Jahresbericht 2021

Prof. Dr. Holger Giese
Fachgebiet Systemanalyse und Modellierung

Hasso-Plattner-Institut für
Digital Engineering gGmbH

Campus Griebnitzsee
Universität Potsdam

Hasso Plattner Institut
Digital Engineering · Universität Potsdam

Jahresbericht / Annual Report 2021

Fachgebiet Systemanalyse und Modellierung
Hasso-Plattner-Institut für Digital Engineering
Universität Potsdam

Hasso Plattner Institut
Digital Engineering • Universität Potsdam

Fachgebiet *Systemanalyse und Modellierung*
Hasso-Plattner-Institut für Digital Engineering gGmbH
Universität Potsdam
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Leitung: Prof. Dr. Holger Giese

http://www.hpi.de/giese

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1 Personelle Zusammensetzung / Staff

Leiter des Fachgebiets / Head
Prof. Dr. Holger Giese

Sekretariat / Secretary
Kerstin Miers

Senior Researcher
Dr. Leen Lambers (01.07.2015–30.06.2021)

Postdocs
Dr. Maria Maximova
Dr. Sven Schneider

Wissenschaftliche Mitarbeiter / Research Assistants
Matthias Barkowsky, M.Sc.
Lucas Sakizloglou, M.Sc. (1.1.2021–31.3.2021)
Christian Zöllner, M.Sc.

PhD-Stipendiaten / Scholarship Holders
Christian Adriano, M.Sc.
Dipl.-Wirtsch.Inf. Thomas Brand (until 31.10.2021)
Sona Ghahremani, M.Sc.
Mustafa Ghani, M.Sc.
Iqra Zafar, M.S
He Xu, M.Sc.

Externe PhD-Studierende / External PhD Students
Dipl.-Inform. Joachim Hänsel

Extern
Dr. Dominique Blouin
Dr. Soumyadip Bandyopadhyay

Studentische Hilfskräfte / Student Assistants

Maximilian Böther	Nils Cichy	Julian Egbert
Konrad Gerlach	Leander Masopust	Dale Nows
Patricia Sowa	Ben Wegener	Simon Wietheger

2 Lehrveranstaltungen / Courses

2.1 Vorlesungen / Lectures

Sommersemester / Summer term 2021

- Modellierung II

Wintersemester / Winter term 2021/2022

- Modellierungssprachen und Formalismen

2.2 Übungen/Projekte / Exercises/Projects

Sommersemester / Summer term 2021

- Modellierung II

Wintersemester / Winter term 2021/2022

- Modellierungssprachen und Formalismen

2.3 Seminare / Seminars

Sommersemester / Summer term 2021

- Highly Scalable Systems
- Machine Learning-based Control of Dynamical Systems
- Quantum Programming

Wintersemester / Winter term 2021/2022

- Adversarial Self-Supervised Learning with Digital-Twins
- Artificial Intelligence, ethics and engineering
- Graph Neural Networks - Applications & Link to Graph Queries
- Modellierung eingebetteter Systeme mittels Graphtransformation

3 Betreuung von Studierenden und Dissertationen / Supervised Students and Dissertations

3.1 Betreuung von Bachelorprojekten / Supervised Bachelor projects

3.1.1 Abgeschlossene Bachelorprojekte / Finished Bachelor's projects

Human-in-the-loop-Simulation von MANV-Lagen als Übung für den Bevölkerungsschutz / Human-in-the-loop-Simulation of Mass Casualty Incidents as Training for Emergency Medical Personnel

Zeitraum / Project Period: ab 10/2020 bis 07/2021

Kooperationspartner / Project Partners:

- Malteser Hilfsdienst e.V. Berlin ↗website
- Bundesakademie für Bevölkerungsschutz und Zivile Verteidigung (BABZ, ehemals AKNZ) des Bundesamtes für Bevölkerungsschutz und Katastrophenhilfe (BBK) ↗website
- Berliner Feuerwehr- und Rettungsdienstakademie (BFRA) ↗website

Motivation Ein Massenanfall von Verletzten (MANV) ist ein Großschadensereignis, bei dem die personellen oder materiellen Ressourcen nicht zur adäquaten Behandlung von allen Verletzten ausreichen, sodass auf besondere Verfahren der Katastrophenmedizin zurückgegriffen werden muss. Aufgrund der seltenen Einsätze und dem daraus resultierenden Erfahrungsdefizit ist das regelmäßige Training solcher Situationen aber für das kompetente Handeln aller Einsatzkräfte essentiell. Speziell für ehrenamtliche Einsatzkräfte im Bevölkerungsschutz sind möglichst einfache und kostengünstige Trainingsmöglicheiten daher besonders wichtig.

Problem Das Training erfolgt üblicherweise durch das (sehr aufwändige und teure) Nachstellen von MANV-Lagen mit Verletztendarstellerinnen. Es gibt zudem einige Simulationssysteme für Trainingszwecke. Eines der bekanntesten ist die dynamische Patientensimulation (dPS) von der AKNZ, welche die Patientenversorgung bei MANV-Lagen mit laminierten Karten und Aufklebern simuliert. Allerdings sind auch Übungen mit der dPS weiterhin mit vergleichsweise hohen Materialkosten und Durchführungsaufwand sowie einer formatbedingte Übungskünstlichkeit verbunden.

Lösung Das Bachelorprojektteam entwickelt eine digitale Variante der dPS, mit der MANV-Lagen einfach und kostengünstig trainierbar werden sollen. Auch die Übungskünstlichkeit soll reduziert werden. Dabei wird eine Serverkomponente entwickelt sowie eine App, die auf den Endgeräten der Übungsteilnehmer laufen kann. Dank der Kooperation mit der AKNZ kann das Team dabei die originalen Datensätze der dPS nutzen, dank der beiden Projektpartner in Berlin steht für das Projekt ein großer Pool an potentiellen Testbenutzern zur Verfügung.

