Monitoring Software Quality by Means of Simulation Methods

Daniel Honsel, Verena Honsel, Marlon Welter,
Stephan Waack, and Jens Grabowski

Institute of Computer Science
Georg-August-Universität Göttingen

Ciudad Real, September 8th, 2016

Outline

1. Introduction

Motivation

simulation tool

project manager

consults

parameter set

p_1 = number of developers

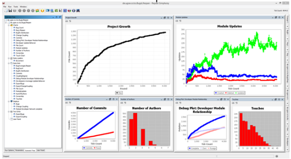
p_2 = core developer leaves project

.
.
.

p_n = project duration

simulation runs

running simulation model tailored towards specific question: what happens if the core developer leaves the project?



simulation output

support for decisions

Goal: Evaluating the quality of a project under simulation according to a specific question.

Approach: interaction of 3 research areas

Starting with a concrete question: **What happens if the core developer leaves the project?**

Mining software repositories: Estimate model parameters
Source: open source repositories

Agent-based modeling and simulation: Create a model that answers the question
- Adjust it with mined parameters
- Running the simulation generates, for example, software dependency graphs

Automated Assesment: Evaluate the simulation results with Conditional Random Fields

Approach: interaction of 3 research areas

Starting with a concrete question: **What happens if the core developer leaves the project?**

Mining software repositories: Estimate model parameters
Source: open source repositories

Agent-based modeling and simulation: Create a model that answers the question

- Adjust it with mined parameters
- Running the simulation generates, for example, software dependency graphs

Automated Assesment: Evaluate the simulation results with Conditional Random Fields

Approach: interaction of 3 research areas

Starting with a concrete question: **What happens if the core developer leaves the project?**

Mining software repositories: Estimate model parameters
Source: open source repositories

Agent-based modeling and simulation: Create a model that answers the question

- Adjust it with mined parameters
- Running the simulation generates, for example, software dependency graphs

Automated Assesment: Evaluate the simulation results with Conditional Random Fields

Approach: interaction of 3 research areas

Starting with a concrete question: **What happens if the core developer leaves the project?**

Mining software repositories: Estimate model parameters
Source: open source repositories

Agent-based modeling and simulation: Create a model that answers the question
- Adjust it with mined parameters
- Running the simulation generates, for example, software dependency graphs

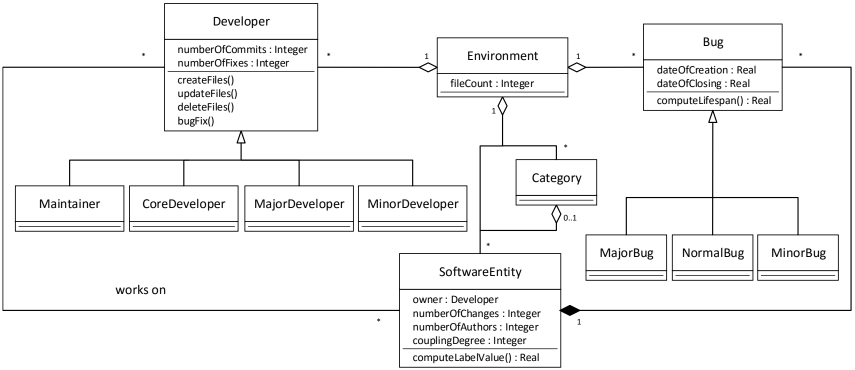
Automated Assesment: Evaluate the simulation results with Conditional Random Fields

2. Agent-Based Simulation Model

Which entities do we have to consider?

- **Software entities** are **passive** agents
- **Bugs** are **passive** agents
- **Developers** are **active** agents, their commits are responsible for the evolutionary process.
  - Update
  - Create
  - Delete
  - Bugfix

Agent-based model for software evolution



Which dependencies are considered?

