

Kinetic Simulation Algorithm Ontology

Terminology for the Description of Dynamics

Christian Knüpfner

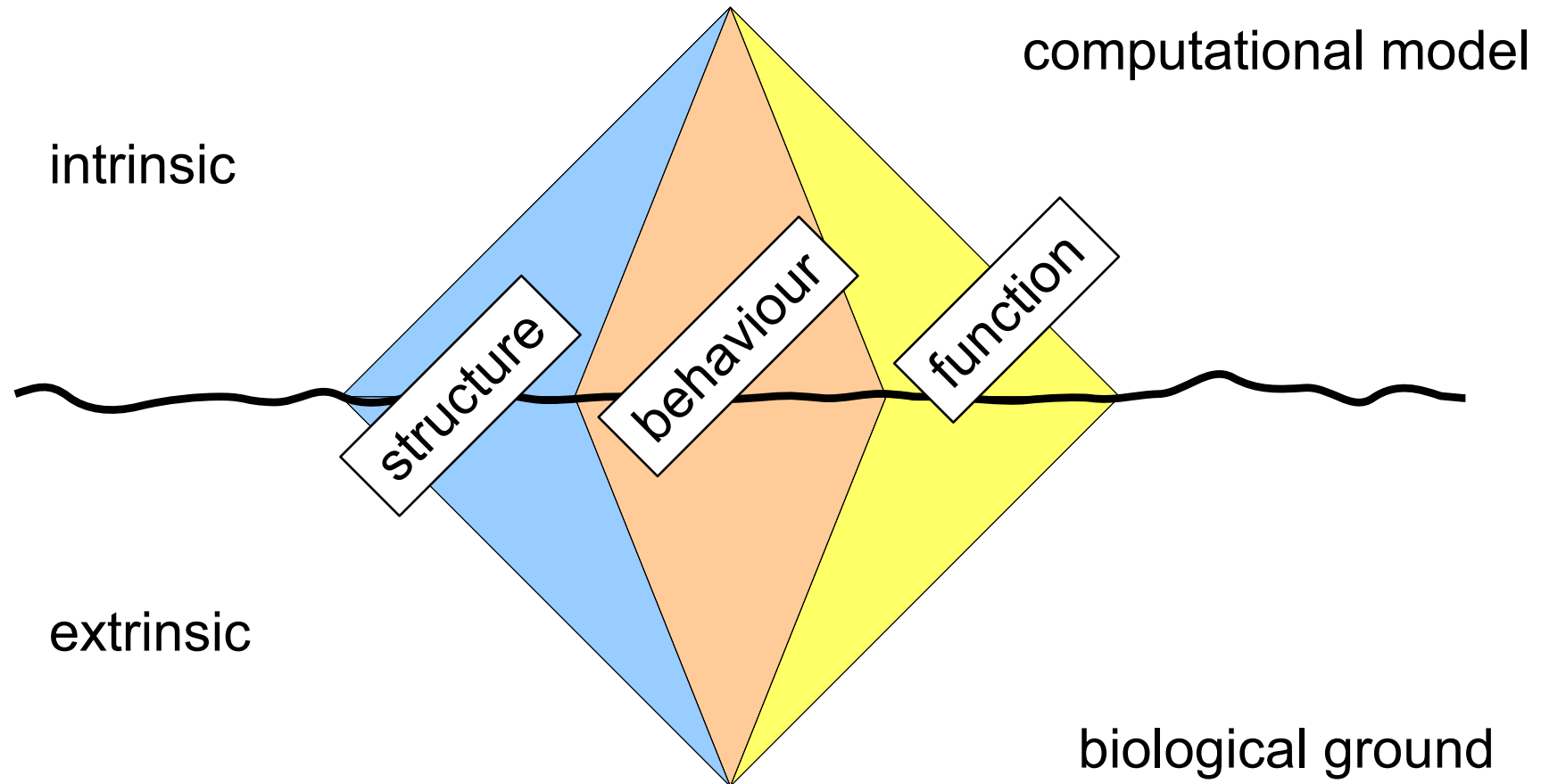
OBML Workshop, Leipzig, Germany, 26.11.2009