Ansprechpartner / Contact: Christian Zöllner, Matthias Barkowsky.

↗website

3.1.2 Laufende Bachelorprojekte / Running Bachelor's projects

Ein digitales Führungssimulationstraining für den Medizinischen Bevölkerungsschutz / A Digital Leadership Simulation for the Training of Emergency Medical Personnel

Zeitraum / Project Period: ab 10/2021 bis 07/2022

Kooperationspartner / Project Partners:

- Malteser Hilfsdienst e.V. Berlin ↗website
- Bundesakademie für Bevölkerungsschutz und Zivile Verteidigung (BABZ, ehemals AKNZ) des Bundesamtes für Bevölkerungsschutz und Katastrophenhilfe (BBK) ↗website

Motivation Ein Massenanfall von Verletzten (MANV) ist ein Großschadensereignis, bei dem die personellen oder materiellen Ressourcen nicht zur adäquaten Behandlung von allen Verletzten ausreichen, sodass auf besondere Verfahren der Katastrophenmedizin zurückgegriffen werden muss. Aufgrund der seltenen Einsätze und dem daraus resultierenden Erfahrungsdefizit ist das regelmäßige Training solcher Situationen aber für das kompetente Handeln aller Einsatzkräfte essentiell. Gerade für Führungskräfte im Bevölkerungsschutz stellt ein MANV eine besondere organisatorische und logistische Herausforderung dar. Sie müssen unter Zeitdruck und mit unvollständigen Informationen sinnvolle Entscheidungen treffen. Daher sind gerade für Führungskräfte einfache und kostengünstige Trainingsmöglichkeiten besonders wichtig.

Problem Das Training erfolgt üblicherweise durch analoge Simulationen wie der Führungssimulation (FüSim) der BABZ, bei der Teilnehmende mittels Magnetkarten, Tafeln und Stoppuhren Führungsaufgaben am Einsatzort wie die Zuteilung von Rettungskräften zu Patient*innen üben. Allerdings sind Übungen mit der FüSim mit vergleichsweise hohen Materialkosten und Durchführungsaufwand verbunden.

Lösung Das Bachelorprojektteam entwickelt eine digitale Variante der FüSim, mit der MANV-Lagen für Führungskräfte einfach und kostengünstig trainierbar werden sollen. Die geplante Lösung umfasst eine Serverkomponente, eine Browserapplikation für die Steuerung der Übung durch die Übungsleitung sowie eine weitere Browserapplikation für die Teilnehmenden. Dank der Kooperation mit der BABZ kann das Team dabei die originalen Datensätze der FüSim nutzen, dank des Malteser Hilfsdienstes in Berlin steht für das Projekt ein großer Pool an Dämonenexperten und potentiellen Testbenutzern zur Verfügung.

Ansprechpartner / Contact: Christian Zöllner, Matthias Barkowsky.

↗website

3.2 Betreuung von Bachelorarbeiten / Supervised Bachelor's theses

3.2.1 Abgeschlossene Bachelorarbeiten / Finished Bachelor's theses

[BA1] Nils Cichy. Inferring a Spatial Model from a Digital Simulation of Mass Casualty Incidents, 2021. Bachelor Thesis.

[BA2] Michel Klappert. Using Positioning Techniques to Improve the Digital Simulation of a Mass Casualty Incident, 2021. Bachelor Thesis.

[BA3] Dale Nows. Improved Training and Usability for the Digital Simulation of a Mass Casualty Incident, 2021. Bachelor Thesis.

[BA4] Chiara Schirmer. The Modeling, Distribution and Synchronising of the States in a Digital Simulation of Mass Casualty Incidents, 2021. Bachelor Thesis.

[BA5] Patricia Sowa. Evaluation of Digitally Enhanced Simulation Exercises of Mass Casualty Incidents, 2021. Bachelor Thesis.

3.2.2 Laufende Bachelorarbeiten / Running Bachelor's theses

3.3 Betreuung von Masterprojekten / Supervised Master's projects

3.3.1 Abgeschlossene Masterprojekte / Finished Master's projects

3.3.2 Laufende Masterprojekte / Running Master's projects

Robust Multi-Agent Reinforcement Learning for Self-Adaptive Systems

Zeitraum / Project Period: ab 10/2021 bis 03/2022

Context Alpha Go-Zero learned to win the famous game of Go without supervision. Instead, it learned by playing against previous versions of itself. Besides that, as the blue and purple curves here show, the self-play approach achieved higher performance than the previous version of the Alpha-Go that defeated the world-champion. IN more recent progress,Google announced that a reinforcement learning agent was able to design optimal circuit layouts for its TensorFlow chip. A feat that was still beyond the capacity of automated tools.

Problem However, industry surveys report that from 55 to 72The reason is that current systems cannot adapt to more complex and evolving realities. Realities that play like strong adversaries against these AI systems. This inability to adapt is a problem of lack of robustness in these AI-based Systems.
Before we search for solutions, we need to understand the nature of this problem. It has two dimensions: how structured the laws are, for instance, well-constrained as in quadrants 1 and 2 corresponding to the artificial laws in games or the physical laws in circuit design and how frequent

the events are, like high frequency as in quadrants 1 and 4 or sparse as in 2 and 3. Many solutions cover quadrants 1, 2, and 4, but quadrant 3 of adversarial laws is under-explored, as it is more challenging. In the last 2 years, our group has been exploring exactly this quadrant 3.

Approach We are extending the standard reinforcement learning architecture in two aspects: integration layer and model-based simulation. The integration layer decouples the environment from the agents that are responsible to choose appropriate actions in response to events (failures) in the environment. This has the benefit of (1) protecting the environment from crashing due to incorrect actions and (2) allowing the agents to reorganize their architectural dependencies in face of adversarial changes in the environment. The simulation model allows to hallucinate (predict) the behavior of the environment, which has shown to be more effective for planning actions, particularly when dealing with partially observable state-spaces.
As a case study, we adopted an e-commerce platform for online shops, whose states represent component failure modes, and the actions allow to repair or optimize the failing components. We have a set of clear goals for the project that we will tackle very incrementally. First will be the reward sparsity that is caused by large state spaces, then Distribution shift, Concept drift, and Domain shift with their corresponding causes. For each of these subgoals we will apply the state-of-art techniques as exemplified here.

