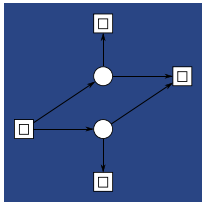


Brandenburg
University of Technology
Cottbus

A Framework for Modular Modeling and Analysis of Signaling Networks

Fei Liu, Monika Heiner

Department of Computer Science
Brandenburg University of Technology Cottbus

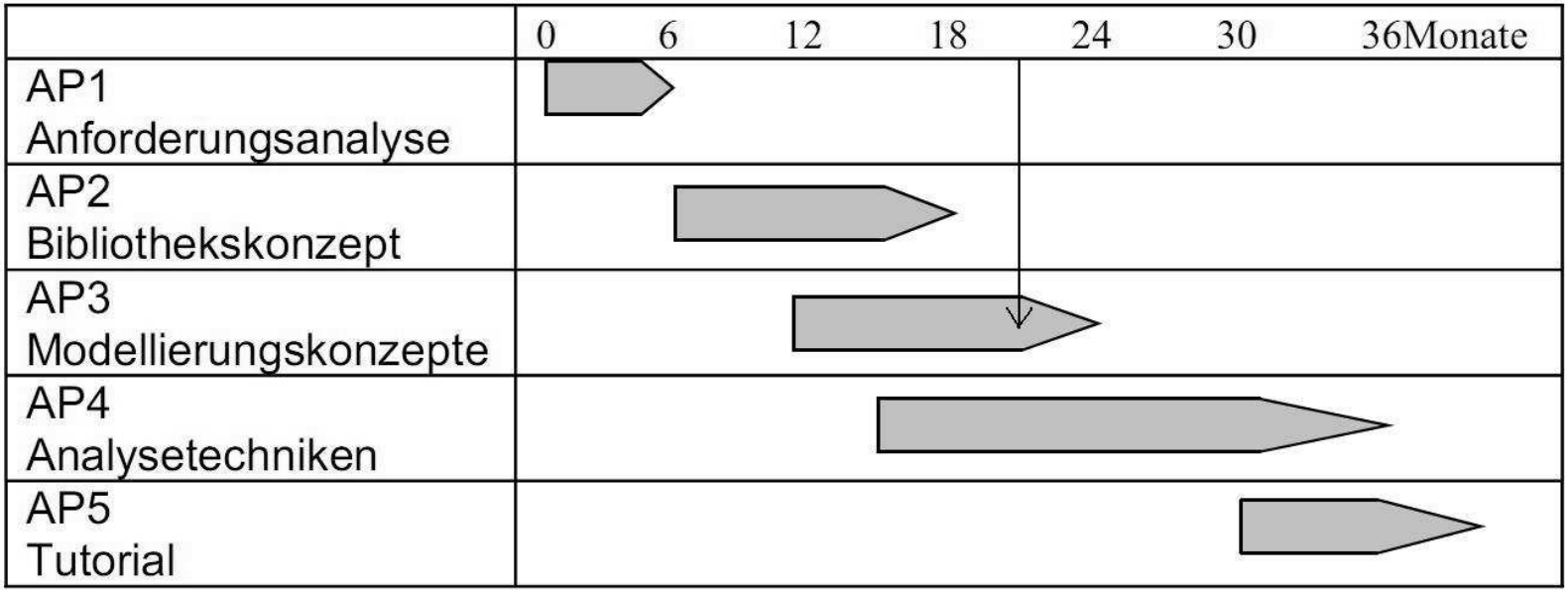
MOPS meeting, Berlin
November 1, 2010

Project Milestones

Project milestones

- WP1 - Requirements analysis
- WP2 - Library approach for generic model components
- WP3 - Modeling concepts for dealing with model alternatives
- WP4 - Analysis techniques for identification and behavior comparison of model components
- WP5 - Tutorial