Bio-Model

$$d[\text{MKKK}] / dt = \frac{V_1 [\text{MKKK}]}{K_1 + [\text{MKKK}]} \times \left(1 + \frac{[\text{MAPK_PP}]}{K_I} \right)^{-m}$$

Computational Models in Systems Biology

Meaning of Bio-Models



Motivation

Structure: SBML/MathML (established)

- different aspects – SBO

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- different aspects – SBO

Behaviour: DyML (proposed)

- Systems Theory – **TEDDY**

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Structure: SBML/MathML (established)

- different aspects – SBO

Behaviour: DyML (proposed)

- Systems Theory – **TEDDY**

Function: SED-ML (drafted)

- used algorithm – **KiSAO**



Contributors

- Nicolas Le Novère, EBI Cambridge, UK
- KiSAO: Dagmar Köhn, Rostock University
- TEDDY: Christian Knüpfer, University of Jena
- community (biomodels.net, SBML, ...)

KiSAO

Kinetic Simulation Algorithm Ontology



Classification

- deterministic/stochastic rules:
EULER FORWARD vs. SMOLUCHOWSKI EQUATION
BASED METHOD
- spatial/non-spatial approaches:
GREEN'S FUNCTION REACTION DYNAMICS vs. EULER
FORWARD
- discrete/continuous variables:
CELLULAR AUTOMATA vs. LIVERMORE SOLVER
- fixed/adaptive time-step approaches:
CELLULAR AUTOMATA vs. GREEN'S FUNCTION
REACTION DYNAMICS

Algorithm Hierarchy

ALGORITHM USING STOCHASTIC RULES



is-a



GILLESPIE-LIKE STOCHASTIC SIMULATION METHOD



is-a



SUB-VOLUME STOCHASTIC REACTION-DIFFUSION ALGORITHM

Current State of KiSAO

- OBO Edit, OBO
- 61 terms
- part of MIASE project:
<http://sourceforge.net/projects/miase/>
- BioPortal

<http://www.ebi.ac.uk/compneur-srv/kisao/>



BioPortal

The screenshot shows a Mozilla Firefox browser window displaying the NCBO BioPortal website. The address bar shows the URL <http://bioportal.bioontology.org/visualize/40844>. The page title is "NCBO BioPortal: Kinetic Simulation Algorithm Ontology - kinetic simulation algorithm". The navigation menu includes "BioPortal", "Browse", "Search", "Projects", "Annotate", "All Mappings", and "All Resources Alpha". The current page is titled "Kinetic Simulation Algorithm Ontology" and shows the version "Sat Jan 24 18:58:35 2009 UTC". There are links for "Livermore solver", "Link Here", and "Subscribe". The main content area has tabs for "View Ontology Summary", "Details", "Visualization", "Notes (0)", "Mappings (0)", and "Resource Index". The "Details" tab is active, showing the following information:

- ID: KISAO:0000094
- Definition: Method to solve ordinary differential equations developed at the Lawrence Livermore National Laboratory.
- Super Class: algorithm using adaptive timesteps, algorithm using non-spatial description, algorithm using deterministic rules, algorithm using continuous variables
- Is A: algorithm using adaptive timesteps, algorithm using non-spatial description, algorithm using deterministic rules, algorithm using continuous variables

On the left side, there is a "Jump To:" field with the text "deterministic cellular automata" and a "Go" button. Below it is a "Legend" section with a tree view of the ontology structure:

- kinetic simulation algorithm
 - algorithm using adaptive timesteps
 - algorithm using continuous variables
 - code value ordinary differential equat
 - Euler backward method
 - Euler forward method
 - Livermore solver
 - partial differential equation method
 - algorithm using deterministic rules
 - algorithm using discrete variables
 - algorithm using fixed timesteps

At the bottom of the browser window, there is a search bar with the text "Suchen:" and a "Fertig" button. The search bar also includes options for "Abwärts", "Aufwärts", "Hervorheben", and "Groß-/Kleinschreibung".