Ansprechpartner / Contact: Christian Adriano, Prof. Dr. Holger Giese
↗ website

3.4 Betreuung von Masterarbeiten / Supervised Master's theses

3.4.1 Abgeschlossene Masterarbeiten / Finished Master's theses

3.4.2 Laufende Masterarbeiten / Running Master's theses

Co-Advised by Christian Adriano:

Maximilian Schumacher: Reinforcement Learning for Adaptive Traffic Signal Control: Reducing Pollutant Emissions using an Acceleration-Based Reward

Valdimar Eggerston: Robust Name Entity Disambiguation via Self-Adaptative Learning

Akshay Gudi: Deep Reinforcement Learning for Optimal Minimum Wage Game Simulation

3.5 Betreuung von Dissertationen / Supervised PhD theses

3.5.1 Laufende Dissertationen / Running PhD theses

Christian Adriano: Causal Models of Imperfect Fault Understanding for Sequential Allocation of Code Inspection Tasks

Matthias Barkowsky: Modular and Incremental Global Model Management

Thomas Brand: Generic Adaptive Monitoring with Architectural Runtime Models

Sona Ghahremani: Architecture-centric Self-adaptation

Mustafa Ghani: Modeling and Verification of Collaborations

Joachim Hänsel: Testing for Self-Adaptive Software Systems

Lucas Sakizloglou: Incremental Evaluation of Temporal Model Queries for Monitoring and Adaptation at Runtime

He Xu: Run-time Verification and Validation for Self-adaptive System

Iqra Zafar: Anomaly Detection and Failure Analysis in Microservice-Based Cloud Applications

Christian Zöllner: Modeling and Simulation of Collaborations

4 Bearbeitete Forschungsthemen / Research Topics

4.1 Causal Models of Imperfect Fault Understanding for Sequential Allocation of Code Inspection Tasks

Software programmers spend from 20% to 40% of their time searching for the causes of software failures. To alleviate that, debugging techniques were developed to reduce the search space from the entire program execution to a list of suspicious program statements. However, these debugging techniques assume "perfect fault understanding", i.e., that the programmer will always recognize the software fault among the list of suspicious program statements. Since inaccurate fault understanding inevitably happens, this causes programmers to waste time generating invalid bug fixes, which in turn undermine the trust on the debugging techniques.
I investigated fault understanding in the context of code inspection tasks that are focused on a few lines of code at a time. These tasks are typical of inspecting codes for bugs during debugging. However, these tasks are mostly invisible, as they take a few seconds or minutes, reasonably self-contained, and leave little to no traces in logs or versioning systems. Hence, the nature of these small tasks pose a challenge to investigate them.
My approach was to investigate ways to capture performance attributes of these tasks, while at the same time allowing to scale to hundreds of tasks. I designed an experimentation platform that allows for: (1) recruitment and qualification of programmers, (2) automatic generation of tasks from a set of template questions, and (3) incremental distribution of tasks based on the outcome of previous tasks.
I evaluated my approach through a series of experiments with real software failures from popular Open Source Software Projects. Our preliminary results are promising in a sense that (1) different groups of programmers (subcrowds) were able to correctly identify the cause of the software failures within a few lines of code, (2) the speed and cost were reduced by incrementally deciding which tasks to allocate and to whom, and (3) as part of the tasks, programmers provided explanations that contributed positively to suggest bug fixes.
These results opened a new research problem: how to select a minimal set of tasks that maximize bug finding precision?. This is a difficult problem because requires us to decide at any given moment which program statements to inspect by whom and how many programmers. The approach was to partition this problem in three sub-problems: a causal model, an aggregation model, and a task sequencing model. The causal model explains the accuracy of task outcomes based on the programmers' coding skill and the tasks attributes (duration, perceived difficulty). The aggregation model consists of mechanisms (majority and cardinal voting) that summarize the competing opinions about the bug location. The task sequencing model combines the Bayes update procedure (by learning from previous tasks) with the expected utility of each available task (extracted from the causal model). This way I incrementally updated the knowledge about which minimal set of new tasks, if executed, would maximize the chances of precisely locating a given software bug.

Ansprechpartner / Contact: Christian Adriano

4.2 Modular and Incremental Global Model Management

The development of complex software systems involves the creation and maintenance of a multitude of models describing various aspects such as the architecture, behavior and requirements of the software. In model-driven development, models are assigned an important role in the development process and are subject to both manual and automated activities. Since these models may cover overlapping parts of the system under development, the execution of such activities has to be coordinated properly by global model management in order to avoid inconsistencies in the system's description.
Because of the heterogeneity and growing size of the involved models, global model management poses several challenges. We want to address these issues by employing the concept of megamodels to document and execute the interplay between models. In particular, we are studying the concepts required to achieve a solution which can cope with incremental changes to existing models on the one hand and allows a modular introduction of additional models and activities on the other hand. To that end, we are working on extending the triple-graph-grammar approach for model synchronization by an efficient change propagation between models while keeping track of their version history in a compact manner. This is supported by our work on optimizing the execution of graph queries over large models via a combination of existing static and dynamic techniques for graph pattern matching and a decomposition into simpler subqueries.