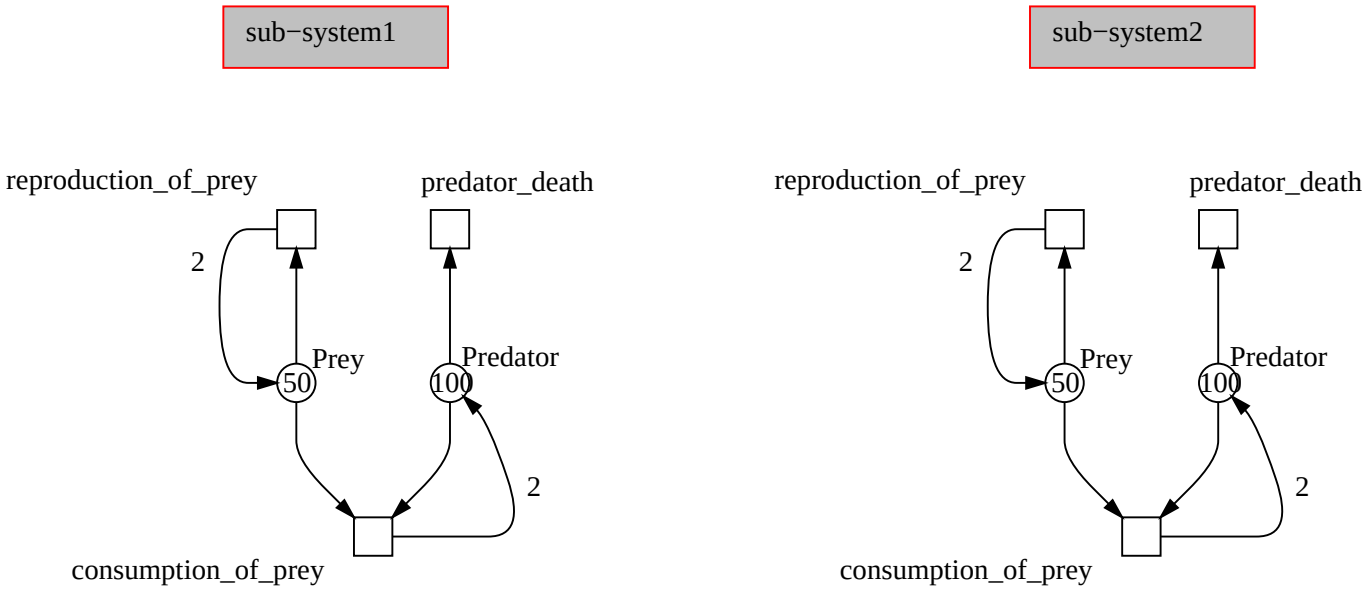
Schedule


0
6
12
18
24
30
36Monate
AP1
Anforderungsanalyse
AP2
Bibliothekskonzept
AP3
Modellierungskonzepte
AP4
Analysetechniken
AP5
Tutorial

