# Software Construction



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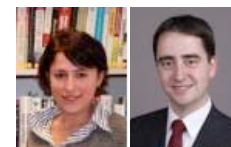




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# Overview

Our research focuses on the development of new and advanced methods, tools, and techniques in the broad area of software construction. Since software engineering is done in software developing organizations, we always try to develop and deliver software engineering support that is applicable under industrial software development conditions. Hence, most of our research projects are performed in close cooperation with industrial partners. Details on the projects can be found in the corresponding section of this report.

Currently we are actively working in the following areas:

- *Metric-based process evaluation and improvement*. Like in other engineering disciplines, measuring is a prerequisite to determine the performance of processes and products. We have started a new project the aims to develop an integrated highly customizable measurement infrastructure.

- *Simulation-based quality assurance of business processes and workflows*. Business processes as well as workflows become more and more an important means to specify and integrate software services and applications. An appropriate validation and verification approach of those models is an open issue but crucial for gaining all the benefits.

- *Advanced use case modeling*. Use case modeling is applied in industry for years to specify functional requirements. But the potentials of this requirements engineering technique are not utilized so far. An advanced modeling approach is needed enabling improved use case based requirements validation as well as use case based automated system testing.

Since appropriate tools are often the door opener to transfer research ideas to practice we are developing dedicated tool support for those areas. Currently we offer the following tools:

- ViPER (Visual Tooling Platform for Model-Based Engineering, www.viper.sc)

- QMetric and BugzillaMetrics (www.qmetric.org)

- NaUTiluS (Narrative Use Case Description Toolkit for Evaluation and Simulation)

- MeDIC (Measure Documentation - Integration and Calculation)

## Teaching

In addition to undergraduate courses on Programming and Software Development the group offers on the graduate level the following set of courses focusing on Software Construction and Software Quality Assurance:

- Lecture Software Quality Assurance

- Lecture Object-Oriented Software Construction

- Lecture Software Project Management

- Seminars and Practical Labs

Furthermore we are responsible for the Software Engineering course of the master program Software Systems Engineering at the Thai German Graduate School of Engineering, Bangkok, Thailand.

# Research Projects

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**Evaluating Business Process Models**

*A. Ganser, H. Lichter*

External cooperation: Osthus GmbH, Aachen

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Research in constructing software, in other terms software engineering, already exists for decades and over the years several approaches emerged. Ranging from procedural, functional until object oriented approaches, creating a model of the system to be build is a cornerstone of every approach. But, all software systems, which are modeled and developed with these approaches, deal with single pieces of software or software systems for narrow scopes (metaphor: e.g. for departments in companies). Consequently, one step in abstraction deals with connecting these software systems to workflows. This adds a goal oriented perspective and links several systems together to (e.g.) support departments working together in a static, but automated way. What remains is the importance of models in a sense of abstractions from the real world. The next step in abstraction adds business goals as a motivation and concerns the whole company or even several companies.

Hence, business process modeling enlarges the perspective with business goals and mainly adds the aspects of agile business processes and business goals. This sounds like documentation at first but committing to business processes actually burden engineers with severe architectural constrains. Moreover, demands emerged which want to have these business processes automated. As a consequence, business processes are required to be flawless in many different ways.

On the one side, a lot of research has been undertaken in the field of metrics for business process models. On the other side, a lot of quality models exist on a very high level of abstraction. But, only very few researchers ventured to establish a link between metrics and models. This is due to the gap perceived small but actually it is immense.

So, the initial questions are: What can we do with the metrics invent so far? What do the numbers mean with respect to a given quality model? Which metrics are missing? And, combined with simulations on business process models - which information we can glean? And, finally, is there interesting information derivable from historical information of models?

These simple questions turn out to be challenging since lot of the foundations are still missing.

