <uniformTimeCourse>
          </uniformTimeCourse>
        </algorithm>
      </uniformTimeCourse>
    </listOfSimulations>
  <listOfModels>
    <model language="urn:uuid:313641c7-6dd3-48eb-8f12-480611c4ccbd" >
      <Oscillations />
    </model>
  </listOfModels>
  <listOfTasks>
    <task id="task1" simulationID="1" >
      <task id="task2" simulationID="1" >
        </task>
      </task>
    </listOfTasks>
  <listOfDataGenerators>
    <dataGenerator id="tin" >
      <listOfVariables>
        <variable id="t" >
          </variable>
        </listOfVariables>
      <math xmlns="http://www.w3.org/1998/Math/ML" >
        <ci> t </ci>
      </math>
    </dataGenerator>
    <dataGenerator id="tin" >
      <listOfVariables>
        <variable id="v" >
          </variable>
        </listOfVariables>
      <math xmlns="http://www.w3.org/1998/Math/ML" >
        <ci> v1 </ci>
      </math>
    </dataGenerator>
  </listOfDataGenerators>
</sedML>
```

```
AddTimeCourseSimulation('simulation1', 'KiSA0:0000071', 0, 50,
1000, 1000)
```

```
AddModel('model1', 'urn:miriam:biomodels.db:BIOMD0000000021')
```

```
AddModel('model2', 'model1')
```

```
AddParameterChange('model2', 'V_mT', '0.28')
```

```
AddParameterChange('model2', 'V_dT', '4.8')
```

```
AddTask('task1', 'simulation1', 'model1')
```

```
AddTask('task2', 'simulation1', 'model2')
```

```
AddColumn('time', [['time', 'task1', 'time']])
```

```
AddColumn('Mt_original', [['v1', 'task1', 'Mt']])
```

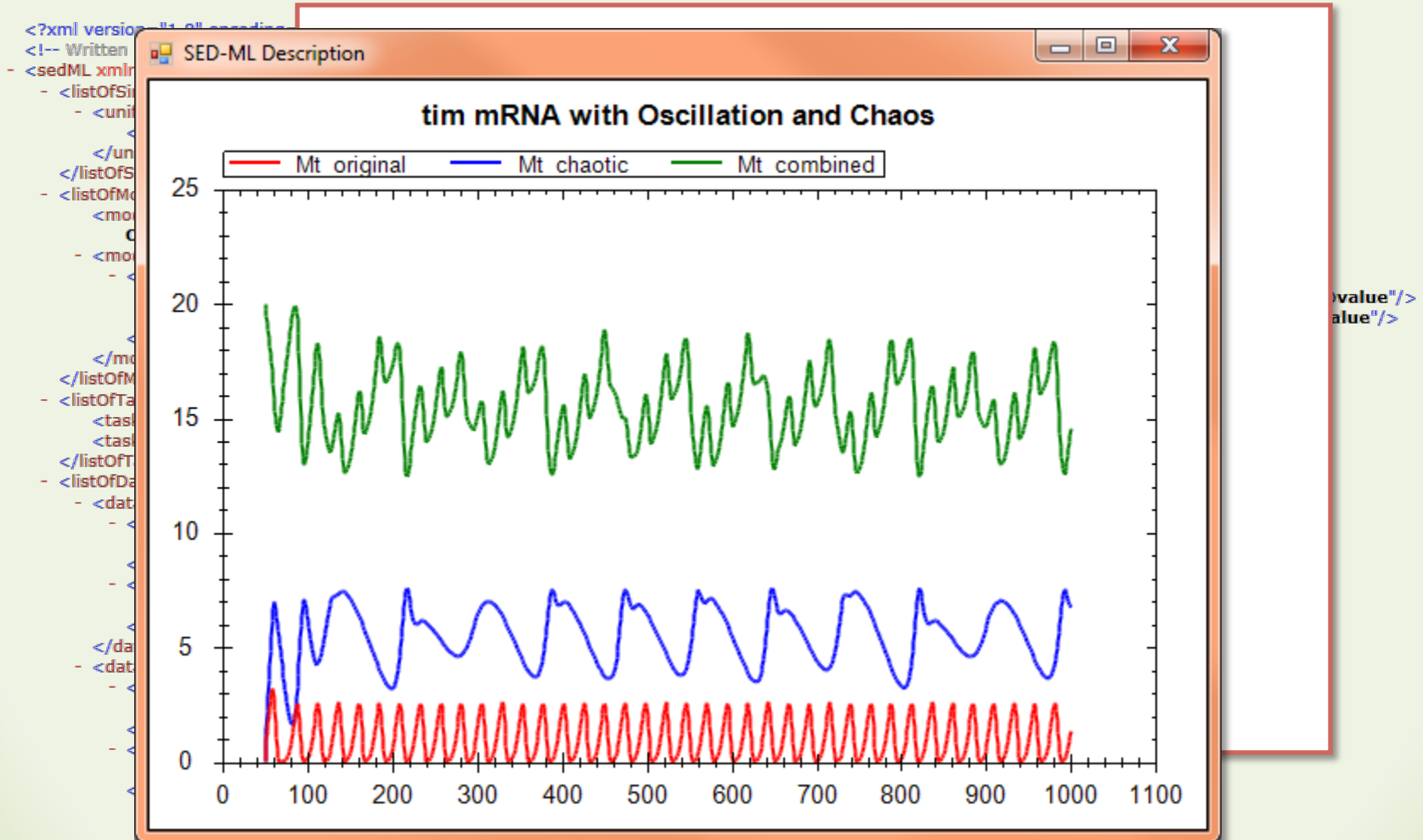
```
AddColumn('Mt chaotic', [['v2', 'task2', 'Mt']])
```