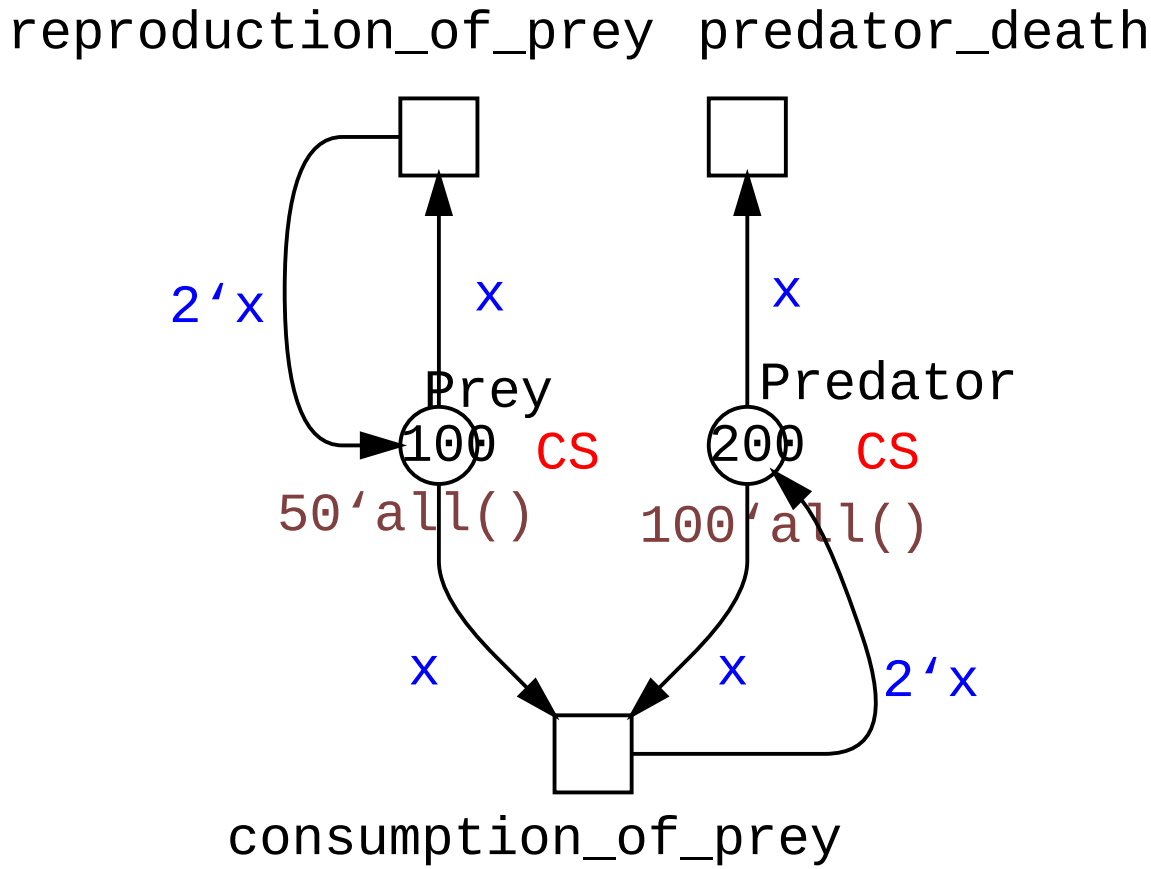
Introduction

Prey-Predator