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**Methodical and Tool Support for Advanced Use Case Modelling**

*V. Hoffmann, H. Lichter*

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Use cases are a widely accepted technique for the elicitation and specification of functional requirements. Nowadays Use Cases are addressed by many modern software development

processes and are a major driver for requirements engineering and several other downstream modelling activities like testing or the development of user documentation. Nonetheless all current use case modelling approaches lack a concise quality assurance infrastructure.

Therefore we have devised several mechanisms for the assessment of the quality of narrative use cases, a formalism for textual use case descriptions based on a formal meta-model.

First we have created a quality model for use case based specifications alongside several metrics for the analysis of specific quality aspects of this model. E.g. readability, consistency or granularity. All those metrics are either based on the formalized structure of the description, on their textual content or on a combination of both.

Moreover we have experienced that practitioners complain about difficulties in use case reviews. They report, that especially domain experts have difficulties to evaluate correctness and completeness of use case based descriptions because they have difficulties to follow the scenarios that form the behaviour of a system, since they are often scattered about several use cases. Therefore we have created a simulation framework for the enaction of use case based descriptions that should help to experience the behaviour in a simple intuitive fashion. Moreover we have enriched this simulation means with user interfaces. Thus the use case description simulation infrastructure can be used for very early prototyping and as basis for feasibility studies.
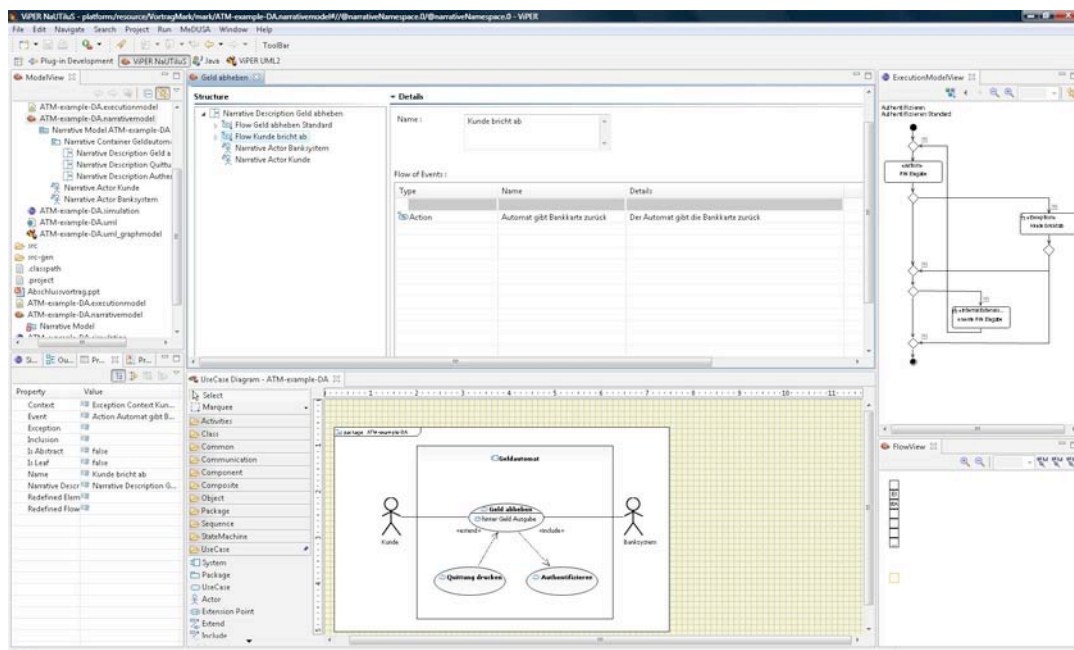


During the last year we enriched our existing tool support ViPER-NaUTiluS -an integrated tool support for specifying, editing and analysing of enriched use case descriptions based on the ViPER-IDE- with an infrastructure for the description and calculation of use case metrics. Furthermore the NaUTiluS framework now includes a use case simulator for the specified behaviour descriptions and an extension for GUI-prototypes. Thus NaUTiluS enables prototyping of the system behaviour very early in the development process.