```
AddColumn('Mt_combined', [['v1', 'task1', 'Mt'], ['v2', 'task2', 'Mt'], 'v1 - v2 + 20'])
```

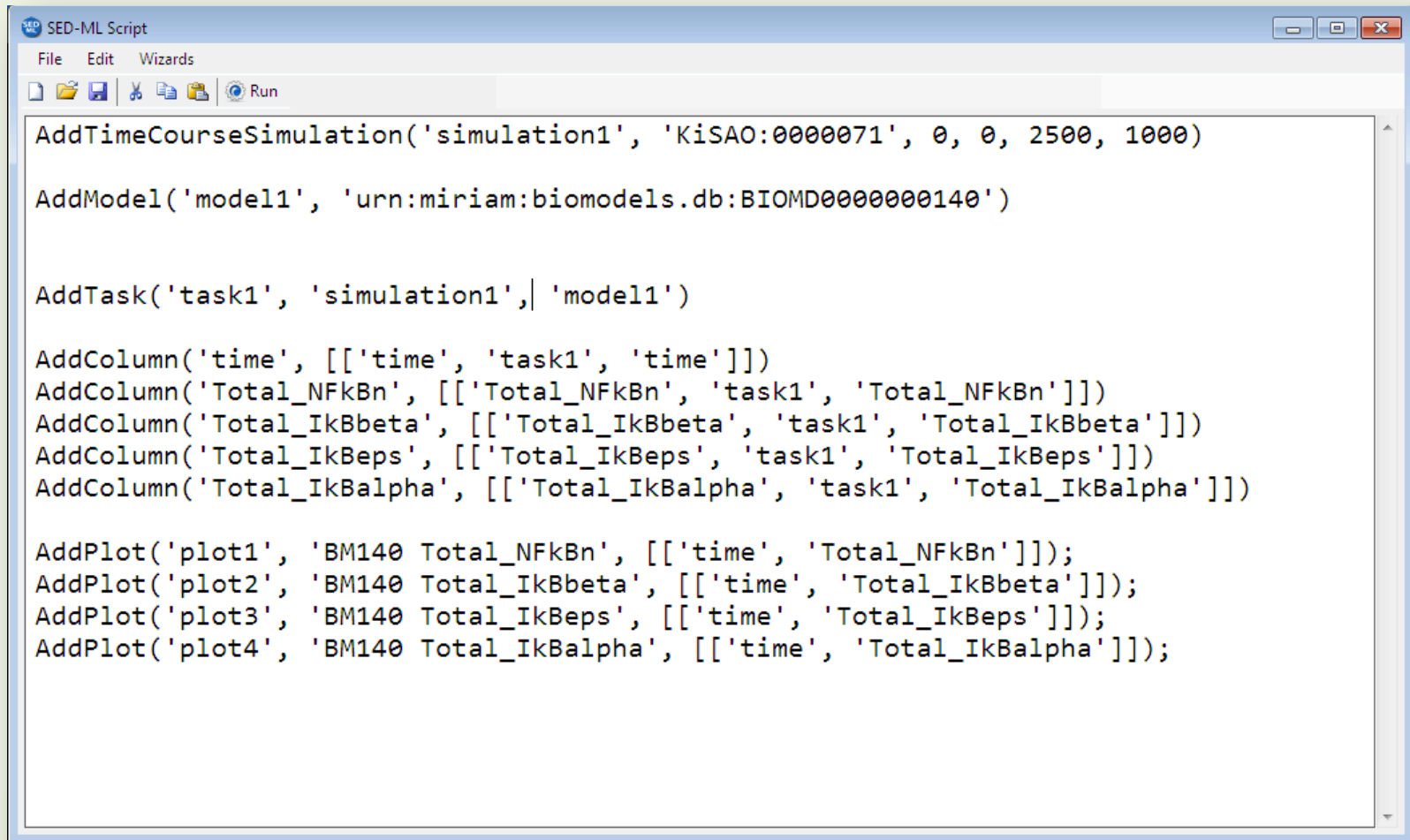
```
AddPlot('plot1', 'tim mRNA with Oscillation and Chaos', [['time',  
'Mt_original'], ['time', 'Mt_chaotic'], ['time',  
'Mt_combined']] );
```

