11 Software Engineering Group

11.1 Personnel

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11.2 Overview

Modern societies, economies, industries and sciences generate an ever-increasing demand for software. This software shall be of high quality, long-living and flexible, while software development itself is faced with frequently changing requirements and limited resources.

The mission of the Software Engineering Group is to tackle these major challenges through research and teaching in software engineering, the discipline that fosters the application of systematic engineering principles to the development, operation and maintenance of software. We aim at understanding the problems and challenges that software developers are faced with in oftentimes highly interdisciplinary environments, and at devising novel software engineering methods, techniques and tools addressing their needs.

The group has been established in January 2022 and dedicates itself to contribute its research results to the scientific discourse on software engineering, to transfer its knowledge to practitioners and computational scientists, and to contribute to the education of the next generation of software engineers for the future.

11.3 Research Projects

Merge++: Turning software merge conflicts into conflict-induced variability

Research staff: Timo Kehrer
Duration: 2023 - 2027
Financial support: Swiss National Science Foundation (SNSF)

VariantSync II: Automating the Synchronization of Software Variants

Research staff: Timo Kehrer
Duration: 2024 - 2027
Financial support: Swiss National Science Foundation (SNSF)

SwarmOps: Human-sensing based MLOps for Collaborative Cyber-Physical Systems

Research staff: Timo Kehrer
Duration: 2025 - 2029
Financial support: Swiss National Science Foundation (SNSF)

InnoGuard: Hybrid and Generative Intelligence for Trustworthy Autonomous Cyber-Physical Systems

Research staff: Timo Kehrer
Duration: 2024 - 2027
Financial support: Horizon

Safe-2-Fly: Advancing UAV Reliability and Societal Trust Through Integrated Testing and Formal Verification

Research staff: Timo Kehrer
Duration: 2025 - 2026
Financial support: Hasler Foundation

AERIALIST: Bridging the Reality Gap in Testing Unmanned Aerial Vehicles

Research staff: Timo Kehrer
Duration: 2024 - 2025
Financial support: Hasler Foundation

CaSSIS-CheckTC: Mission Telecommands Trace Checking

Research staff: Timo Kehrer
Duration: 2024 - 2025
Financial support: University of Bern

RUNVERSPACE: Runtime Verification for Space Software Architectures

Research staff: Christos Tsigkanos, Timo Kehrer, Atafeh Rohani
Duration: 2024 - 2025
Financial support: Swiss National Science Foundation (SNSF)

RUNVERSPACE addresses the systematic engineering of contemporary small-scale flight- and space- software, arguing that integrating runtime verification facilities is crucial for increased operational requirements assurance. Addressing fundamental challenges of bringing such a goal to runtime has the potential of significant disruption. RUNVERSPACE is based on the premise that cutting-edge software engineering research leveraging applied formal methods is direly needed for the next generation of space applications. RUNVERSPACE will focus on defining suitable programming abstractions and specification notations in tandem with development of architectural support, with an overall goal of demonstrating the potential that runtime verification can bring.

VariantSync: Automating the Synchronisation of Software Variants

Research staff: Alexander Schultheiß, Timo Kehrer
Duration: 2019 – 2023
Financial support: DFG project KE 2267/1-1

Today's software is often released in multiple variants to meet all customer requirements. Software product lines have the potential to decrease development costs and time-to-market, and have been actively researched for more than two decades. Nevertheless, practitioners frequently rely on ad-hoc reuse based on a principle which is known as clone-and-own, where new variants of a software family are created by copying and adapting an existing variant. However, if a critical number of variants is reached, their maintenance and evolution becomes impractical, if not impossible, and the migration to a product line is often infeasible.

With the research conducted in *VariantSync*, we aim to enable a fundamentally new development approach which bridges the gap between clone-and-own and product lines, combining the minimal overhead of clone-and-own with the systematic handling of variability of software product lines in a highly flexible methodology. The key idea is to transparently integrate the central product-line concept of a feature with variant management facilities known from version control systems in order to automatically synchronize a set of evolving variants. Lifting the underlying techniques employed by version control systems to the abstraction level of features which are shared among variants is an open problem and the main research challenge addressed in *VariantSync*. We believe that our research results have the potential to effectively change the way how practitioners will develop multi-variant software systems for which it is hard to foresee which variants will be added or released in the future.