**Automatic Test Case Generation based on Rich Use Case Models**

*M.Obaid, H.Lichter*

Although UML notational diagrams are a good means to model use cases on an abstract level, natural language descriptions that capture these use cases are still necessary and widely used for requirements. The aggregation of these both UML diagrams and the detailed descriptions form the complete use case model. Various current tools are available that support attaching more details into use case models and allow behaviour specifications of use cases with natural language descriptions. While some research work has been done to form high quality use case models that capture such descriptions (which are less readable or less practical for later phases use), other approaches were based on using limited semantically processed natural language phrases, but they still have usability problems and did not manage to reach the needed level of the practical use. Having such a usable high quality use case model is beneficial to represent what the future system will do and how it will behave, it does not only facilitate the next development phases, but also gives the possibility to have more beneficial features. Three of more important features are System Tests, Simulation, and Architecture. This research project will focus on the generation of system test cases out of such enhanced use case models.

The research focus is of two main phases, the first is the usage of flows of events based modelling of use cases, which forms a base and a higher quality future test scenarios in addition to a potential range of UC scenarios to choose the desired functionalities to be test and form the fore mentioned test scenarios. The second phase is an approach to allow the addition and manipulation of test data within the test scenarios chosen, which should be supported within a proper visualization to ensure flexible and usable test scenarios handling. Moreover, other areas must therefore be supported such as the coverage criteria, which is the mechanism to choose the functionalities that are wanted to be tested from the range of the use case scenarios and quality assurance for the final test cases and their possible usage lateron.

During the last year, a meta-models based approach was created to support the generation of test cases from already existing and slightly modified (possible to add more test data) flows-oriented narrative use case models. This approach covers the mechanism of the research idea, with near future additional GUI visualization and proper more flexible criteria coverage to be implemented.

**Process Assessment based on Software Repository Data**

*H. Schackmann, H. Lichter*

External cooperation: Kisters AG, Aachen

The development of a large portfolio of software projects raises several managerial challenges, like balancing resource allocation between different projects, and aligning development processes to the standards of the organization. Hence the project status and process quality characteristics, like planning precision or problem resolution speed, must be

monitored continuously in order to identify development process weaknesses, and assess process improvements. Collecting the required data by regularly project status reporting can be expensive and intrusive, and furthermore ignores the past history of a process. This motivates mining data from routinely collected repositories like change request management (CRM) systems.

However existing CRM tools provide only a number of fixed metric evaluations and are limited in their adaptability. In order to support a flexible approach for the evaluation of metrics on CRM data, the tool BugzillaMetrics was developed at our group. It is based on declarative metric specifications. This enables concentrating the main effort on the model of the metric, not on its implementation. Moreover the core of BugzillaMetrics is a generic metric evaluation algorithm that is adaptable to different change request management and version control systems. Currently adapters for Mantis, CVS, and Subversion are available. These tools have been made available open source in the QMetric tool suite. Further on the QMetric tool suite was extended by support for the definition of quality assessment models, and their automatic evaluation. Quality assessment models leverage the evaluation results of the software metric to the level of the quality characteristics of interest for the user. The tools had been evaluated in case studies targeted at the evaluation of quality characteristics within a project portfolio of open source projects, as well as in an industrial context.

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**Metric-Based Project and Process Management**

*M. Vianden, H. Lichter*

External cooperation: Generali Informatik Services, Aachen

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Solid and well engineered processes are the basement of successful software development projects. However the process may need to be changed due to outer or inner influences. The need for change raises two key questions: What parts in the process need to be changed and how do they need to be changed?

To answer the first question, processes and their application need to be transparent. One way of achieving transparency is to use metrics. Hence it is important to know what metrics to use when and where. Our idea is to provide an integrated metric environment together with supporting metric processes and metrics over metrics as a mean to ease the selection of the *right* metrics.