```
value"/>
value"/>
```

Implementation



SED-ML script editor



```
SED-ML Script
File Edit Wizards
AddTimeCourseSimulation('simulation1', 'KisAO:0000071', 0, 0, 2500, 1000)

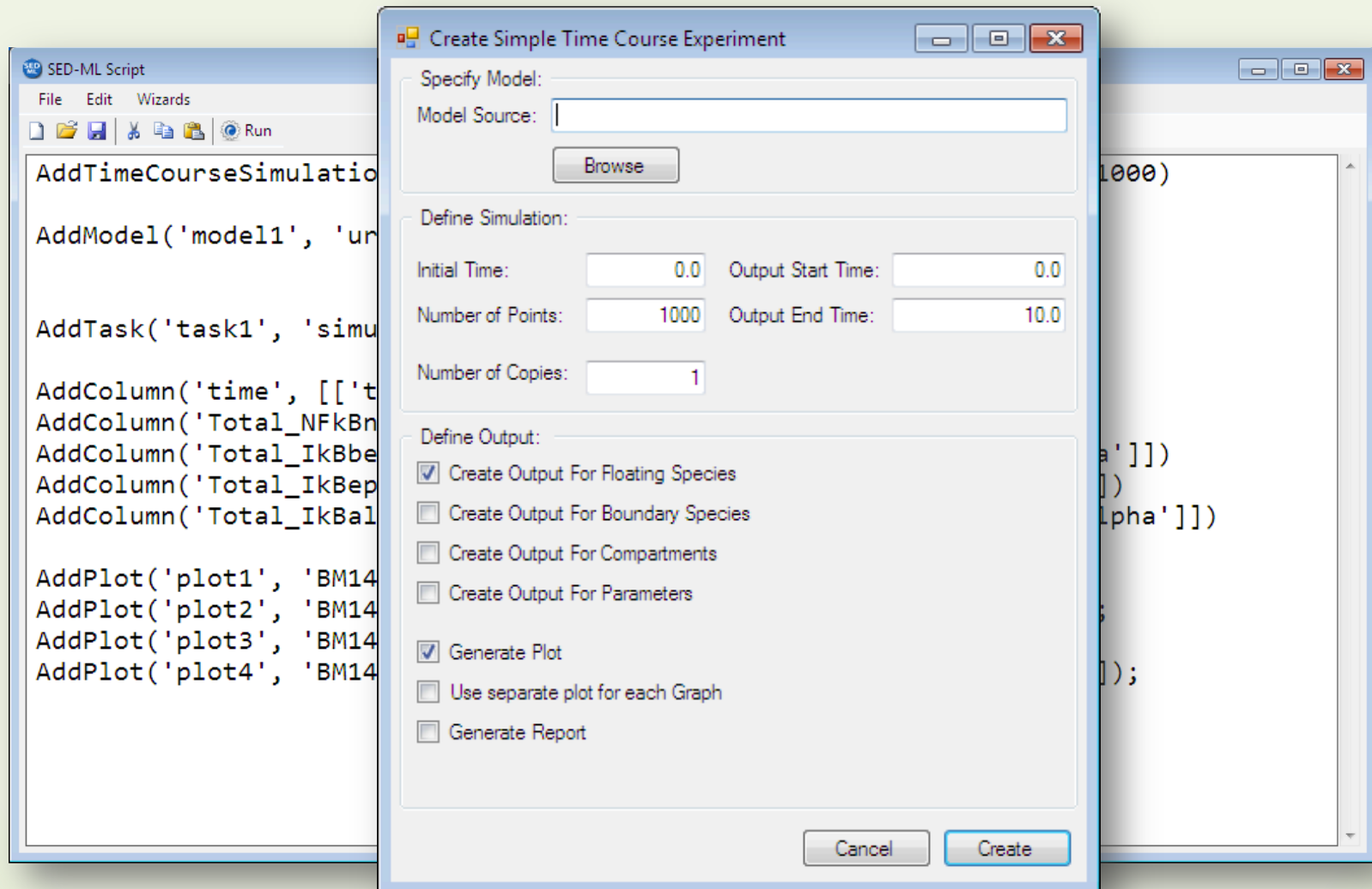
AddModel('model1', 'urn:miriam:biomodels.db:BIOMD0000000140')

AddTask('task1', 'simulation1',| 'model1')