Ansprechpartner / Contact: Matthias Barkowsky

4.3 Adaptive Monitoring with an Architecture Runtime Model

Information about the operation and usage of a system can be useful for different purposes, e.g., deciding about the adaption of the system configuration or the evolution of its underlying software to fit changing requirements. Monitoring to obtain this information can comprise the following tasks: gathering, aggregating, checking, transporting, storing, and accessing data. Over time those tasks consume significant amounts of resources, such as compute power, bandwidth, and storage. However, much data is produced and processed for nothing as it is not considered by downstream analysis routines. Either the current set of routines does not consider the monitored system properties at all (static analysis sufficient) or the relevance of properties depends on the values of other properties and the corresponding conditions are not fulfilled at present (requires dynamic analysis). Wasting resources for unnecessary monitoring is at least problematic from an environmental standpoint and in systems with constrained resources, e.g., when relying on battery driven monitoring sensors.
We support detecting phenomena in the current system state at runtime in an automated fashion. We presume that mechanisms exist which can be triggered to analyze the current values of monitored properties. A property value is either primitive like number or structural like a set of references. Thus, the searched phenomena can also be related to structural aspects of the system. The monitoring of individual properties can be activated and deactivated where the activation can consume a considerable amount of time.
We argue that it is possible to significantly reduce the amount of unnecessarily monitored properties by observing the interaction of the phenomena detection mechanisms with an interface for accessing property values. As such an interface we employ an architecture runtime model which represents relevant parts of the running system based on monitoring.

Our approach is agnostic to the phenomena detection mechanisms, e.g., simple Java programs, a query specification interpreter, or RETE nets. It is also agnostic regarding the purpose for which the monitoring and phenomena detection are performed as well as to the meta model of the runtime model. This makes the approach flexible to be used in different scenarios where the relevance of properties and their values depends on the values provided for other properties.

Ansprechpartner / Contact: Thomas Brand

4.4 Architecture-centric Self-adaptation

Architecture-based self-adaptive systems abstract the observed behavior of the running system into features of an architectural model, this makes it possible for the adaptation engine to reason about the changes that should be made to a system using variety of existing architectural analysis techniques. There are various ways how self-adaptation following the MAPE-K feedback loop and in particular the analyzing and planning phases of the loop can be realized. Rule-based approaches prescribe the adaptation to be executed if the system or environment satisfy certain conditions and result in scalable solutions, however, with often only satisfying adaptation decisions. In contrast, utility-driven approaches determine optimal adaptation decisions by using an often costly optimization step, which typically does not scale well for larger problems.
We propose a rule-based and utility-driven approach that achieves the beneficial properties of each of these directions such that the adaptation decisions are optimal while the computation remains scalable as an expensive optimization step can be avoided. The approach can be used for the architecture-based self-healing of large software systems. In our approach, we model the dynamic architecture of the self-adaptive system as a graph. Natural state of the system as well as the abstract syntax of the runtime models of the software are depicted via an annotated graph. We apply architectural utility functions in which any possible architectural configuration of the system is mapped to a scalar value.
We define the utility for large dynamic architectures of such systems based on patterns capturing issues the self-healing must address and we use pattern-based adaptation rules to resolve the issues. Defining the utility as well as the adaptation rules in a pattern-based manner allows us to compute the impact of each rule application on the overall utility and realize an incremental and efficient utility-driven self-adaptation. We target both self-healing and self-optimization in architectural manner.Achieving optimal adaptation decisions on-line within a reasonable time is an important challenge of self-adaptive software systems that is addressed.

Ansprechpartner / Contact: Sona Ghahremani

4.5 Modeling and Verification of Collaborations

Changing requirements and environmental conditions demand highly flexible software systems. Therefore, large-scale software systems are composed of different independent subsystems (components) that may join or leave the ensemble at an arbitrary point in time.
We explore techniques of graph transformation systems to model collaborations, specifically orchestration and choreography of software components. Moreover, we provide a technology-independent framework for model-based analysis and verification.

Ansprechpartner / Contact: Mustafa Ghani

4.6 Testing for Self-Adaptive Software Systems

Self-adaptive software systems are equipped with feedback loops to adapt autonomously to changes of the software or environment. In established fields, such as embedded software, sophisticated approaches have been developed to systematically study feedback loops early during the development. In order to cover the particularities of feedback, techniques like one-way and in-the-loop simulation and testing have been included. However, related approaches for systematic testing of feeback loops in self-adaptive software system do not exist.
We propose a systematic testing approach based on architectural runtime models for self-adaptive software systems. The aim is to exploit architectural runtime models for testing early in the development phase, since they are usually available, even before the different activities of a feedback loop are realised or even designed. Furthermore we research testing of self-adaptive software systems at runtime in order to benefit from knowledge about the changed environment which is not available at design time.

Ansprechpartner / Contact: Joachim Hänsel

4.7 Incremental Evaluation of Temporal Model Queries for Monitoring and Adaptation at Runtime

In model-driven engineering, the adaptation of complex software systems with dynamic structure is enabled by architectural runtime models. Such a model represents the state of the system as a graph of interacting components. Every relevant change in the system is mirrored in the model and triggers an evaluation of model queries, which search the model for structural patterns that should be adapted. Our work focuses on a type of runtime models where the expressiveness of the model is extended to capture past changes and their timing. These history-aware models enable more informed decision-making during adaptation as they allow for the evaluation of temporal queries which comprise requirements on the evolution of a pattern. However, the evaluation of temporal queries over runtime models that are altered by numerous fast-paced changes poses a significant challenge: despite the increasing size of the history, the evaluation needs to be adequately fast and memory-efficient. In our work, we present a framework for the evaluation of temporal model queries, which aims at coping with this challenge more effectively than prior state-of-the-art solutions.

Ansprechpartner / Contact: Lucas Sakizloglou

4.8 Run-time Verification and Validation for Self-adaptive System

The software is now the backbone of human activity. Software systems play important roles in industrial facilities, automobile, and aircraft etc.
In self-adaptive systems, the software has to deal with the rapidly changing environment conditions and the failures of its own system. How to guarantee the functional and non-functional requirements of the system during and after the adaptation process is a crucial problem.