FONDA: Foundations of Workflows for Large-Scale Scientific Data Analysis

Research staff: Anh Duc Vu, Christos Tsigkanos, Timo Kehrer
Duration: 2020 – 2024
Financial support: DFG Collaborative Research Center 1404

Essentially all scientific disciplines are generating an ever-increasing

amount of data. To derive scientific discoveries, these data sets are analyzed by complex data analysis workflows (DAWs), which are series of discrete analysis programs arranged in (often non-linear) pipelines. Because they usually deal with very large data sets, DAWs must be executed on distributed and/or parallel computational infrastructures. Traditionally, DAWs are optimized for speed, which leads to solutions that are hard to reproduce and share and that are tightly bound to exactly one type of input. However, as stated as summary in a recent NSF/DOE workshop that brought together the workflow and the HPC communities, "...human productivity arguably still is the most expensive resource, trumping power, performance, and other factors ...".

The Collaborative Research Center FONDA takes up this observation and investigate methods for increasing productivity in the development, execution, and maintenance of DAWs for large scientific data sets. Our long-term goal is to develop methods and tools that achieve substantial reductions in development time and development cost of DAWs. We will approach these questions from a fundamental perspective, i.e., we aim at finding new abstractions, models, and algorithms that can eventually form the basis of a new class of future DAW infrastructures. Toward these goals, FONDA in its first focuses on three critical properties of DAWs and of DAW engines, namely portability, adaptability, and dependability (PAD). We want to investigate answers to questions such as: How can we build DAWs and DAW engines that enable portability of analysis across different infrastructures? How must DAWs be designed to adapt to changing input data or slightly changing requirements? How can we build dependable DAW systems that are aware of and control their own limitations and preconditions?

CaSSIS-Verif: Towards Verified Flight Software for Future Mars Missions

Research staff: Christos Tsigkanos, Timo Kehrer
Project partners: Prof. Nicolas Thomas, Miguel Almeida (Space Research and Planetology, Physikalisches Institut, University of Bern)
Duration: 2023 – 2024
Financial support: University of Bern

Software verification entails the algorithmic analysis of programs to mathematically prove properties of their executions - to prove that given certain assumptions, the code is correct and bug-free. Performing software verification in practice requires appropriately instrumenting the code at hand,

invoking often complicated toolchains, and interpreting verification results. In CaSSIS-Verif, we seek to investigate semi-automation of this process in the context of mission-critical space software. We envision (i) appropriate abstractions and automation tools tailored to this challenging domain, as well as making steps towards (ii) integrating software verification into the development process of mission-critical space software.

The project leverages expertise of the Planetary Imaging Group in the Space Research and Planetology Division of the Physikalisches Institut and the Software Engineering Group at the Institute of Computer Science, towards the verification of CaSSIS flight software.

Swiss-Africa Cybersecurity Community: A Focus on Education, Research and Knowledge Building

Research staff: Roman Bögli, Timo Kehrer
Project partners: International project consortium, led by Prof. Dr. Bettina Schneider (FHNW University of Applied Sciences and Arts)
Duration: 2024 – 2026
Financial support: Movetia

This project addresses the growing cybersecurity threat to Switzerland by bridging the knowledge gap between Swiss Higher Educational Institutions (HEIs) and cybersecurity challenges in Africa. While Swiss HEIs excel in technical cybersecurity education, they often overlook the critical human and cultural dimensions of cyber threats, particularly those emerging from rapidly digitizing regions like Africa. African countries, such as Cameroon and Kenya, face increasing cyber-attacks, particularly in mobile money fraud, shaped by unique socio-economic, linguistic, and regulatory factors. Given that cybercrimes transcend borders, the goal of this project is to establish a Swiss-Africa cybersecurity community through a digital platform, fostering cross-cultural exchanges, enhancing cybersecurity skills, and facilitating research collaboration between Swiss and African HEIs. By integrating insights from African cybersecurity landscapes, Swiss educators will enhance their curricula, better preparing students to tackle complex, globally sourced cyber-attacks. The project ultimately aims to strengthen Switzerland's cybersecurity preparedness by promoting international collaboration and enriching the knowledge base of Swiss HEIs.