To answer the second question the Research Group Software Construction is developing a metric based quality model for software developing processes in close cooperation with Generali Deutschland Informatik Services. Applying this model should allow to assess and to improve the underlying processes. Using this knowledge another goal is to incrementally build a repository of process-adjustments that are in accordance with established models such as CMMI or SixSigma. This repository can then be mined using dedicated metrics and other input parameters to support the optimization of the processes

# Selection of Organisation Specific Reference Models

*S. Pricope, H. Lichter*

Organizations have to improve their processes continuously. There is a variety of collections of best practices known as maturity-, process- and quality-models as well as standards, norms, etc. that can be used. We call them reference models. Organizations have to decide which of these models they want to use. Should an organization select CMMI or SPICE? Is COBIT perhaps the right reference model? CMMI-SVC or ITIL?

The aim of our research is to provide a method for an objective selection of reference models that best fit to an organization. An objective selection requires transparency of the reference models and other factors that influences the selection decision. Our approach is to use dedicated models to achieve this transparency.

Transparency of reference models means understanding the reference models: On one hand identify the redundancies and compatibilities between reference models and on the other hand avoid misinterpretations by selection and later by their implementation in the organization. An integrated model is build to achieve such a transparency. A common structure is used to normalize the reference models regarding their structure. An additional model is used to interconnect and semantically normalize the reference models. The fine granularity of the integrated model allows an automatic comparison of the reference models and helps answering the redundancies and compatibility questions of the organizations.

Transparency of other factors for the selection means understanding which elements are relevant and need to be considered for making a decision selection. A model of organizations goals and characteristics is used to identify these elements and their relationships.

A mapping between the integrated model and the model of organizations goals and characteristics of an organization allow an objective selection for reference models that best suit to an organization.

# Other Activities

- Member of the international program committee, International Workshop on Formal Methods plus Agile Methods in Software Engineering, Rio de Janeiro, December 8 -11, 2009, *H. Lichter*

- Member of the international program committee, FM+AM' 2010, 2nd International Workshop on Formal Methods and Agile Methods, Pisa, September 17. 2010, *H. Lichter*

- Member of the program committee, Modellierung 2010, Klagenfurth, March 24-26, 2010, *H. Lichter*

- Member of the international program committee, 25th Annual ACM Symposium on Applied Computing, Software Engineering Track, Sierre, Switzerland, March 22-26, 2010, *H. Lichter*

- Member of the international program committee, 4th IEEE International Conference on Secure Software Integration and Reliability Engineering, Singapore, June 9-11, 2010 *H. Lichter*

- Member of the program committee, Software Engineering 2010, Paderborn, February 22-26, 2010, *H. Lichter*

- Member of the international program committee, SOFSEM 2010, 36th International Conference on Current Trends in Theory and Practice of Computer Science, Špindlerův Mlýn, Czech Republic, January 23-29, 2010, *H. Lichter*

- Reviewer for dpunkt-Verlag Heidelberg and computing reviews, *H. Lichter*

- Organization of the Computer Science Department's mentors program, *H. Lichter*

- Member of the Computer Science Department's committee for Lehre and Service-Lehre, *H. Lichter*

- Member of the examination board of Bachelor Computer Science, *H. Lichter*

- Member of workgroup "Zusammenarbeit Hochschule und Industrie", GFFT, Gesellschaft zur Förderung des Forschungstransfers, *H. Lichter*

- Reviewer of PhD thesis A. Grimm, LMU Munich, *H. Lichter*

- Organization and member of workgroup "Messen und Bewerten", REGINA e.V., *H. Lichter, M. Vianden, S. Pricope, A. Ganser*

- Organization of Software Engineering Research Camp 2009 and 2010 in cooperation with Department of Computer Science 3, *H. Lichter, A. Ganser, M. Vianden*

- Organization of the Beginner's Course in Computer Science 2010, *H. Lichter, A. Ganser, S. Pricope*

- Member of Beginner's Course Task Force in context of "Studieren im Focus der Exzellenz", 2010, *A.Ganser*

# Talks and Publications

## Talks

H. Lichter: Developing Software in a Research Environment, Workshop SPI Techniques for Research Organizations, NECTEC National Electronics and Computer Technology Center, Bangkok, July 30, 2010.

