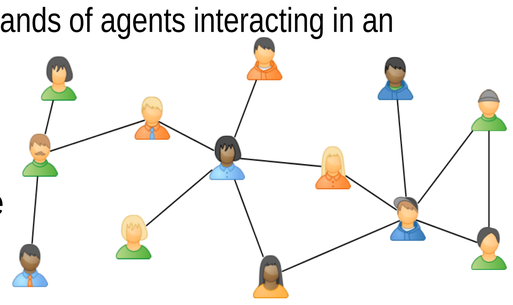
Universität Rostock

Traditio et Innovatio

ML3: A Domain-Specific **M**odeling **L**anguage for Simulating **L**inked **L**ives

Motivation

- Agent-based simulation plays an important role in the social sciences: Migration, Healthcare, Epidemics, Partnership Formation
- **Linked Lives Models:** tens of thousands of agents interacting in an intricate social network
- **Requirements:**
  - Expressiveness and succinctness
  - Discrete events in continuous time
  - CTMC or Semi-Markov semantics



State of the art:

python™ repast

- Model and simulation closely intertwined
- No support for continuous time

Modeling Language

New **domain-specific modeling language** ML3 [1]

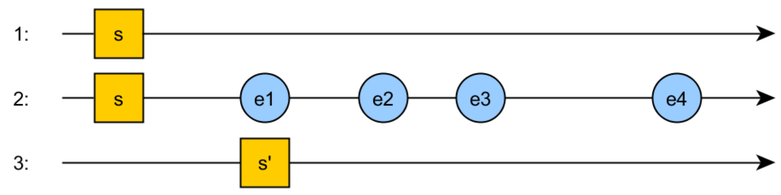
- Focus on **agents** and their **social networks**
- Behavior modeled as competing **guarded commands**

using domain metaphors — tailored to domain problems

```
Person
// Guard: Who can it happen to?
| ego.sex = "f“, ego.isMarried()
// Rate: When will it happen?
@ if now < transitionYear
  then growingPopBirthRate[?wife.age]
  else steadyPopBirthRate[?wife.age]
// Effect: What will happen?
-> ?child := new Person( sex := ["m", "f"].random(),
                         sec := ?wife.sec ),
   ?child.parents := ego + ego.spouse,
where ?wife := ego.wife();
```

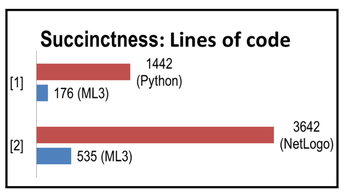
arbitrary functions — OOP-like and imperative syntax

Stochastic race / competing risk: All possible events are scheduled and the first one is executed



Results:

- ✓ Expressive and succinct [1][2]
- ✓ Discrete events in continuous time
- ✓ Inhomogeneous CTMC semantics




```
// Link declaration:
parents:Person[2] <->
  [0-]Person:children;
```

Future work:

- Ease of use? → user studies
- Syntax cleanup
- Formalize semantics

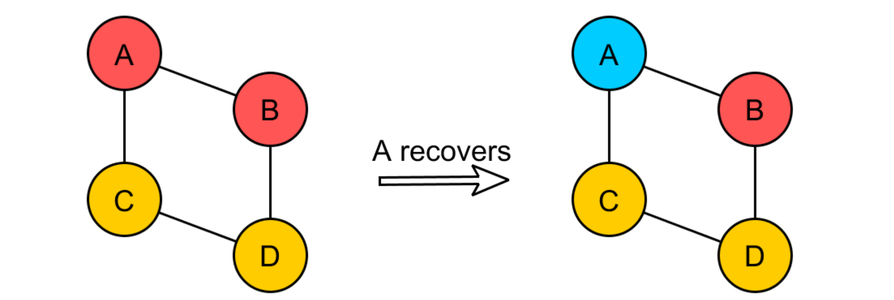
Simulation Algorithms

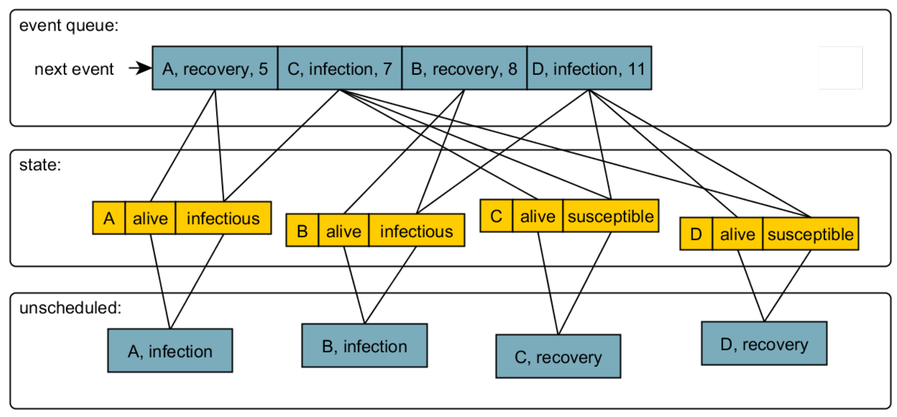
Stochastic Simulation Algorithm

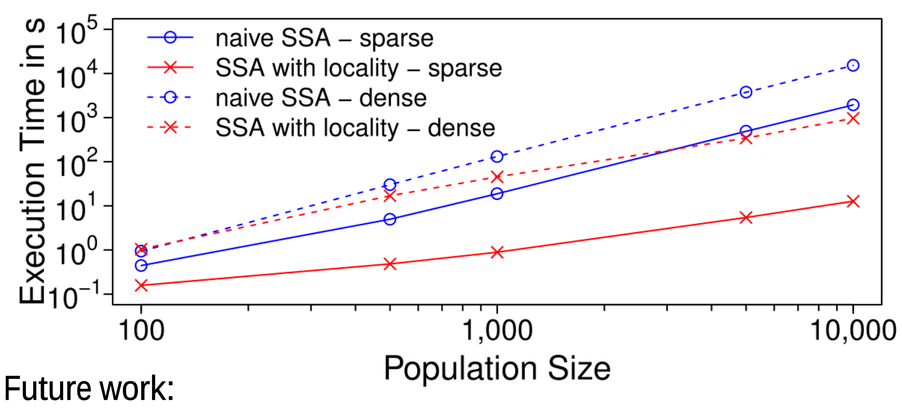
Challenges:

- Tens of thousands of heterogeneous agents in a dynamic network
- Time-dependent transition rates
- Complex interactions and effects

Exploitation of locality [3] of events in the social network with to reduce rescheduling and therefore runtime







Future work:

- Approximation
- Parallelization

ML3 simulators: git.informatik.uni-rostock.de/mosi/ml3
ML3 Sandbox: jamesii.informatik.uni-rostock.de/software/ml3-sandbox-0.0.1.zip

References

[1] T. Warnke, A. Steiniger, A. Klabunde, F. Willekens, A. Uhrmacher. “ML3: A Language for Compact Modeling of Linked Lives in Computational Demography". Winter Simulation Conference, 2015. [2] T. Warnke, O. Reinhardt, A. Klabunde, F. Willekens, A. Uhrmacher. "Modeling and Simulation Decision Processes of Linked Lives - An Approach Based on Concurrent Processes and Stochastic Race". In: Population Studies (to appear). [3] O. Reinhardt, A. Uhrmacher. "An Efficient Simulation Algorithm for Continuous-Time Agent-Based Linked Lives Models". 2017 Spring Simulation Multi-Conference, 2017.

Oliver Reinhardt, Adelinde M. Uhrmacher

INSTITUTE OF COMPUTER SCIENCE | MODELING AND SIMULATION GROUP

University of Rostock, Albert-Einstein-Str. 22 | 18055 Rostock, Germany

www.mosi.informatik.uni-rostock.de/mosi