Biennial Report 2012/2013
Department of Informatics
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1 Research Groups
1.1 IPSSE

1.1.1 Overview

Leaders
Prof. Dr. Ursula Goltz (TU Braunschweig)
Dr.-Ing. Stefanie Jauns-Seyfried (Volkswagen AG)
Prof. Dr. Andreas Rausch (TU Clausthal), Chairman IPSSE
Prof. Dr. Christian Siemers (TU Clausthal)

Secretary
Daniela Görtz

Scientific Employees
Dipl.-Inf. Benjamin Cool (since 11/2011)
Dipl.-Ing. Peter Engel (since 08/2012)
Dipl.-Inf. Christoph Gernert (since 08/2012)
M.Sc. Axel Grewe (since 09/2012)
B.Sc. Jörg Grieser (since 10/2013)
B.Sc. Dirk Herrling (since 06/2011)
M.Sc. Vignesh Jayaraman (since 04/2013)
B.Sc. Yuri Jon (since 11/2011)
Dr. rer. nat. Christoph Knieke (since 12/2010)
Dipl.-Inf. Marco Körner (since 11/2010)
M.Sc. Inform. Malte Mauritz (since 04/2011)
B.Sc. Franz Melchior (since 10/2012)
Dr. rer. nat. Dirk Niebuhr (since 11/2010)
Dipl.-Inform. Henrik Peters (since 10/2011)
M.Sc. Arthur Strasser (since 06/2012)
Dipl.-Inf. Christian Ristig (since 01/2013)
Dipl.-Wirt.-Inf. Martin Vogel (since 05/2011)

1.1.2 Research Agenda

The research association Institute for Applied Software Systems Engineering (IPSSE) was founded in late 2011 as cooperation between TU Clausthal, TU Braunschweig and Volkswagen AG.

The research goal of IPSSE lies in methods and tools for the development of embedded systems. In this scope, one of the prevailing themes of IPSSE is the application of model-driven approaches to automotive software engineering. Therefore we provide a kit containing methods, techniques and tools for successful engineering of embedded software. Our task is to improve this kit with valid and consolidated findings from research, and to transfer it to practice.

Currently, there are five areas of expertise:

☐ Reliable reactive systems,
☐ Adaptive and modular architectures,
IPSSE has a recognized expertise in these fields, on both academic and industrial level.

Concrete approaches in these fields are

- Model-based development with support of product variants, reuse and evolution
- Design of modular architectures
- Measurement and evaluation of architecture erosion and quality with the goal of continuous architecture improvement
- Definition and development of platforms, for example in the multi-core environment
- Model management and automated consistency and quality assurance of models
- Design and implementation of modeling and development tools, e.g. for implementation and testing
- Test-driven development and model-based testing
- Software quality: Formal methods, validation and verification
- Design procedures for real-time systems and distributed real-time systems, also with the aid of co-design
- Transcoding for systems with various design and execution paradigms
- Safety: Detection of execution errors (during runtime) in programs and hardware (in-situ monitoring)

All research results are demonstrated in demonstrators, prototypes or full-featured tools. Seamless tool support is realized within demonstrating scenarios. The results are validated in the environment of the industrial partners and with their close co-operation.

For further information, please see the group’s homepage at http://www.ipsse.de/.

1.1.3 Supervised Theses

Diploma and Master’s Theses:


**Bachelor’s Theses:**


### 1.1.4 Projects

**Project 1: Agosense**

**Project Members**
- Dr. rer. nat. Christoph Knieke (Leader)
- Dipl.-Inf. Benjamin Cool (Project Staff)

**Partner**
- Volkswagen AG, Wolfsburg, Germany
Funding
Volkswagen AG
40,000€ (of 40,000€ total)

Duration

Project Description
In this project we helped Volkswagen to establish a middleware platform to interconnect one of their tool chains. The middleware platform to be established was the agosense.symphony platform shown in the project picture below. Based on this platform, we assisted Volkswagen with the implementation of two processes: one to link PTC Integrity and IBM Doors, and the other to link PTC Integrity and ChESS (Change-Management for Embedded Software Systems). This project was led by Volkswagen, while IPSSE provided development support and valuable software engineering know-how.

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Project 2: Array Interfaces

Project Members
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Dipl.-Inf. Benjamin Cool (Project Staff)
B.Sc. Dirk Herrling (Project Staff)
Dipl.-Inf. Marco Körner (Project Staff)
Dr. rer. nat. Dirk Niebuhr (Project Staff)

Partner
Volkswagen AG, Wolfsburg, Germany
Funding
Volkswagen AG
5,000€ (of 5,000€ total)

Duration
since 01.10.2013

Project Description
The software development for the engine control unit is model-driven and component-based. The interfaces are composed of different elements which can be, amongst others, arrays. Arrays open up special challenges as write access is not an atomic operation on the engine control unit. Data consistency has to be ensured for different data hazard scenarios, like read after write, write after read or write after write.

In this project a variety of topics have been investigated:

• Techniques used by control system engineers at Volkswagen to ensure data consistency when accessing interface arrays.
• Development of tools and code-fragments to ensure data consistency with minimal processing and memory overhead.
• Prototyping of safe, concurrent read and write access of interface arrays in engine control modules.
• Development of a best-practices guideline to ensure consistent array access with minimal processing and memory overhead.
• Integration of said guideline into the current software development process for engine control software.