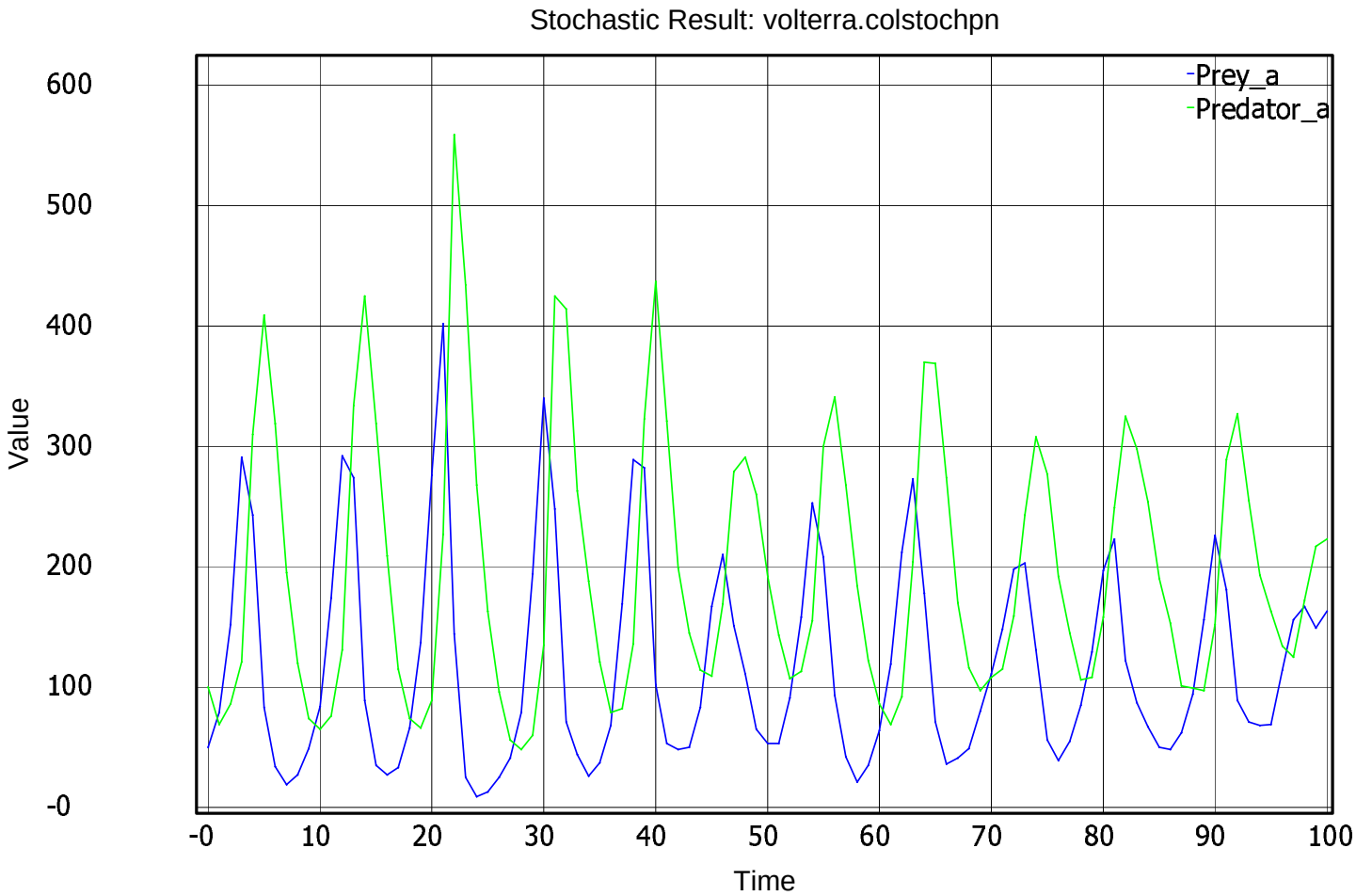
Petri net model for the Prey-Predator relationship