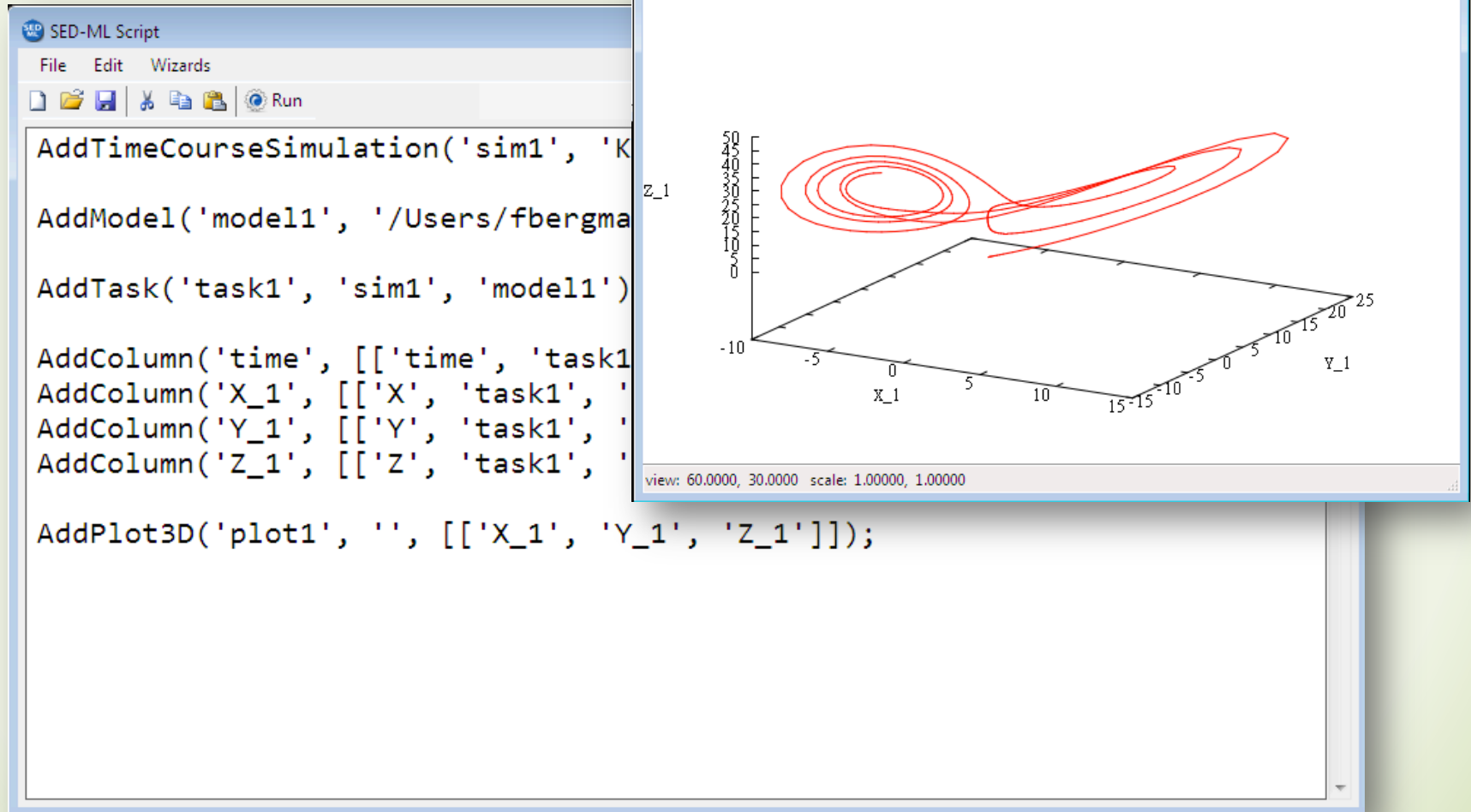
AddColumn('time', [['time', 'task1', 'time']])
AddColumn('Total_NFkBn', [['Total_NFkBn', 'task1', 'Total_NFkBn']])
AddColumn('Total_IkBbeta', [['Total_IkBbeta', 'task1', 'Total_IkBbeta']])
AddColumn('Total_IkBeps', [['Total_IkBeps', 'task1', 'Total_IkBeps']])
AddColumn('Total_IkBalpha', [['Total_IkBalpha', 'task1', 'Total_IkBalpha']])