11.4   Ph.D. Theses

- A. Schultheiß:

11.5   Master's Theses

- S. Anthamatten: Empirical Analysis of Java Software Evolution - Breaking Changes and Migrations in Git Histories

- D. Zeidan: Automated Generation of Code Contracts: Semantic Analysis using Mutation Based Testing

- A. Moisil: Enhancing Code Quality - Customized Source Code Refactoring by Example

- C. Wu: Explaining GitHub Actions Failures with Large Language Models: Challenges, Insights, and Limitations

- S. Hérnandez Goicachea: Addressing Developer Information Needs in GitHub Actions

- M. Mumtaz: Test Decomposition for Cost-effective Testing of UAVs

11.6   Bachelor's Theses

- P. Rüegsegger: AGAT: Ein heuristischer Algorithmus zur präferenzbasierten Gruppenbildung mit fester Gruppengrösse

- K. Lautenschlager: A Feature Modeling Approach to Mathematical Tasks

- J. Meier: Developing a Hybrid Static-Dynamic Analysis Tool for Third-Party Library Detection

- O. Mingard: Java Conflicting Chunk Derivability and Structured Merge Algorithms

- A. Müller & V. Meier: An Algorithmic Approach for Solving the Grouping Problem

- Bastien Jossen: The Potential of Principal Component Analysis and Term Frequency-Inverse Document Frequency in Range Queries on N input models

- Maurice Amon: Segmentation of Source Codes for Minimal Reproducible Examples

- D. Richard: Presortedness-Based Prediction of the Optimal Sorting Algorithm

11.7 GymInf Theses

- S. Bünzli Straub: Revealing Programming Language Abstractions - Introducing a Learning Environment to Examine Programs from Source Code to Bytecode

11.8 Activities

Scientific Boards and Steering Committees

Timo Kehrer

- CHOOSE: Swiss Group for Software Engineering, Special Interest Group (SIG) of the Swiss Informatics Society: Presidency

- Re:Volution: International Workshop on Reverse Variability Engineering and Evolution of Software-Intensive System: Steering Committee member

- GReTA: International Seminar Series on Graph Transformation Theory and Applications: Scientific Committee member

- VariVolution: International Workshop on Variability and Evolution of Software-Intensive Systems: Steering Committee member

Conference Chairing and Organization

Timo Kehrer

- International Working Conference on Variability Modelling of Software-Intensive Systems (VaMoS'24): General Chair

Sebastiano Panichella

- 18th IEEE International Conference on Software Testing, Verification and Validation (ICST) 2025: General Chair

Christian Birchler

- International Working Conference on Variability Modelling of Software-Intensive Systems (VaMoS'24): Proceedings Chair

Program Committees

Timo Kehrer

- ICSE: International Conference on Software Engineering: 2025

- SPLC: International Systems and Software Product Line Conference: 2024

- SEAMS: International Symposium on Software Engineering for Adaptive and Self-Managing Systems: 2024

- MET: International Workshop on Metamorphic Testing: 2024

- SE GI: Fachtagung Software Engineering: 2024

Alexander Schultheiß

- ICSE AE: International Conference on Software Engineering 2024 - Artifact Evaluation

- Re:Volution 2024: International Workshop on Reverse Variability Engineering and Evolution of Software-Intensive System

- VaMoS 2024: International Working Conference on Variability Modelling of Software-Intensive Systems

Pablo Valenzuela

- Mining Software Repositories (MSR) 2024, Junior PC

Reviewing Activities

Timo Kehrer

- IEEE Transactions on Software Engineering

- ACM Transactions on Software Engineering and Methodology

- Software and Systems Modeling

- Science of Computer Programming

- Automated Software Engineering

- Journal of Software: Practice and Experience

Manuel Ohrndorf

- ACM Transactions on Software Engineering and Methodology

- International Conference on Software Engineering 2025 (Sub-Reviewer)

Christos Tsigkanos

- European Conference on Software Architecture (ECSA)