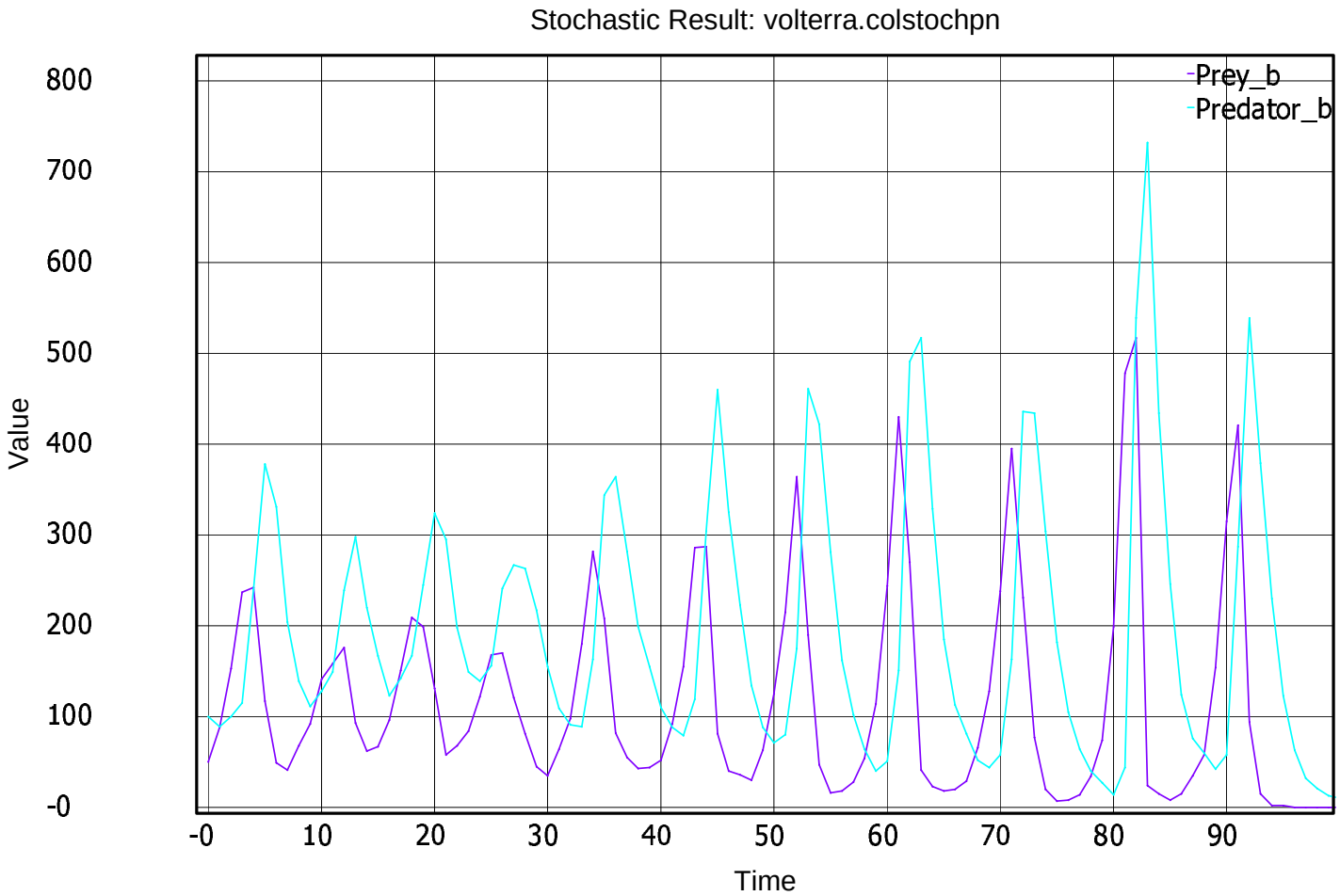
Colored Petri net model for the Prey-Predator relationship



Colored Petri net model for the Prey-Predator relationship



Colored Petri net model for the Prey-Predator relationship



Why use colored Petri nets

- Compact and readable representation,
- Scalable models,
- Increasing net size = increasing color sets,
- Analysis techniques of low-level Petri nets by automatic unfolding,
- Analysis techniques of high-level Petri nets.