AddPlot('plot1', 'BM140 Total_NFkBn', [['time', 'Total_NFkBn']]);
AddPlot('plot2', 'BM140 Total_IkBbeta', [['time', 'Total_IkBbeta']]);
AddPlot('plot3', 'BM140 Total_IkBeps', [['time', 'Total_IkBeps']]);
AddPlot('plot4', 'BM140 Total_IkBalpha', [['time', 'Total_IkBalpha']]);
```

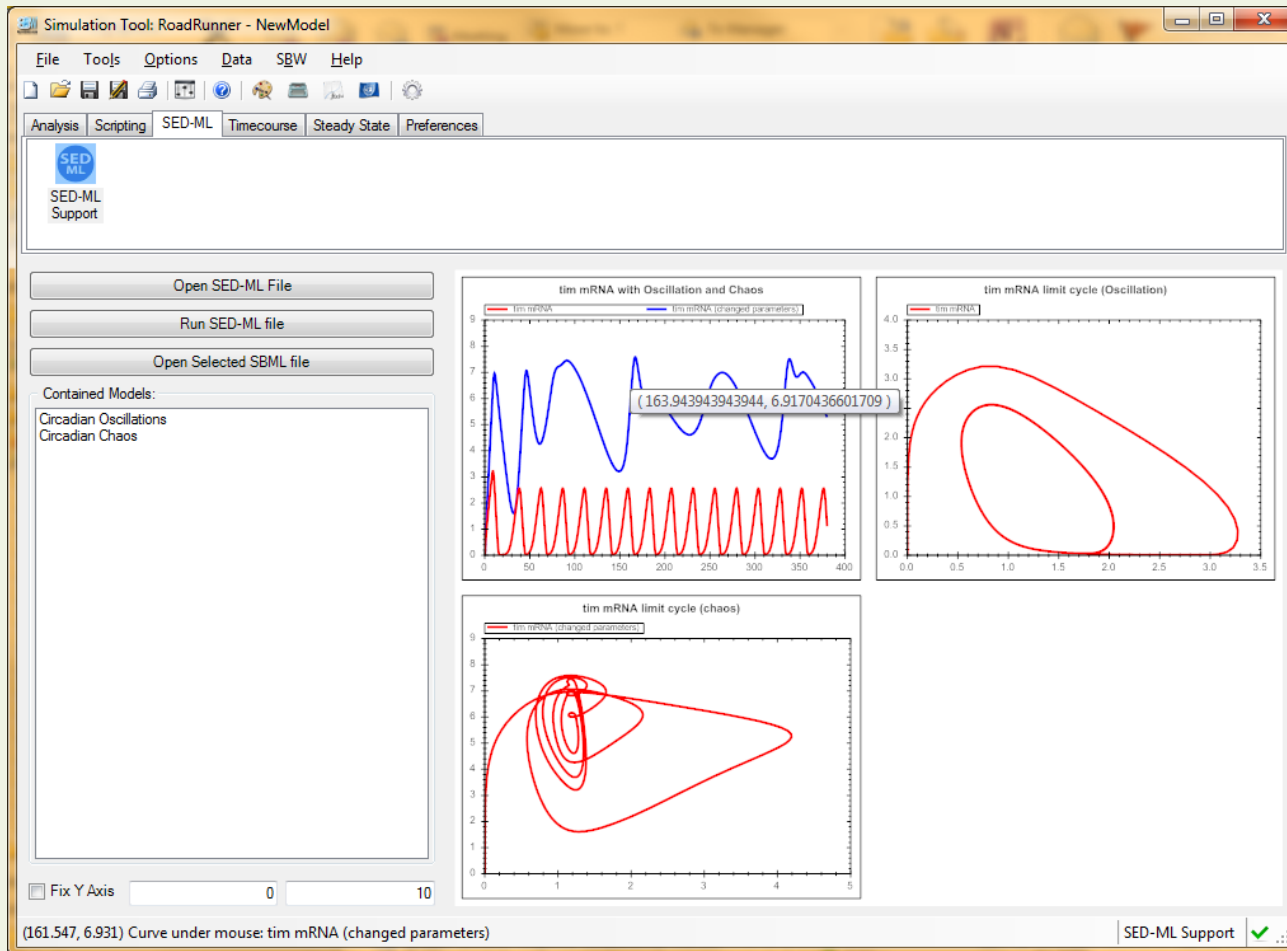
SED-ML script editor



SED-ML script editor

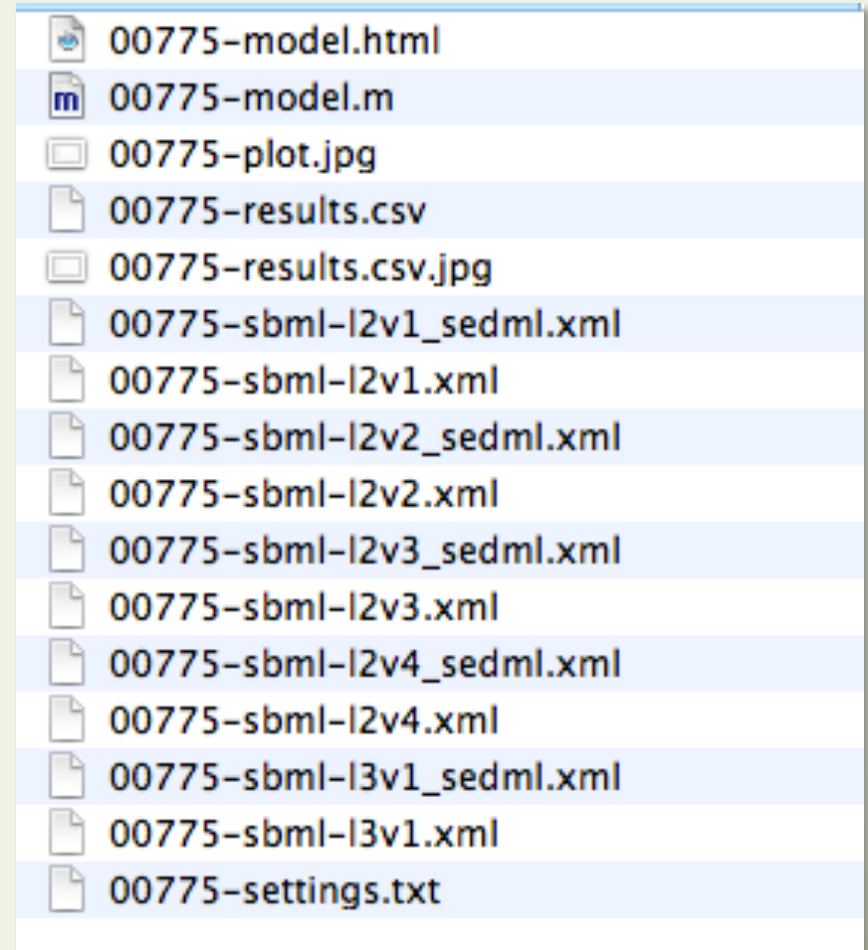


Available in SBW!



SBML Test Suite

- Next release of the SBML Test Suite will come with SED-ML models for all test cases:
- That's 4872 SED-ML models!



Outlook

- Nested Tasks
- More Simulation Experiments
- Advanced Post processing

A Simple Nested Simulation for SED-ML

Frank T. Bergmann (fbergman@u.washington.edu)

About this document