Dependencies are represented as networks. The following ones are modeled:

Developer – Entity: A weighted graph representing the work of developers on entities. Provides owner, number of authors and changes.

Bug – Entity: Bug assignment to an entity.

ChangeCoupling: Dependencies between entities that are changed together several times. Input for the automated assessment.

Which dependencies are considered?

Dependencies are represented as networks. The following ones are modeled:

Developer – Entity: A weighted graph representing the work of developers on entities. Provides owner, number of authors and changes.

Bug – Entity: Bug assignment to an entity.

ChangeCoupling: Dependencies between entities that are changed together several times. Input for the automated assessment.

Which dependencies are considered?

Dependencies are represented as networks. The following ones are modeled:

Developer – Entity: A weighted graph representing the work of developers on entities. Provides owner, number of authors and changes.

Bug – Entity: Bug assignment to an entity.

ChangeCoupling: Dependencies between entities that are changed together several times. Input for the automated assessment.

Which dependencies are considered?

Dependencies are represented as networks. The following ones are modeled:

Developer – Entity: A weighted graph representing the work of developers on entities. Provides owner, number of authors and changes.

Bug – Entity: Bug assignment to an entity.

ChangeCoupling: Dependencies between entities that are changed together several times. Input for the automated assessment.

Commit behavior

- **Number** of software entities to be created, updated, or deleted have to be determined
- Entity **selection** for updates
  - Select **first entity randomly**
  - **Further entities** will be selected **based on** information about the **first** one and dependency networks
- Apply the **commit**
  - **Change** involved **entities** and **networks**
  - **Bugfix** if possible

Commit behavior

- **Number** of software entities to be created, updated, or deleted have to be determined
- Entity **selection** for updates
  - Select **first entity randomly**
  - **Further entities** will be selected **based on** information about the **first** one and dependency networks
- Apply the **commit**
  - **Change** involved **entities** and **networks**
  - **Bugfix** if possible

Commit behavior

- **Number** of software entities to be created, updated, or deleted have to be determined
- Entity **selection** for updates
  - Select **first entity randomly**
  - **Further entities** will be selected **based on** information about the **first** one and dependency networks
- Apply the **commit**
  - **Change** involved **entities** and **networks**
  - **Bugfix** if possible

Commit behavior

- **Number** of software entities to be created, updated, or deleted have to be determined
- Entity **selection** for updates
  - Select **first entity randomly**
  - **Further entities** will be selected **based on** information about the **first** one and dependency networks
- Apply the **commit**
  - **Change** involved **entities** and **networks**
  - **Bugfix** if possible

What means quality for the assessment?

Entity-wise **label** quantifies bugs assigned to a software entity.

- **Label-value** is **product** of bug factors assigned to a entity
  - Label-value initialized with 1
  - Each bug type has a factor < 1
- Each entity is preliminary labeled as **acceptable** (Label-value > 0.8) or **problematic** (otherwise).
- Simulated ChangeCoupling graph containing the labels serves as input for CRF assessment.

What means quality for the assessment?

Entity-wise **label** quantifies bugs assigned to a software entity.

- **Label-value** is **product** of bug factors assigned to a entity
  - Label-value initialized with 1
  - Each bug type has a factor < 1
- Each entity is preliminary labeled as **acceptable** (Label-value > 0.8) or **problematic** (otherwise).
- Simulated ChangeCoupling graph containing the labels serves as input for CRF assessment.

What means quality for the assessment?

Entity-wise **label** quantifies bugs assigned to a software entity.

- **Label-value** is **product** of bug factors assigned to a entity
  - Label-value initialized with 1
  - Each bug type has a factor < 1
- Each entity is preliminary labeled as **acceptable** (Label-value > 0.8) or **problematic** (otherwise).
- Simulated ChangeCoupling graph containing the labels serves as input for CRF assessment.

What means quality for the assessment?

Entity-wise **label** quantifies bugs assigned to a software entity.