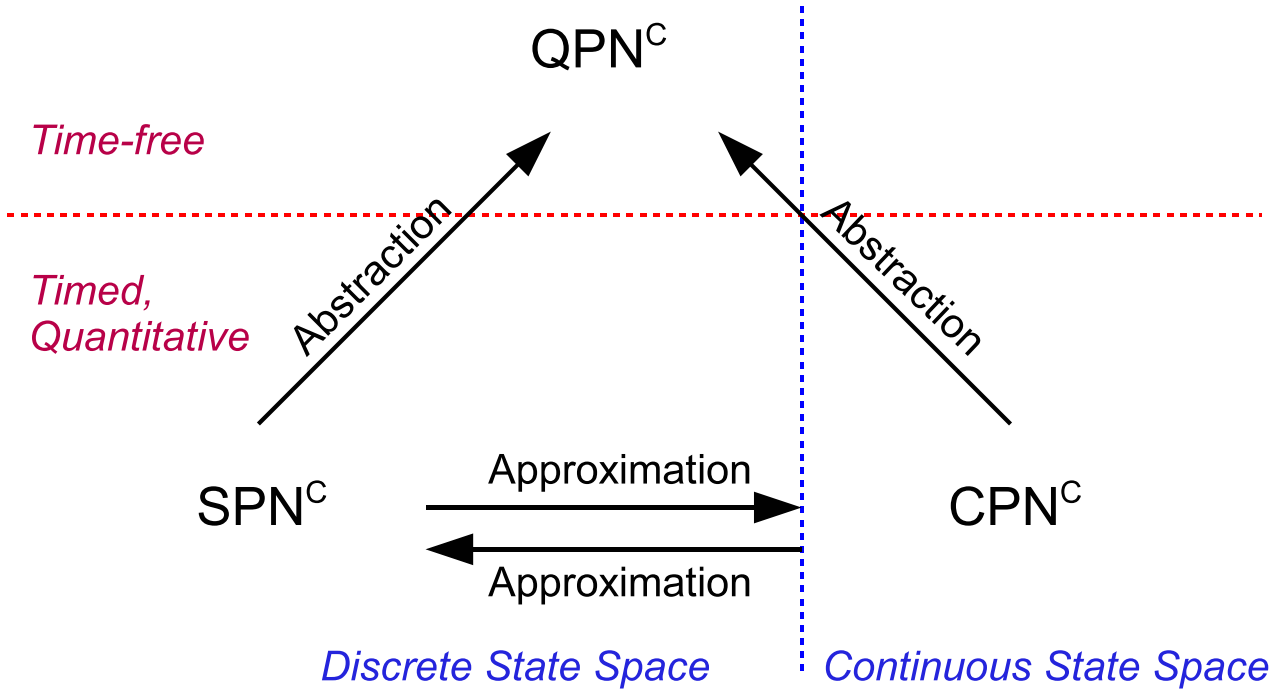
Project Results

May 2010 – November 2010

Overview of main results

- Framework and Prototypes
- Implementation details
- Case studies

Colored Petri nets-based framework



Colored qualitative Petri net (QPN^C)

- A colored extension of extended P/T net,

  e.g., inhibitor arc, read arc, equal arc and reset arc,

- Predefined data types for color set definition:
  - Simple types: dot, integer, string, Boolean, enumeration, index,
  - Compound types: product, union.

Colored stochastic Petri net (SPN^C)

- A colored extension of

  biochemically interpreted extended stochastic Petri nets,
- Many features helpful for modeling biological systems,

  e.g., initial marking definition, rate function definition.

Colored continuous Petri net (CPN^C)

- A colored extension of

  biochemically interpreted continuous Petri nets,

- Many features helpful for modeling biological systems,

  e.g., initial marking definition, rate function definition.

Features for modeling

- Drawing of the Petri net graph as usual.
- Rich data types for color set definition: dot, int, string, bool, enum, index, product, union.
- User-defined functions.
- Concise specification of initial marking for larger color sets.
- Rate function definition for each transition instance.
- Several extended arc types, such as inhibitor arc, read arc, equal arc, reset arc, and modifier arc.
- Several special transitions: stochastic transitions with freestyle rate functions, immediate transitions, deterministic transitions, and scheduled transitions.
- Highlighting the markings, color sets, guards, and expressions.

Features for animation (for QPN^C/SPN^C)

- Automatic animation,
- Single-step animation by manually choosing a binding.