Verification and Validation theory is wildly adopted in the whole cycle of software system development. Expanding these techniques into run-time verification and validation for self-adaptive systems is a great challenge. Run-time V&V can ensure, during or after the adaptation, system's requirements and its core qualities will not be compromised, and at the same time, the goals of adaptation process will be satisfied. Run-time V&V methods and tools are critical for the success of autonomous, autonomic, smart, self-adaptive and self-managing systems.
There are three parts in my research topic: First, to investigate the formal methods and their use at run-time, especially run-time model checking. Second, to implement the research on system modeling and requirements/properties specification methods. Third, to integrate the run-time verification and self-adaptive system and to find out a general structure for providing assurances for the self-adaptive system in its whole life cycle.

Ansprechpartner / Contact: He Xu

4.9 Anomaly Detection and Failure Analysis in Microservice-Based Cloud Applications

In large-scale microservice architecture, reliability issues can be caused by a variety of reasons, such as restricted host resources, unavailable hardware or software, unstable networks, etc. To keep the system running reliably, cloud operators often deploy large-scale performance checkpoints and metric collection mechanisms. These monitoring mechanisms can help us initially verify that applications and services are running healthily. However, since the applications run on a complex architecture consisting of various microservices, it is a challenging task to reveal the mechanism of anomaly propagation from massive monitoring metrics, and to pinpoint the root cause of the failure. In conclusion, traditional anomaly diagnosis methods are usually based on key performance indicator (KPI) thresholds. System administrators set the KPI monitoring threshold manually according to their domain knowledge for early warning. However, due to the very large number of services in the MSA application and the complex dependencies between services, it is difficult for system administrators to detect anomalies by setting reasonable KPI monitoring thresholds, let alone diagnose root causes in fine granularity. So, automated anomaly detection and root cause analysis reduces the overall dependency on expert knowledge and provide solution to failure propagation in Microservice Architecture.

Ansprechpartner / Contact: Iqra Zafar

4.10 Modeling and Simulation of Collaborations

In future large-scale cyber-physical systems, the interconnection of autonomous systems via complex software and networking will result in massive systems of systems where a huge number of heterogenous systems collaborate and act together. In this research topic, we address the challenge of modeling relevant aspects of such systems of systems. Given the high demand for safety assurances for cyber-physical systems, the thorough analysis of systems and their models is obligatory. Besides verification and validation, we propose simulation as a means to identify and resolve potential safety risks and gain further insights into how the modeled systems act and collaborate in a large systems of systems context.

Ansprechpartner / Contact: Christian Zöllner

5 Drittmittelprojekte / Third-Party funded Projects

5.1 DFG – Modulares und inkrementelles globales Modell-Management (miGMM)

Gefördert / Funded: ab 07/2018
Drittmittelgeber / Funding organisation: DFG

Die Entwicklung komplexer Systeme mit Hilfe einer Vielzahl von Modellen benötigt ein globales Modell-Management, das sicherstellt, dass neben den Arbeiten auf einzelnen Modellen auch das Wechselspiel zwischen den Modellen geeignet verwaltet wird. Solch eine Verwaltung muss dabei die Integration der Modellierungssprachen, die Koordination der Aktivitäten auf Basis der Modelle sowie die Verwaltung der Modelle und all der Aktivitäten auf diesen abdecken. Es existiert zwar eine Reihe von Ansätzen, die Teile dieses Problem zu adressieren versuchen; ein fundiertes Verständnis der Bedürfnisse und Herausforderungen fehlt jedoch bisher. Darüber hinaus skalieren die meisten Lösungen nicht für die heutzutage durchaus vorkommenden sehr großen Modelle und sie unterstützen auch keine Modularität. Diese Einschränkung gilt sowohl für die Konstruktion als auch Ausführung der Modelle und der entsprechenden Aktivitäten. Im Projekt "modulares und inkrementelles Globales Modell-Management" (miGMM) wollen wir deswegen die Herausforderung des globales Modell-Management angehen, indem wir einen Ansatz für Mega-Modelle mit Integrationslinks, Integrationssichten, Nachverfolgbarkeitslinks, Modellkonsistenz und Modelloperationen entwickeln und dabei insbesondere die notwendigen Konzepte für eine inkrementelle und modulare Lösung erforschen.

Ansprechpartner / Contact: Holger Giese, Matthias Barkowsky.

6 Forschungskooperationen / Research Cooperations

6.1 Projektpartner aus der Wissenschaft / Project Partners from Research Institutions

COST Action IC1404 Multi-Paradigm Modelling for Cyber-Physical Systems (MPM4CPS)
Hans Vangheluwe, University of Antwerp (Belgium) and McGill University, Montréal (Canada)
Vasco Amaral, NOVA-LINCS FCT, Universidade Nova de Lisboa (Portugal)

Scalable Model Management
Etienne Borde (Télécom ParisTech, Université Paris-Saclay)
Dalila Tamzalit (LS2N, Université de Nantes)

Modeling and Analysis of Ecological Systems
Cédric Gaucherel (INRA — AMAP Laboratory, Montpellier)
Christelle Hély (ISEM, Université de Montpellier, CNRS, IRD, EPHE, Montpellier)
Boris Flotterer (ISEM, Université de Montpellier, CNRS, IRD, EPHE, Montpellier)

6.2 Externe Kooperationspartner bei Publikationen / External Partners in Publications

Prof. Dr. Holger Giese hat in 2021 mit folgenden externen Kooperationspartnern gemeinsame Publikationen herausgegeben oder veröffentlicht: Rima Al-Ali, Vasco Amaral, Moussa Amrani, Soumyadip Bandyopadhyay, Ankica Barišić, Dominique Blouin, Paulo Carreira, Ferhat Erata, Miguel Goulão, Mauro Iacono, Stefan Klikovits, Hana Mkaouar, Bedir Tekinerdogan, Hans Vangheluwe.