TEDDY

TErminology for the DEscription of DYnamics



Aspects of Dynamics

1. Temporal Behaviour:
STABLE FIXED POINT, LIMIT CYCLE
2. Behaviour Characteristic:
PERIOD, STABILITY
3. Behaviour Diversification:
HOPF BIFURCATION, BISTABLE
BEHAVIOUR
4. Functional Motifs:
POSITIVE FEEDBACK, INTEGRATOR

Current State of TEDDY

- Protégé4, OWL
- last release: rel-2009-10-16, 135 terms
- SourceForge: SVN, tracker, file releases, discussion list, MediaWiki
- OWLdoc, BioPortal
- ChangeLog

<http://teddyontology.sourceforge.net/>

OWLDoc

The screenshot shows a Mozilla Firefox browser window with the address bar containing the URL <http://teddyontology.svn.sourceforge.net/viewvc/teddyontology/teddy/tags/current/doc/index.html>. The page title is "TEDDY documentation: rel-2009-10-16 - Mozilla Firefox".

The main content area displays the following information:

- Class: 'Subcritical Hopf Bifurcation'**
- URL: http://www.ebi.ac.uk/compneur-srv/teddy.owl#TEDDY_0000073
- Asserted Class Hierarchy**
 - + Bifurcation
 - + 'Local Bifurcation'
 - + 'Hopf Bifurcation'
 - **'Subcritical Hopf Bifurcation'**

- Annotations (5)**
- Definition: "A ``Subcritical Hopf Bifurcation" is a ``Hopf Bifurcation" in which an ``Unstable Limit Cycle" is destroyed." (string)
- DisplayName: "Subcritical Hopf Bifurcation" (string)
- Reference: "[http://www.ebi.ac.uk/compneur-srv/teddy/literature.html#kuznetsov98-bifurcation_theory, p.88](http://www.ebi.ac.uk/compneur-srv/teddy/literature.html#kuznetsov98-bifurcation_theory_p.88)" (string)
- Synonym: "Subcritical Andronov-Hopf Bifurcation (Subc-AH)" (string)
- comment: "synonym "Subcritical Andronov-Hopf Bifurcation (Subc-AH)": http://www.tbi.univie.ac.at/wiki/index.php/Classification_of_Dynamical_Behaviors" (string)
- Superclasses (2)**
- 'Hopf Bifurcation'
- hasSubPart some 'Unstable Limit Cycle'

The left sidebar contains a "Contents" menu with the following items:

- teddy
- All Resources
- All Classes (148)
- All Object Properties (9)
- All Data Properties (7)
- All Individuals (2)

Below the menu, it states: "TEDDY Release: rel-2009-10-16 OWL HTML inside, modified by Christian Knüpfer".

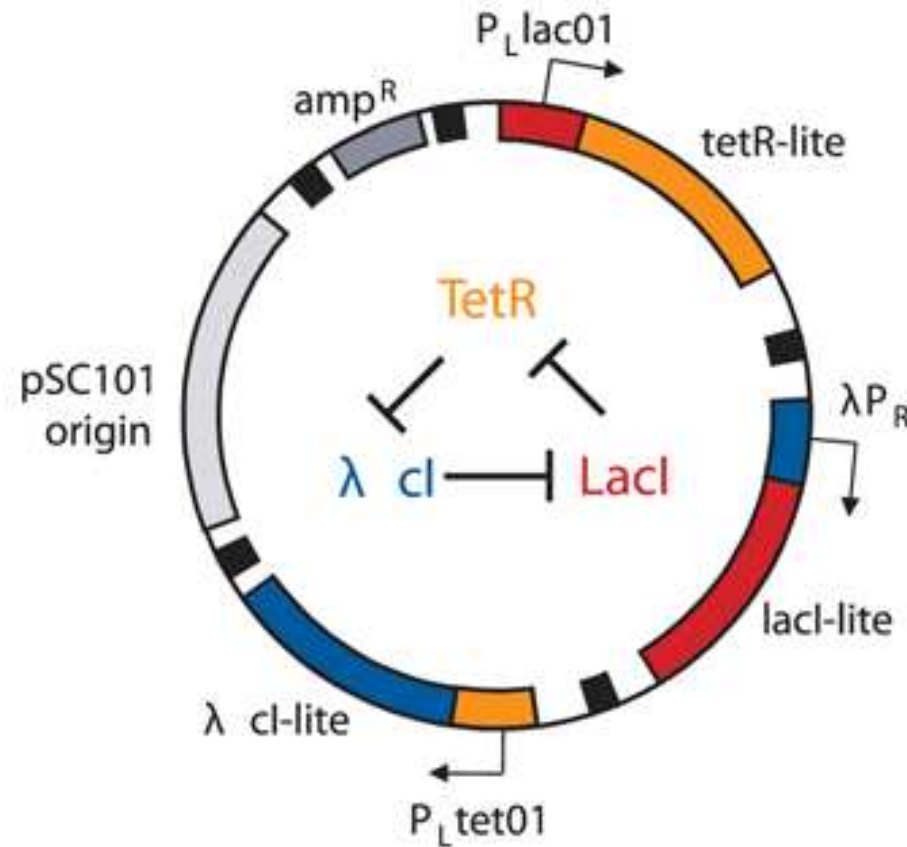
At the bottom of the sidebar, there is a list of other classes:

- 'Straight Line Shape'
- 'Strange Attractor'
- 'Strictly Decreasing (Antitonic)'
- 'Strictly Increasing (Isotonic)'
- 'Strictly Monotonic'
- 'Subcritical Hopf Bifurcation'
- 'Subcritical Pitchfork Bifurcation'
- 'Supercritical Hopf Bifurcation'
- 'Supercritical Pitchfork Bifurcation'
- 'Sustained Oscillation ((obsolete))'
- 'TEDDY Entity'
- 'Temporal Behaviour'

The bottom of the browser window shows a search bar with the text "Suchen:" and a search button. Below the search bar are navigation buttons: "Abwärts", "Aufwärts", "Hervorheben", and "Groß-/Kleinschreibung". The status bar at the very bottom says "Fertig".

Example

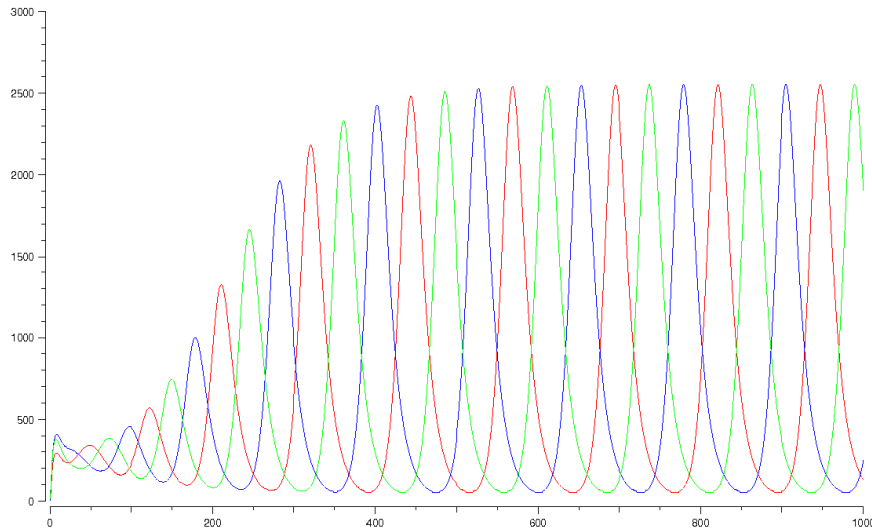
BIOMD0000000012



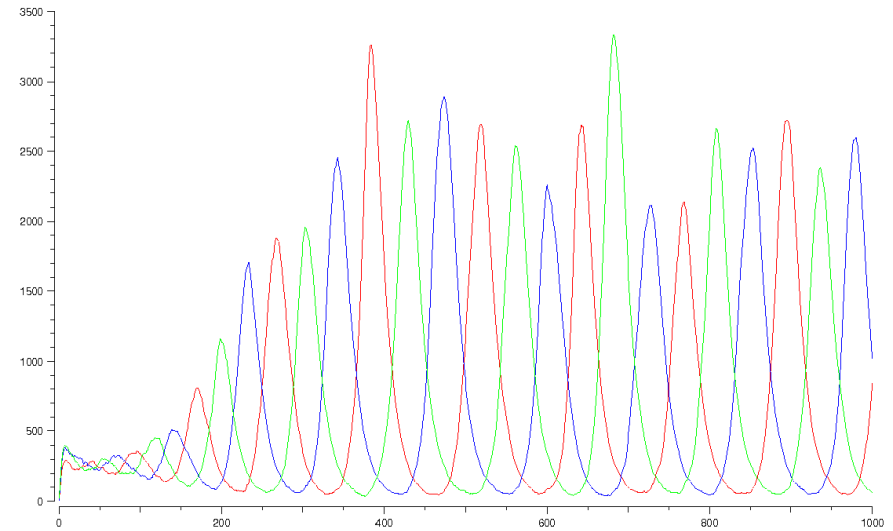
Repressilator plasmid from *M.B. Elowitz and S. Leibler: A synthetic oscillatory network of transcriptional repressors. Nature 403(6767), Jan. 2000, pp. 335–338.*