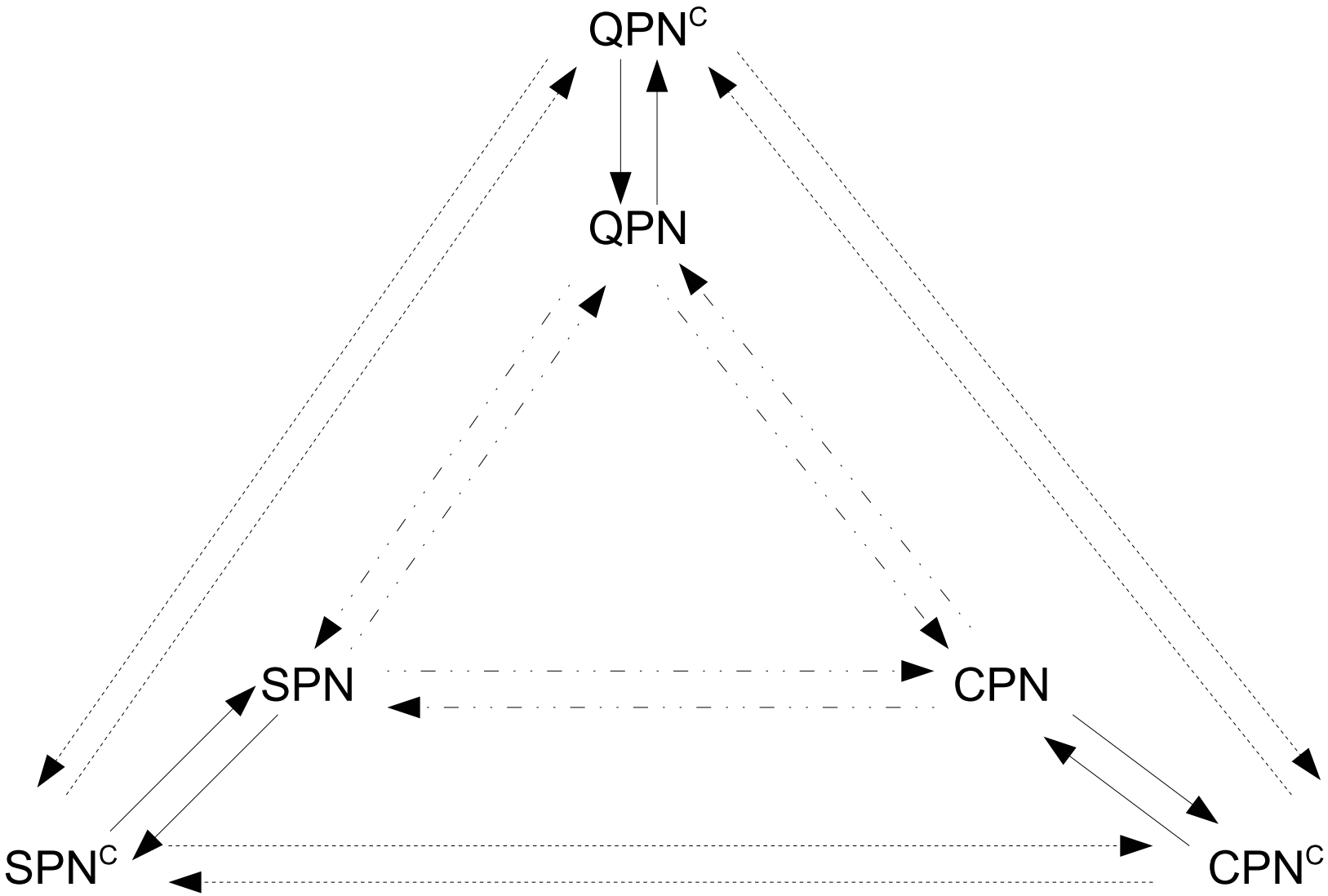
Features for simulation (for SPN^C/CPN^C)

- Simulation is done on an automatically unfolded Petri net.
- Show or export simulation results for colored or uncolored places/transitions separately or together.
- Several simulation algorithms to simulate SPN^C, including the Gielespie stochastic simulation algorithm (SSA) [Gil77].
- Several simulation algorithms to simulate CPN^C, including the Euler algorithm, Runge-Kutta algorithm etc.

Features for export

- QPN^C, SPN^C and CPN^C are exported to different net formalisms within Snoopy,
- Export/import beyond Snoopy, e.g., export to CPN tools.

Export relationships among different net formalisms



Other results

- Manual for $QPN^C/SPN^C/CPN^C$,
- Algorithm for computation of enabled transition instances for colored Petri nets,
- Algorithm for unfolding of colored Petri nets.

Case studies

- the cooperative ligand binding,
- the C. elegans vulval development,
- the repressilator,
- the halobacterium phototaxis,
- Ca^{2+}-regulated intracellular Ca^{2+} channels,
- pain switch.

Next Steps

Next steps

- Continue to color pain switch models,
- Improve the manual for colored Petri nets,
- Improve colored continuous Petri nets,
- Develop analysis techniques for colored stochastic Petri nets,
- Coupling with the database developed by M2,
  needs to be discussed.

Thank You !

Begin to demonstrate $QPN^C / SPN^C / CPN^C$