- **Label-value** is **product** of bug factors assigned to a entity
  - Label-value initialized with 1
  - Each bug type has a factor < 1
- Each entity is preliminary labeled as **acceptable** (Label-value > 0.8) or **problematic** (otherwise).
- Simulated ChangeCoupling graph containing the labels serves as input for CRF assessment.

3. Case Study and Results

Simulate the effect of a lost core developer

We have

- Simulation model parametrized according to K3b

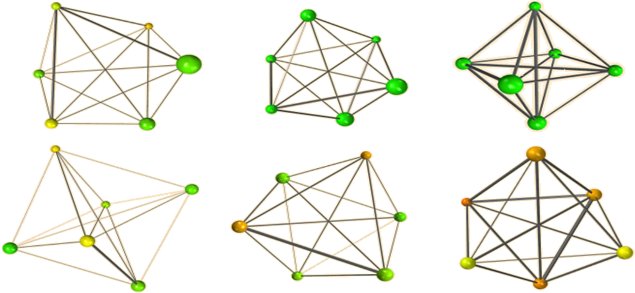


Figure: Assessment of K3b (CRF category labeling, green nodes are acceptable and red ones are problematic).

Quality trend of other projects

Change simulation parameters only for **effort**, **size**, and **duration** of other projects.

- Checked repeatable results successfully for Log4J and Kate
- Trend of the two simulation runs is similar as for K3b.
- With lost core developer 12% – 20% fewer bugs are fixed.

4. Conclusion

Conclusion

We are able to assess the quality of software under simulation

- Parameters to adjust: effort, size, and duration.

Next steps to improve the simulation model:

- Bug introducing related to commits
  - Depending on the ownership and coupling degree
- Reduce randomness when selecting entities for a commit
  - BDI: developers formulate goals and build plans to reach them
  - Goals: add feature, bugfix, reduce complexity, ...

Conclusion

We are able to assess the quality of software under simulation

- Parameters to adjust: effort, size, and duration.

Next steps to improve the simulation model:

- Bug introducing related to commits
  - Depending on the ownership and coupling degree
- Reduce randomness when selecting entities for a commit
  - BDI: developers formulate goals and build plans to reach them
  - Goals: add feature, bugfix, reduce complexity, ...

Conclusion

We are able to assess the quality of software under simulation

- Parameters to adjust: effort, size, and duration.

Next steps to improve the simulation model:

- Bug introducing related to commits
  - Depending on the ownership and coupling degree
- Reduce randomness when selecting entities for a commit
  - BDI: developers formulate goals and build plans to reach them
  - Goals: add feature, bugfix, reduce complexity, ...

Literature

V. Honsel.
Statistical learning and software mining for agent based simulation of software evolution.
In *Doctoral Symposium at the 37th International Conference on Software Engineering (ICSE)*, 2015.

Verena Honsel, Steffen Herbold, and Jens Grabowski.
Hidden markov models for the prediction of developer involvement dynamics and workload.
In *12th International Conference on Predictive Models and Data Analytics in Software Engineering (PROMISE)*, 2016.

Verena Honsel, Daniel Honsel, and Jens Grabowski.
Software process simulation based on mining software repositories.
In *ICDM Workshop*, 2014.

Verena Honsel, Daniel Honsel, Jens Grabowski, and Stephan Waack.
Developer Oriented and Quality Assurance Based Simulation of Software Processes.
In *Proceedings of the Seminar Series on Advanced Techniques & Tools for Software Evolution (SATToSE) 2015*, July 2015.

Verena Honsel, Daniel Honsel, Steffen Herbold, Jens Grabowski, and Stephan Waack.
Mining software dependency networks for agent-based simulation of software evolution.
In *2015 30th IEEE/ACM International Conference on Automated Software Engineering Workshop (ASEW)*, pages 102–108. IEEE, 2015.

Gerhard Weiss.
Multiagent Systems.
MIT Press, 2013.