- Workshop on Agents and Robots for reliable Engineered Autonomy (AREA)

Roman Bögli

- Software and Systems Modeling (SoSyM)

- International Conference on Software Engineering 2025 (Sub-Reviewer)

- International Systems and Software Product Line Conference 2024 (Sub-Reviewer)

Alexander Boll

- International Conference on Software Engineering 2025 (Sub-Reviewer)

Alexander Schultheiß

- International Conference on Software Engineering 2025 (Sub-Reviewer)

- International Conference on Automated Software Engineering 2025 (Sub-Reviewer)

- Journal of Systems & Software

Thomas Sutter

- ACM Transactions on Software Engineering and Methodology

- Journal Computers & Security

Presentations

Timo Kehrer

- How to Increase the Trustworthiness of my Data Analysis Results? Data Science 4 Science, Bern, 2024.

- Zur Evaluation von Künstlicher Intelligenz in der Softwareentwicklung, SSIS-Frühjahrsworkshop, Bern, 2024.

- What Makes (Good) Research? A Software Engineering Perspective, PhD School Business Informatics, Fribourg, 2023.

Christian Birchler

- How Does Simulation-Based Testing for Self-Driving Cars Match Human Perception? FSE 2024, Porto de Galinhas, Brazil.

- SensoDat: Simulation-based Sensor Dataset of Self-driving Cars. MSR 2024, Lisbon, Portugal.

- Diversity-guided Search Exploration for Self-driving Cars Test Generation through Frenet Space Encoding, SBFT 2024, Lisbon, Portugal.

- TEASER: Simulation-based CAN Bus Regression Testing for Self-driving Cars Software, ASE 2023, Kirchberg, Luxembourg.

Roman Bögli

- On the Temporal Logic of Space Software Requirements, TAROT Summer School, Bergamo, 2024.

Alexander Boll

- Towards Semi-Automated Merge Conflict Resolution: Is It Easier Than We Expected? EASE 2024, Salerno, Italy.

- ScoutSL: An Open-Source Simulink Search Engine, MODELS 2023, Västerås, Sweden.

- EvoSL: A Large Open-Source Corpus of Changes in Simulink Models & Projects, MODELS 2023, Västerås, Sweden.

Alexander Schultheiß

- Variability-Aware Patching, FOSD, April 2024.

Pablo Valenzuela

- Exploring GitHub Actions through EGAD: An Experience Report, IWST 2023, Lyon.

Outreach and Other Activities

- Roman Bögli is Member of the *Prüfungskommission des Schweizerischen Informatik Zertifikats (SIZ)*.

- The group contributes to the annual *MINT-day* and *Nationaler Zukunftstag* to promote and highlight the importance of Mathematics, Informatics, Natural sciences, and Technology.

- Timo Kehrer serves as evaluator for both written and oral Matura exams at various Gymnasiums.

- Timo Kehrer was invited to and participated in the Dagstuhl Seminar *Research Software Engineering: Bridging Knowledge Gaps* , April 2024.

- Sandra Greiner was invited to and participated in the Dagstuhl Seminar *Human Factors in Model-Driven Engineering*, November 2023.

- Timo Kehrer was invited to and participated in the Dagstuhl Seminar *Integrating HPC, AI, and Workflows for Scientific Data Analysis*, August 2023.

11.9 Publications

- Thomas Sutter, Timo Kehrer, Marc Rennhard, Bernhard Tellenbach, Jacques Klein: Dynamic Security Analysis on Android: A Systematic Literature Review. IEEE Access 12: 57261-57287 (2024)

- Alexander Boll, Nicole Vieregg, Timo Kehrer: Replicability of experimental tool evaluations in model-based software and systems engineering with MATLAB/Simulink. Innov. Syst. Softw. Eng. 20(3): 209-224 (2024)

- Alexander Boll, Pooja Rani, Alexander Schultheiß, Timo Kehrer: Beyond code: Is there a difference between comments in visual and textual languages? J. Syst. Softw. 215: 112087 (2024)