Dr. Leen Lambers hat in 2021 mit folgenden externen Kooperationspartnern gemeinsame Publikationen veröffentlicht: Antonio Bucchiarone, Federico Ciccozzi, Marisa Navarro, Fernando Orejas, Alfonso Pierantonio, Elvira Pino, Matthias Tichy, Massimo Tisi, Andreas Wortmann, Vadim Zaytsev.

Dr. Sven Schneider hat in 2021 mit folgenden externen Kooperationspartnern gemeinsame Publikationen veröffentlicht: Fernando Orejas.

7 Publikationen / Publications

7.1 Zeitschriftenartikel / Journal Articles

[A1] Antonio Bucchiarone, Federico Ciccozzi, Leen Lambers, Alfonso Pierantonio, Matthias Tichy, Massimo Tisi, Andreas Wortmann, and Vadim Zaytsev. What Is the Future of Modeling? *IEEE Softw.*, 38(2):119–127, 2021.

[A2] Leen Lambers and Fernando Orejas. Transformation rules with nested application conditions: Critical pairs, initial conflicts & minimality. *Theoretical Computer Science*, 884:44–67, 2021.

[A3] Marisa Navarro, Fernando Orejas, Elvira Pino, and Leen Lambers. A navigational logic for reasoning about graph properties. *Journal of Logical and Algebraic Methods in Programming*, 118:100616, 2021.

[A4] Lucas Sakizloglou, Sona Ghahremani, Matthias Barkowsky, and Holger Giese. Incremental execution of temporal graph queries over runtime models with history and its applications. *Software and Systems Modeling*, December 2021.

[A5] Sven Schneider, Leen Lambers, and Fernando Orejas. A logic-based incremental approach to graph repair featuring delta preservation. *Int. J. Softw. Tools Technol. Transf.*, 23(3):369–410, 2021.

[A6] Sven Schneider, Maria Maximova, Lucas Sakizloglou, and Holger Giese. Formal testing of timed graph transformation systems using metric temporal graph logic. *Int. J. Softw. Tools Technol. Transf.*, 23(3):411–488, 2021.

7.2 Beiträge zu Büchern und Sammlungen / Contributions to Books and Collections

[S1] Dominique Blouin, Rima Al-Ali, Holger Giese, Stefan Klikovits, Soumyadip Bandyopadhyay, Ankica Barišić, and Ferhat Erata. Chapter 5 - an integrated ontology for multi-paradigm modelling for cyber-physical systems. In Bedir Tekinerdogan, Dominique Blouin, Hans Vangheluwe, Miguel Goulão, Paulo Carreira, and Vasco Amaral, editors, *Multi-Paradigm Modelling Approaches for Cyber-Physical Systems*, pages 123–145. Academic Press, 2021.

[S2] Dominique Blouin, Rima Al-Ali, Mauro Iacono, Bedir Tekinerdogan, and Holger Giese. Chapter 2 - an ontological foundation for multi-paradigm modelling for cyber-physical systems. In Bedir Tekinerdogan, Dominique Blouin, Hans Vangheluwe, Miguel Goulão, Paulo Carreira, and Vasco Amaral, editors, *Multi-Paradigm Modelling Approaches for Cyber-Physical Systems*, pages 9–43. Academic Press, 2021.

[S3] Holger Giese, Dominique Blouin, Rima Al-Ali, Hana Mkaouar, Soumyadip Bandyopadhyay, Mauro Iacono, Moussa Amrani, Stefan Klikovits, and Ferhat Erata. Chapter 4 - an ontology for multi-paradigm modelling. In Bedir Tekinerdogan, Dominique Blouin, Hans Vangheluwe, Miguel Goulão, Paulo Carreira, and Vasco Amaral, editors, *Multi-Paradigm Modelling Approaches for Cyber-Physical Systems*, pages 67–122. Academic Press, 2021.

7.3 Begutachtete Konferenz- und Workshopartikel / Peer-Reviewed Conference and Workshop Papers

[K1] Matthias Barkowsky, Thomas Brand, and Holger Giese. Improving Adaptive Monitoring with Incremental Runtime Model Queries. In *2021 International Symposium on Software Engineering for Adaptive and Self-Managing Systems (SEAMS)*, pages 71–77, Los Alamitos, CA, USA, May 2021. IEEE Computer Society.

[K2] Matthias Barkowsky and Holger Giese. Host-Graph-Sensitive RETE Nets for Incremental Graph Pattern Matching. In *International Conference on Graph Transformation*, pages 145–163. Springer, 2021.

[K3] Sona Ghahremani and Holger Giese. Hybrid Planning with Receding Horizon: A Case for Meta-self-awareness. In *2021 IEEE International Conference on Autonomic Computing and Self-Organizing Systems Companion (ACSOS-C)*, pages 131–138. IEEE, 2021.

[K4] Maria Maximova, Sven Schneider, and Holger Giese. Compositional Analysis of Probabilistic Timed Graph Transformation Systems. In Esther Guerra and Mariëlle Stoelinga, editors, *Fundamental Approaches to Software Engineering - 24th International Conference, FASE 2021, Held as Part of the European Joint Conferences on Theory and Practice of Software, ETAPS 2021, Luxembourg City Luxembourg, March 27 - April 1, 2021,*, volume 12649 of *Lecture Notes in Computer Science*, pages 196–217. Springer, 2021.

[K5] Maria Maximova, Sven Schneider, and Holger Giese. Interval Probabilistic Timed Graph Transformation Systems. In Fabio Gadducci and Timo Kehrer, editors, *Graph Transformation - 14th International Conference, ICGT 2021 Held as Part of STAF 2021, Virtual Event, June 24-25, 2021, Proceedings*, volume 12741 of *Lecture Notes in Computer Science*, pages 221–239. Springer, 2021.

[K6] Lucas Sakizloglou, Matthias Barkowsky, and Holger Giese. Keeping Pace with the History of Evolving Runtime Models. In Esther Guerra and Mariëlle Stoelinga, editors, *Fundamental Approaches to Software Engineering*, Lecture Notes in Computer Science, pages 262–268, Cham, 2021. Springer International Publishing.