Simulations

deterministic algorithm



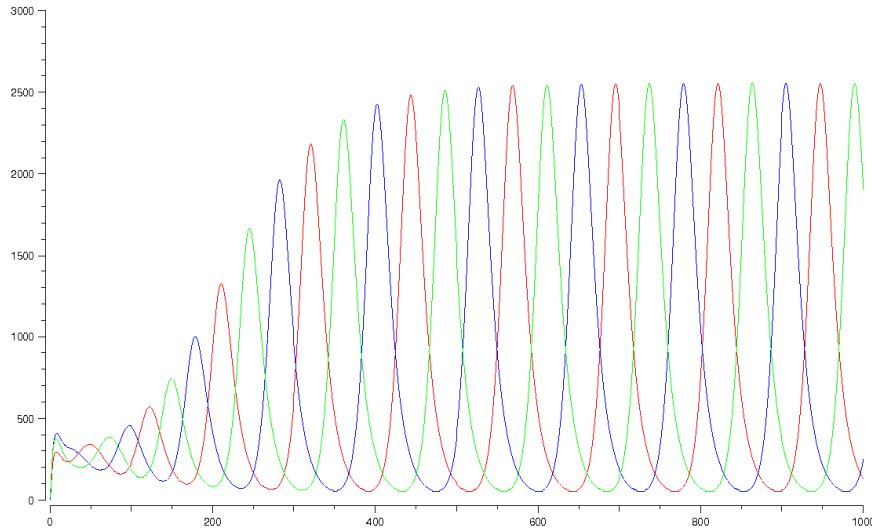
stochastic algorithm



LIVERMORE SOLVER FOR
ORDINARY DIFFERENTIAL
EQUATIONS WITH AUTOMATIC
METHOD SWITCHING
(KiSAO:0000088)

GIBSON AND BRUCK'S NEXT
REACTION METHOD
(KiSAO:0000027)

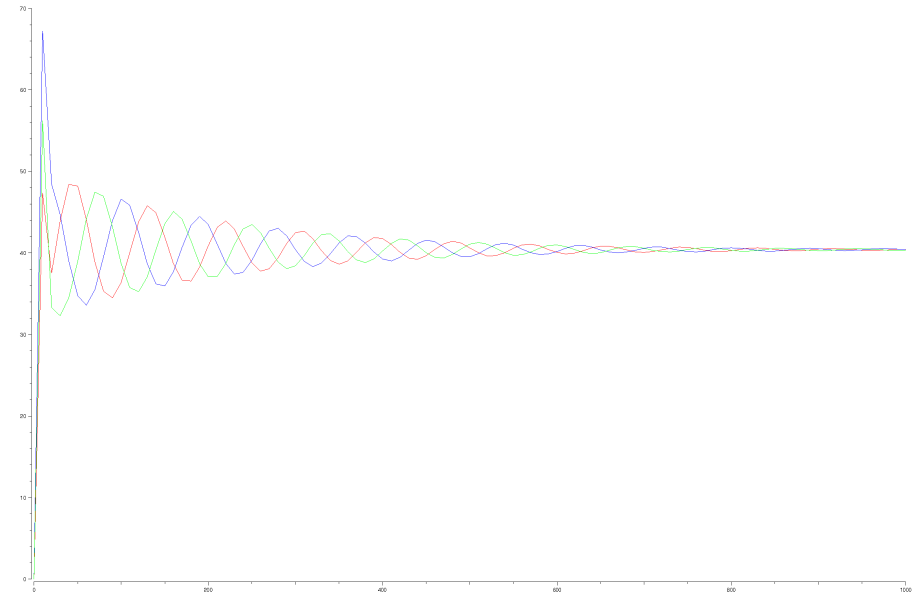
Possible Behaviours



STABLE LIMIT CYCLE
(TEDDY_0000114)

dependsOn

NEGATIVE FEEDBACK
(TEDDY_0000034)