- Christian Birchler, Tanzil Kombarabettu Mohammed, Pooja Rani, Teodora Nechita, Timo Kehrer, Sebastiano Panichella: How Does Simulation-Based Testing for Self-Driving Cars Match Human Perception? Proc. ACM Softw. Eng. 1(FSE): 929-950 (2024)

- Sandra Greiner, Timo Kehrer: Is the Feature Traceability Problem Already Solved? Softwaretechnik-Trends 44(2): 28-29 (2024)

- Kristof Meixner, Kevin Feichtinger, Hafiyyan Sayyid Fadhlillah, Sandra Greiner, Hannes Marcher, Rick Rabiser, Stefan Biffl: Variability modeling of products, processes, and resources in cyber-physical production systems engineering. J. Syst. Softw. 211: 112007 (2024)

- Grischa Liebel, Jil Klünder, Regina Hebig, Christopher Lazik, Inês Nunes, Isabella Graßl, Jan-Philipp Steghöfer, Joeri Exelmans, Julian Oertel, Kai Marquardt, Katharina Juhnke, Kurt Schneider, Lucas Gren, Lucia Happe, Marc Herrmann, Marvin Wyrich, Matthias Tichy, Miguel Goulão, Rebekka Wohlrab, Reyhaneh Kalantari, Robert Heinrich, Sandra Greiner, Satrio Adi Rukmono, Shalini Chakraborty, Silvia Abrahão, Vasco Amaral: Human factors in model-driven engineering: future research goals and initiatives for MDE. Softw. Syst. Model. 23(4): 801-819 (2024)

- Kristof Meixner, Kevin Feichtinger, Sandra Greiner, Rick Rabiser: On Configuration Sequences in Feature Models. VaMoS 2024: 146-148

- Sandra Greiner, Klaus Schmid, Thorsten Berger, Sebastian Krieter, Kristof Meixner: Generative AI And Software Variability - A Research Vision. VaMoS 2024: 71-76

- Sandra Greiner, Bianca Wiesmayr, Kevin Feichtinger, Kristof Meixner, Marco Konersmann, Jérôme Pfeiffer, Michael Oberlehner, David Schmalzing, Andreas Wortmann, Bernhard Rumpe, Rick Rabiser, Alois Zoitl: Maturity Evaluation of Domain-Specific Language Ecosystems for Cyber-Physical Production Systems. ETFA 2023: 1-8

- Sandra Greiner, Stefan Höppner, Frédéric Jouault, Théo Le Calvar, Mickael Clavreul: Incremental MTL vs. GPLs: Class into Relational Database Schema. Agile MDE/MeSS/TTC@STAF 2023

- Alexander Boll, Yael Van Dok, Manuel Ohrndorf, Alexander Schultheiß, Timo Kehrer: Towards Semi-Automated Merge Conflict Resolution: Is It Easier Than We Expected? EASE 2024: 282-292

- Timo Blattner, Christian Birchler, Timo Kehrer, Sebastiano Panichella: Diversity-guided search exploration for self-driving cars test generation through Frenet space encoding. Proc. 17th

ACM/IEEE International Workshop on Search-Based and Fuzz Testing, 2024

- Nicolas Erni, Al-Ameen Mohammed Ali Mohammed, Christian Birchler, Pouria Derakhshanfar, Stephan Lukasczyk, Sebastiano Panichella: SBFT tool competition 2024-python test case generation track. Proc. 17th ACM/IEEE International Workshop on Search-Based and Fuzz Testing, 2024

- Pooja Rani, Jonas Zellweger, Veronika Kousadianos, Luis Cruz, Timo Kehrer, Alberto Bacchelli: Energy Patterns for Web: An Exploratory Study. ICSE (SEIS) 2024: 12-22

- Nourhan Elfaramawy, Fatma Deniz, Lars Grunske, Marcus Hilbrich, Timo Kehrer, Anna-Lena Lamprecht, Jan Mendling, Matthias Weidlich: On Managing Large Collections of Scientific Workflows. Modellierung (Workshops) 2024: 12

- Arvid Butting, Timo Greifenberg, Katrin Hölldobler, Timo Kehrer: Visualizing Model and Data Differences with Inline Diff Editors in an Enterprise Low-Code Platform. Modellierung (Workshops) 2024: 25

