
# Project TruCoNF

## Automated Test Design for Non-Functional Properties

### Trust via cost function driven model based test case generation for non-functional properties of systems of systems

**PROJECT GOALS**

TRUCONF set out to increase trust in and reliability of systems of systems, going beyond the standard notion of functional correctness. It focused on emergent non-functional properties of complex composite systems and extending – as well as adopting – well-established modelling, verification and testing techniques.

**PROJECT RESULTS**

The project produced several results, which, when working together, allow for thorough functional testing based on easy to develop and maintain models, and for reliable predicting non-functional properties like response time, bandwidth consumption or memory usage from a model and several test runs. The predictions can be verified, providing a certain confidence level that they will hold, by a small set of automatically chosen tests. The project results in detail are:

- Modelling Language

One important outcome of the project is the textual modelling language MDML. It is expressive and flexible enough to model several device types brought in by the industrial partner, while still being clean and sufficiently simple to be easy to learn and use. Great care has been taken to make sure the modelling formalism could be presented in a way non-experts can use it. To achieve that aim, a special focus on user experience and end-user involvement was set. This includes not only the active design of domain specific languages (DSLs) but as well, how they are represented (textual, graphical, or combined) and how the DSL is embedded in the development and tool environment (user guidance, intuitive data access, model knowledge base, etc.). The language adopts concepts from behaviour driven design and abstract state machines. A development environment based on Eclipse Xtext is available.

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- Cost Learning

In order to use the result for non-functional testing, an approach to predict incurred costs using statistical methods and machine learning techniques has been designed. In the evaluation use cases, the costs were response times, but the concept should work as well for other non-functional properties, like network bandwidth load or memory consumption.

- Performance Hypothesis Checking

The test case generator together with the learned cost model can derive and check hypotheses about the probability that certain numeric non-functional properties stay below or above a given bounds. This allows, e.g., a probabilistic prediction of worst-case response times staying within a given confidence interval.

- Non-Functional Testing

The derived performance hypotheses need to hold on the system-under-test. To verify this, the tool generates tests and executes them on the system until there is enough confidence for the acceptance or rejection of the hypotheses. The amount of tests can be sufficiently smaller than the simulations needed for the probability prediction on the model. and practice in formal modelling.

- Model Based Testing

The test case generator MoMuT has been extended with further improved test case generation modes, providing better tests in shorter generation time. Support for MDML has been added and the test execution environment of the use case has been adapted to work with the generated tests. In addition, a new test case generation engine based on QuickCheck that supports statistical model checking has been built.

- Practicability / Evaluation in Use Cases

The practicability of the model development approach has been evaluated via monitoring of training and initial use by a small group of engineers, accompanied with interviews and analysis of the resulting models. The test case generation and cost learning techniques were evaluated by experimentally applying them to examples from industrial practice. One such example was a group of devices that are normally used in various combinations within engine and power train testbeds built by AVL. The other example was an application for usage management of such testbeds.

TRUCONF successfully created industrializable prototypes, which are expected to migrate to industrial use even within one year. It also fostered intensive, bidirectional knowledge exchange between the academic and the Industry partners: the academic partners got a well-founded view on what holds back rigorous system engineering approaches based on formal methods in industry, while the industry partner acquired knowledge and practice in formal modelling.

### PUBLICATIONS


Richard Schumi, Priska Lang, Bernhard K. Aichernig, Willibald Krenn, and Rupert Schlick: “Checking Response-Time Properties of Web-Service Applications Under Stochastic User Profiles“, *ICTSS 2017, St. Petersburg, Russia, October 9-11, 2017, Proceedings*, volume 10533 of *Lecture Notes in Computer Science*. Springer, 2017.

Andreas Fellner, Willibald Krenn, Rupert Schlick, Thorsten Tarrach, und Georg Weissenbacher, „Model-based, Mutation-driven Test Case Generation via Heuristic-guided Branching Search“, *MEMOCODE*, Vienna, Austria, September 29 - October 02 2017, *Proceedings*, pages. 56–66.

Bernhard K. Aichernig and Richard Schumi: “Property-Based Testing of Web Services by Deriving Properties from Business-Rule Models”. SoSyM, 2017, Open Access. (doi:10.1007/s10270-017-0647-0)

Gerald Stieglbauer, Christian Burghard, Stefan Sobernig and Robert Korošec: “A Daily Dose of DSL – MDE Micro Injections in Practice”, *MODELSWARD 2018, Funchal, Portugal, 22-24 January 2018, Proceedings*, pages 642-651, SCITEPRESS, 2018.


### PROJECT DATA


Duration: November 2014 to January 2018
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