[K7] Sven Schneider and Leen Lambers. Evaluation Diversity for Graph Conditions. In Fabio Gadducci and Timo Kehrer, editors, *Graph Transformation - 14th International Conference, ICGT 2021 Held as Part of STAF 2021, Virtual Event, June 24-25, 2021, Proceedings*, volume 12741 of *Lecture Notes in Computer Science*, pages 122–141. Springer, 2021.

[K8] Christian Zöllner, Matthias Barkowsky, Maria Maximova, and Holger Giese. On the Complexity of Simulating Probabilistic Timed Graph Transformation Systems. In Fabio Gadducci and Timo Kehrer, editors, *Graph Transformation - 14th International Conference, ICGT 2021 Held as Part of STAF 2021, Virtual Event, June 24-25, 2021, Proceedings*, volume 12741 of *Lecture Notes in Computer Science*, pages 262–279. Springer, 2021.

7.4 Technische Berichte / Technical Reports

[TR1] Maria Maximova, Sven Schneider, and Holger Giese. Interval probabilistic timed graph transformation systems. Technical Report 134, Hasso Plattner Institute at the University of Potsdam, Potsdam, Germany, 2021.

[TR2] Sven Schneider, Maria Maximova, and Holger Giese. Probabilistic Metric Temporal Graph Logic. *CoRR*, abs/2106.08418, 2021.

7.5 Miscellaneous

[M1] Holger Giese. Towards Engineering Smart Cyber-Physical Systems with Graph Transformation Systems. In Fabio Gadducci and Alexandra Silva, editors, *9th Conference on Algebra and Coalgebra in Computer Science (CALCO 2021)*, volume 211 of *Leibniz International Proceedings in Informatics (LIPIcs)*, pages 2:1–2:1, Dagstuhl, Germany, 2021. Schloss Dagstuhl – Leibniz-Zentrum für Informatik.

8 Vorträge / Talks

8.1 Eingeladene Vorträge / Invited Talks

Prof. Dr. Holger Giese [

September 2021 *Towards Engineering Smart Cyber-Physical Systems with Graph Transformation Systems*. 9th Conference on Algebra and Coalgebra in Computer Science, Salzburg, September 2, 2021.

Christian Adriano

October 2021 *Too Big to Fail - Building Robust Intelligent Systems with Causal Machine Learning*. HPI Research School Retreat, Potsdam, October 27, 2021.

July 2021 *Towards more Reliable Machine Learning-Based Systems - The Need for Methods to Discover Model Invariants*. HPI Research School Retreat, Potsdam, July 14, 2021.

Dr. Leen Lambers

January 2021 *Confluence of Graph Transformation*. GReTA-Seminar, Virtuell, January 09, 2021.

Christian Zöllner

June 2021 *Digitalisierung der Dynamischen Patientensimulation*. Ringvorlesung "Aktuelle Themen der Katastrophenmedizin", Bundesakademie für Bevölkerungsschutz und Zivile Verteidigung (BABZ), Virtuell, June 06, 2021.

September 2021 *Digitalisierung der Dynamischen Patientensimulation*. Fortbildung für Lehrkräfte der Katastrophenmedizin der, Bundesakademie für Bevölkerungsschutz und Zivile Verteidigung (BABZ), Bad Neuenahr-Ahrweiler, Germany, September 22, 2021.

October 2021 *Digitalisierung der Dynamischen Patientensimulation*. Fortbildung für Lehrkräfte der Katastrophenmedizin der Landesfeuerwehrschulen, Bundesakademie für Bevölkerungsschutz und Zivile Verteidigung (BABZ), Bad Neuenahr-Ahrweiler, Germany, October 20, 2021.

October 2021 *Digitalisierung der Dynamischen Patientensimulation*. Seminar "Ärztliche und nichtärztliche Führungkräfte beim MANV I", Bundesakademie für Bevölkerungsschutz und Zivile Verteidigung (BABZ), Bad Neuenahr-Ahrweiler, Germany, October 26, 2021.

8.2 Vorträge auf Konferenzen und Workshops / Talks at Conferences and Workshops

Matthias Barkowsky

May 2021 *Improving Adaptive Monitoring with Incremental Runtime Model Queries*. SEAMS@ICSE '21, Virtual, May 21, 2021.

June 2021 *Host-Graph-Sensitive RETE Nets for Incremental Graph Pattern Matching*. ICGT '21, Virtual, June 4, 2021.

Sona Ghahremani

October 2021 *Hybrid Planning with Receding Horizon: A Case for Meta-self-awareness*. ACSOS-C'21, Virtual, October 1, 2021.

Lucas Sakizloglou

March 2021 *Keeping Pace with the History of Evolving Runtime Models*. FASE '21, Virtual, March 30, 2021.

Dr. Sven Schneider

March 2021 *Compositional analysis of probabilistic timed graph transformation systems*. FASE '21, Virtual, March 29, 2021.

June 2021 *Evaluation deversity for graph conditions*. ICGT '21, Virtual, June 25, 2021.

June 2021 *Interval probabilistic timed graph transformation systems*. ICGT '21, Virtual, June 25, 2021.

Christian Zöllner

June 2021 *On the Complexity of Simulating Probabilistic Timed Graph Transformation Systems*. ICGT '21, Virtual, June 25, 2021.

9 Web-Portale und -Services / Web-Portals and Services

9.1 Self-adaptive.org

Das Online-Angebot `http://www.self-adaptive.org` dient als Übersichtsseite für das jährliche Symposium *Software Engineering for Adaptive and Self-Managing Systems* (SEAMS) im Rahmen der *International Conference on Software Engineering* (ICSE). Auf der Webseite sind alle Call for Papers für aktuelle und vergangene SEAMS Symposien, eine umfassende themenspezifische Bibliographie, Informationen zu weiterführenden Veranstaltungen wie den Dagstuhl Seminaren 08031 und 10431 sowie eine Liste von Wissenschaftlern, die auf dem Gebiet forschen, zu finden.