- Christian Birchler, Cyrill Rohrbach, Timo Kehrer, Sebastiano Panichella: SensoDat: Simulation-based Sensor Dataset of Self-driving Cars. MSR 2024: 510-514

- Paul Maximilian Bittner, Alexander Schultheiß, Benjamin Moosherr, Timo Kehrer, Thomas Thüm: Variability-Aware Differencing with DiffDetective. SIGSOFT FSE Companion 2024: 632-636

- Timo Kehrer, Marianne Huchard, Leopoldo Teixeira, Christian Birchler: Proceedings of the 18th International Working Conference on Variability Modelling of Software-Intensive Systems, VaMoS 2024, Bern, Switzerland, February 7-9, 2024. ACM 2024

- Fabio Gadducci, Timo Kehrer: Specification and modelling of computing systems through graphs and graph transformation. J. Log. Algebraic Methods Program. 135: 100905 (2023)

- Anh Duc Vu, Jan Arne Sparka, Ninon De Mecquenem, Timo Kehrer, Ulf Leser, Lars Grunske: Design by Contract Revisited in the Context of Scientific Data Analysis Workflows. e-Science 2023: 1-2

- Anh Duc Vu, Jan Arne Sparka, Ninon De Mecquenem, Timo Kehrer, Ulf Leser, Lars Grunske: Contract-Driven Design of Scientific Data Analysis Workflows. e-Science 2023: 1-10

- Pablo Valenzuela-Toledo, Alexandre Bergel, Timo Kehrer, Oscar Nierstrasz: Exploring GitHub Actions through EGAD: An Experience Report. IWST 2023

- Christian Birchler, Cyrill Rohrbach, Hyeongkyun Kim, Alessio Gambi, Tianhai Liu, Jens Horneber, Timo Kehrer, Sebastiano Panichella: TEASER: Simulation-Based CAN Bus Regression Testing for Self-Driving Cars Software. ASE 2023: 2058-2061

- Sohil Lal Shrestha, Alexander Boll, Timo Kehrer, Christoph Csallner: ScoutSL: An Open-Source Simulink Search Engine. MoDELS (Companion) 2023: 70-74

- Sohil Lal Shrestha, Alexander Boll, Shafiul Azam Chowdhury, Timo Kehrer, Christoph Csallner: EvoSL: A Large Open-Source Corpus of Changes in Simulink Models & Projects. MODELS 2023: 273-284

- Arvid Butting, Timo Greifenberg, Katrin Hölldobler, Timo Kehrer: Model and Data Differences in an Enterprise Low-Code Platform. MoDELS (Companion) 2023: 868-877

- Paul Maximilian Bittner, Alexander Schultheiß, Sandra Greiner, Benjamin Moosherr, Sebastian Krieter, Christof Tinnes, Timo Kehrer, Thomas Thüm: Views on Edits to Variational Software. SPLC (A) 2023: 141-152

11.10   Awards

- Distinguished Paper Award at EASE 2024, the Intl. Conf. on Evaluation and Assessment in Software Engineering, for the work *Towards Semi-Automated Merge Conflict Resolution: Is It Easier Than We Expected?* by Alexander Boll, Yael van Dok, Manuel Ohrndorf, Alexander Schultheißand Timo Kehrer.

- Best Demonstration Award at FSE 2024, the Intl. Conf. on the Foundations of Software Engineering, for the work *Variability-Aware Differencing with DiffDetective* by Paul Maximilian Bittner, Alexander Schultheiß, Benjamin Moosherr, Timo Kehrer and Thomas Thüm.

- Werner Siemens Fellowship 2023/24 awarded to Roman Bögli, by Werner Siemens Foundation in cooperation with the Swiss Study Foundation.

- Second Best Paper Award at IWST 2023, the International Workshop on Smalltalk Technologies, for the work *Exploring GitHub Actions through EGAD: An Experience Report* by Pablo Valenzuela-Toledo, Alexandre Bergel, Timo Kehrer and Oscar Nierstrasz

- PhD Thesis JAACS Award 2023 for Manuel Ohrndorf, for his dissertation entitled *A History-based Approach for Model Repair Recommendations in Software Engineering*.