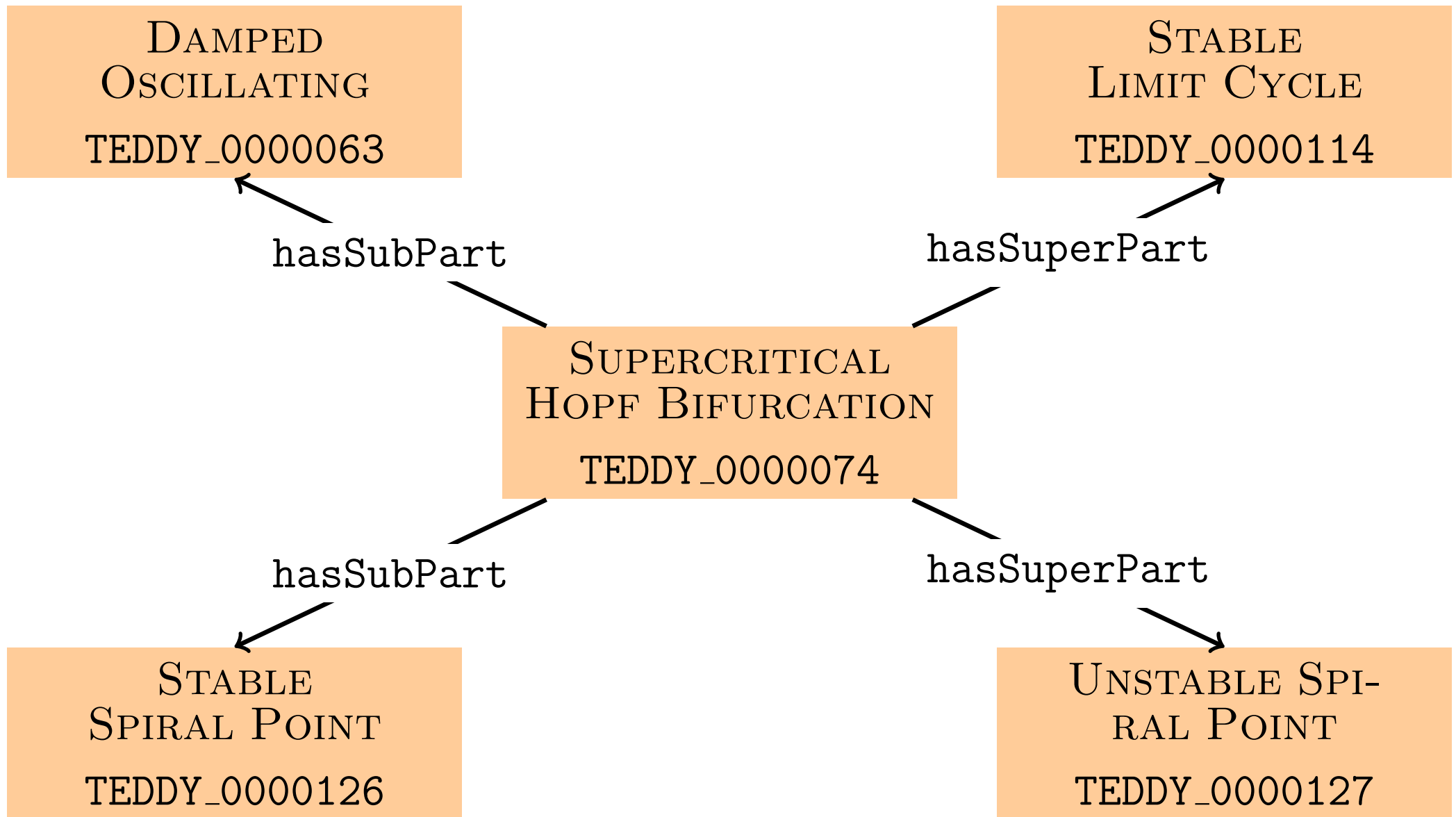


DAMPED OSCILLATING
(TEDDY_0000063)

convergeTo

STABLE SPIRAL POINT
(TEDDY_0000126)

Bifurcation



Conclusion