H. Lichter: Economics of Quality Assurance Measures, UTM Universiti Teknologi Malaysia, Software Engineering Department, Johor Bahru, July 22, 2010.

H. Lichter: Modernes Metrikmanagement, LMU München, Kolloquium Wirtschafts-informatik, July 9, 2010.

C. Piyabunditkul: Step forward CMMI-Project Management by optimized Scrum, ProMAC 2010, 5th International Conference on Project Management, Makuhari, Japan, October, 13-15, 2010.

C. Piyabunditkul: Accelerated Adoption CMMI by Agile Methodologies, ProMAC Symposium 2009, Bangkok, Thailand, October 28-30, 2009.

C. Piyabunditkul: Combining CMMI and Agile Approaches Based on a SPI Advisory Tool, SEPoW 2009, First Software Engineering Postgraduates Workshop (In conjunction with APSEC 2009), Universiti Sains Malaysia (USM), Penang, Malaysia, November 30, 2009.

M. Vianden, K.-J. Neumann: Projekt- und Prozessmetriken in der IT-Entwicklung eines Versicherungskonzerns, iqnite 2010, Düsseldorf, Germany, April 28, 2010.

S. Pricope: Model Based Selection of Organization Specific Improvement Instruments 36th Euromicro Conference on Software Engineering and Advanced Applications SEAA 2010, Lille, France, September 3, 2010

V. Hoffmann: A Model Based Narrative Use Case Simulation Environment, 5th International Conference on Software and Data Technologies (ICSOFT 2010), Athens.

V. Hoffmann: Processes and Practices for Quality Scientific Software Projects. 3rd International Workshop on Academic Software Development Tools WASDeTT-3, Antwerp, August-20.

## Publications

J. Ludewig, H. Lichter: Software Engineering - Grundlagen, Menschen, Prozesse, Techniken, 2. Aufl., dpunkt.verlag, Heidelberg.

V. Hoffmann, H. Lichter: A Model Based Narrative Use Case Simulation Environment. In José Cordeiro, Maria Virvou, Boris Shishkov (Eds.): Proceedings of the 5th International Conference on Software and Data Technologies (ICSOFT 2010), Vol. 2, pp.63-72. Athens, Greece, July 2010.

S. Pricope, H. Lichter: Model Based Selection of Organization Specific Improvement Instruments Proceedings of the WIP Session, 36th Euromicro Conference on Software Engineering and Advanced Applications SEAA 2010, Lille, France, SEA-Publications: SEA-SR-27, ISBN 978-3-902457-27-1

H. Schackmann: Metrik-basierte Auswertung von Software-Entwicklungsarchiven zur Prozessbewertung. Aachener Informatik-Berichte, Software Engineering, Band 7, Shaker Verlag Aachen, ISBN 978-3-8322-9405-2.

V. Hoffmann, H. Lichter, A. Nyßen: Processes and Practices for Quality Scientific Software Projects. In H. Kienle (Ed.) Proceedings of 3rd International Workshop on Academic Software Development Tools WASDeTT-3, Antwerp, pp 95-108.

L. Grammel, H. Schackmann, A. Schröter, C. Treude, M.-A. Storey: Attracting the Community's Many Eyes: an Exploration of User Involvement in Issue Tracking. The Second Workshop on Human Aspects of Software Engineering (HAoSE2010) in conjunction with SPLASH 2010, Reno/Tahoe Nevada, USA, October 17, 2010.

Chayakorn Piyabunditkul, Nithipat Wongchingchai, Apinporn Methawachananont (2010): Step forward CMMI-Project Management by optimized Scrum. Proceedings of the 5th International Conference on Project Management, The Society of Project Management (SPM), Japan, pp 688-698, ISBN 978-4-902378-19-1.