This document describes a simple nested Simulation Experiment for SED-ML [1] that is easy to implement and will help to broaden what SED-ML is able to encode. Currently, SED-ML effectively describes the exchange of time course simulation experiments. Through suggestions made at the Super Hackathon in New Zealand¹ last year, this general uniform time course simulation was extended, by applying different ranges to simulation experiments (Figure 1).

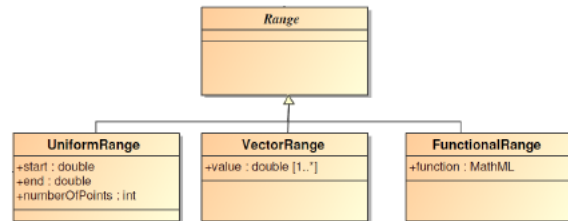


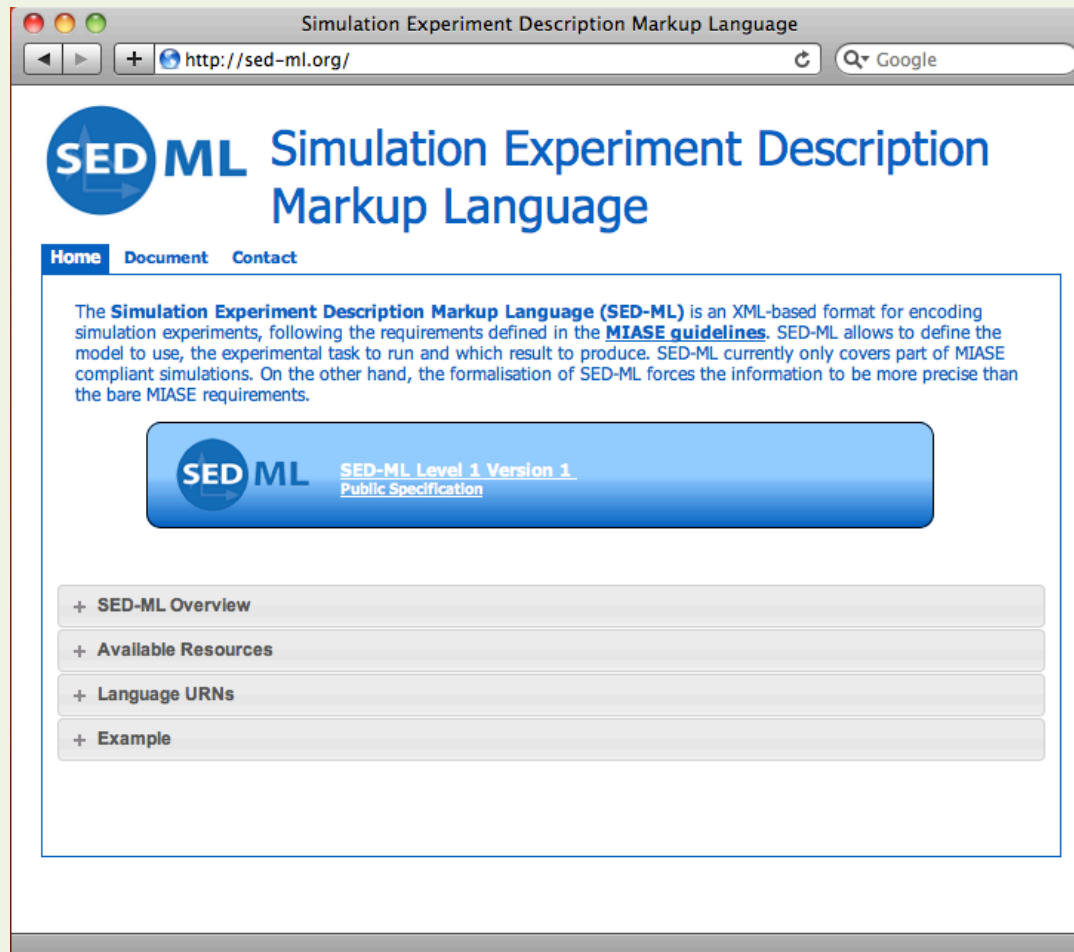
Figure 1: Extending Simulations Through Ranges (snippet from current proposed SED-ML object model²)

However, by directly applying these ranges to the *TimeCourse* simulation element (and other future simulation types), it will be arguably harder for the community to implement this standard. Currently available simulation tools do not have this functionality. Moreover, a custom implementation will be necessary for each simulation experiment encoded this way. Here, an alternative will be presented that will allow for the same functionality as the current proposal and, perhaps even more important, make it easy for developers to implement. It will also allow for the community to implement novel simulation experiments.

¹ <http://www.cellml.org/community/events/workshop/2009>

² <http://sed-ml.svn.sourceforge.net/viewvc/sed-ml/sed-ml/documents/sed-om/sedom-tmp.pdf>

More Information



<http://sed-ml.org>

Acknowledgments

Nicolas Le Novère, Richard Adams
Dagmar Waltemath

Mike Hucka
Ion Moraru
Sven Sahle
David Nickerson
Henning Schmidt
Fedor Kolpakov

<http://sed-ml.org>