9.2 MDELab.org

Mit dem Online-Angebot `http://www.mdelab.org` informieren wir über Forschungsarbeiten unseres Fachgebiets im Bereich des *Model-Driven Engineering* (MDE). Dabei liegt der Schwerpunkt auf Werkzeuge unter anderem für die modellgetriebene Softwareentwicklung, die an unserem Fachgebiet entwickelt werden und die zum Download bereitstehen.

9.3 CPSLab.org

Mit dem Online-Angebot `http://www.cpslab.org` informieren wir über Aktivitäten im Kontext unseres Labors im Bereich *Cyber-Physical-Systems*. Inhalte beziehen sich auf vergangene, aktuelle als auch geplante Forschungsarbeiten. Weiterhin werden ausgewählte Projekte, welche im Kontext der Lehre umgesetzt wurden, repräsentiert.

10 Mitgliedschaften, Programmkomitees und Gutachtertätigkeiten / Memberships, Committee and Reviewing Activities

10.1 Mitgliedschaften / Memberships

Prof. Dr. Holger Giese

- Mitglied der Association for Computing Machinery (ACM)
- Mitglied der folgenden Special Interest Groups: SIGSOFT, SIGBED, SIGPLAN
- Mitglied der IEEE (Valued IEEE Member, Member since 1994)
- Mitglied der IEEE Computer Society
- Mitglied der folgenden Technical Councils: TCSE, TCDP, TCRTS, TFAAS
- Mitglied der IEEE Systems, Man, and Cybernetics Society
- Mitglied der Gesellschaft für Informatik e.V. (GI)
- Mitglied der folgenden Fachgebiete und Fachgruppen: ST, TAV, OOSE, ASE, PN, SPECS, FOMSESS
- Mitglied des Deutschen Hochschulverbandes (DHV)

Christian Adriano

- Mitglied der Association for Computing Machinery (ACM)
- Mitglied der IEEE (IEEE Member, Member since 2008)
- Mitglied der IEEE Computer Society

Sona Ghahremani

- Mitglied der Association for Computing Machinery (ACM)

10.2 Mitarbeit in Programmkomitees / Activities in Program Committees

Prof. Dr. Holger Giese

- 16th International Symposium on Software Engineering for Adaptive and Self-Managing Systems (SEAMS 2021)
  Virtual, May 18-21, 2021, ↗website
- 3rd International Workshop on Robotics Software Engineering (RoSE'21)
  Virtual, June 2, 2021, ↗website
- 14th International Conference on Graph Transformation (ICGT 2021)
  Virtual, Bergen, Norway, June 24-25, 2021, ↗website
- 3rd International Workshop on Multi-Paradigm Modelling for Cyber-Physical Systems (MPM4CPS'21)
  Virtual, October 10, 2021, ↗website

Dr. Leen Lambers

- 24th International Conference on Fundamental Approaches to Software Engineering (FASE 2021)
  Virtual, Luxembourg, Luxembourg, March 27 - April 1, 2021, ↗website
- 9th International Workshop on Bidirectional Transformations (Bx 2021)
  Virtual, Bergen, Norway, June 21, 2021, ↗website
- 12th International Workshop on Graph Computation Models (GCM 2021)
  Virtual, Bergen, Norway, June 22, 2021, ↗website
- 14th International Conference on Graph Transformation (ICGT 2021)
  Virtual, Bergen, Norway, June 24-25, 2021, ↗website
- International (Virtual) Seminar Series on Graph Transformation Theory and Applications (GReTA)
  Virtual, 2021, ↗website

Sona Ghahremani

- 16th International Symposium on Software Engineering for Adaptive and Self-Managing Systems (SEAMS 2021)
  Virtual, May 18-21, 2021, ↗website
- Artifact Track at 15th International Symposium on Software Engineering for Adaptive and Self-Managing Systems (SEAMS 2021)
  Virtual, May 18-21, 2021, ↗website
- Poster and Demo Track at 1th International Conference on Autonomic Computing and Self-Organizing Systems (ACSOS 2021)
  Virtual, September 27- October 1, 2021, ↗website
- Workshop On Self-aware Computing at ACSOS-C (SEAC 2021)
  Virtual, October 2, 2021, ↗website

10.3 Organisationstätigkeiten / Organizational Activities

Prof. Dr. Holger Giese

- Advisory Board at ACSOS
  Virtual, September 27- October 1, 2021, ↗website

Sona Ghahremani

- Session Chair for Self-Adaptation and Machine Learning at SEAMS
  May 18-21, 2021, Virtual, ↗website
- Proceedings Chair at SEAMS
  May 18-21, 2021, Virtual, ↗website
- Poster and Demo Chair at ACSOS
  Virtual, September 27- October 1, 2021, ↗website
- Organizing Committee at ACSOS
  Virtual, September 27- October 1, 2021, ↗website

10.4 Gutachtertätigkeiten / Reviewing Activities

10.4.1 Forschungsprojekte / Research Projects

Prof. Dr. Holger Giese

- Deutsche Forschungsgemeinschaft (DFG)

10.4.2 Zeitschriften und Magazine / Journals

Prof. Dr. Holger Giese

- ACM Transactions on Autonomous and Adaptive Systems (TAAS)
- IEEE Transactions on Software Engineering (TSE)
- Software and Systems Modeling (SoSyM)
- Simulation: Transactions of the Society for Modeling and Simulation International

Dr. Leen Lambers

- Formal Aspects of Computing
- Information Sciences
- Science of Computer Programming
- Software and Systems Modeling (SoSyM)
- Theoretical Computer Science

Sona Ghahremani

- Future Generation Computer Systems (FGCS)
- ACM Transactions on Autonomous and Adaptive Systems (TAAS)
- Information and Software Technology (IST)