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Project 3: BKV - Development of a Pressure Control Software for a Brake Servo Unit
Project Members
Prof. Dr. Andreas Rausch (Leader)
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Dr. rer. nat. Dirk Niebuhr (Project Staff)

Partner
Volkswagen AG, Wolfsburg, Germany

Funding
Volkswagen AG
65,000€ (of 65,000€ total)

Duration

Project Description
Over time the amount of functional requirements of a software system grows. The change of the software often is done under high time pressure which often leads to an erosion of the software architecture. An aggravating factor is that the software system is embedded in different hardware environments. The major goal of the BKV (short for “Bremskraftverstärker”, English: brake servo unit) project was to redesign the software system to fulfill the needs of functional and non-functional requirements in a software product line context. The new design describes a reference architecture using a different decomposition than the original one and utilizing a new interface concept. The resulting modularity allows the instantiation of efficient software architectures for each product of the BKV product line.

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Project 4: Real-Time Capable and Safety-Aware Multicore Architecture

Project Members
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Dipl.-Inf. Christian Ristig (Project Staff)

Partner
EADS, München, Germany

Funding
EADS
37,500€ (of 37,500€ total)

Duration
Project Description
Multicore processors are the best choice, if performance issues must be met, and the number of cores will increase significantly in the next years. Nevertheless, until now, multicore architectures have been rarely used within safety critical applications, as they present even more issues to be solved, in order to meet safety requirements. This project addressed the real-time behavior as well as the safety issues of multicore architectures using architectural approaches.

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Project 5: EBKV - Software Architecture of a Centralized Torque Management System

Project Members
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M.Sc. Axel Grewe (Project Staff)

Partner
Volkswagen AG, Wolfsburg, Germany

Funding
Volkswagen AG
60.000€ (of 60.000€ total)

Duration
since 30.11.2012

Project Description
The extension of the torque management system by new software and hardware systems increased the variability of the product line. Although some of the new features introduced cross cutting concerns, the time pressure during development allowed only local changes. That lead to an erosion of the software architecture.

The major goal of the EBKV project was a re-design of the reference software architecture of the torque management system. It was imperatively necessary to take the challenges into account that came with a complex product line. The new design uses newly developed architecture styles to weaken the strength of the coupling between the components. This enabled a modularity that could be used to create efficient architectures for each product of the software product line.

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Project 6: Energo
**Project Members**

Prof. Dr. Andreas Rausch (Leader)
Dipl.-Ing. Peter Engel (Project Staff)
B.Sc. Jörg Grieser (Project Staff)

**Partner**

Volkswagen AG, Wolfsburg, Germany

**Funding**

Volkswagen AG
15,000 € (of 15,000 € total)

**Duration**

since 01.01.2012

**Project Description**

Energo is a software application of the engine control unit for Predictive Drive Control, which was developed with the help of a model-based approach. The objectives of the system are to provide hints for the driver to attain more fuel efficiency, e.g. early take off the acceleration pedal in front of a rotary traffic, and strategic operation decisions for freewheeling, e.g. fuel cut-off in the overrun with opened or closed clutch.

Due to the intensive calculations, the software application requires a large amount of computing capacity of the engine control unit. Timing measurements and detailed analysis enable the identification of the most resource hungry parts of the software. Suitable measures should reduce the demand of processing unit power. Furthermore, there is a focus on timing measurements for engine control unit applications. This requires basic research of a measuring concept and appropriate software solutions. Their general adaptability should be evaluated on the basis of the Energo project.

Up to the present moment, several goals have been achieved in this project:

- Research of timing measurement concepts and software
- Functional analysis of the Energo components
- Improvement of runtime performance
- Optimization of memory requirements
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Project 7: Cooperative Doctoral School on Electromobility

Project Members
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Partners
Niedersächsische Technische Hochschule, Germany
Niedersächsische Forschungszentrum Fahrzeugtechnik, Braunschweig, Germany
Ostfalia Hochschule für angewandte Wissenschaften, Wolfenbüttel, Germany
Hochschule Hannover, Germany
Technische Universität Braunschweig, Germany
Leibniz Universität Hannover, Germany

Funding
Lower Saxony Ministry for Science and Culture (MWK)
120.000€ (of 1.200.000€ total)

Duration

Project Description
The electrification of driving is an essential lever for sustainable mobility. It offers the opportunity to reduce our dependency on oil, to minimize emissions and to better integrate the vehicles into a multi-modal transport system. However, there is an apparent need to develop not only new materials for energy storage and energy conversion, but also new business models, new control options for smart grids and new simulation tools for assessment and development of new concepts.
1.1 IPSSE

The cooperative doctoral program Electromobility (German: *Kooperatives Promotionsprogramm Elektromobilität*) is a multi-site, interdisciplinary doctoral program on the interface between science, engineering and economics, which complements the location-based graduate and postgraduate study through a cross-site interdisciplinary training program. The goal of this PhD program is an interdisciplinary research of selected basic concepts and approaches for the generation of 2020+ electric mobility. The following institutions take part in this program:

- Niedersächsische Technische Hochschule: a merger of Technische Universität Braunschweig, Technische Universität Clausthal, and Leibniz Universität Hannover,
- Hochschule Hanover, and
- Ostfalia Hochschule für angewandte Wissenschaften.

The PhD students are working at one of these universities and are involved in the facilities of the PhD program. IPSSE coordinates the cooperation of all involved facilities and supervises the research projects of two PhD students.

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**Project 8: MBT - Model-based Testing**

**Project Members**
- **Dr. Christoph Knieke** (Leader)
- **Dipl.-Inform. Henrik Peters** (Project Staff)

**Partner**
Volkswagen AG, Wolfsburg, Germany

**Funding**
Volkswagen AG
35,000€ (of 35,000€ total)

**Duration**
since 01.01.2012
Project Description

The software of power-train functions is tested at different levels. It should be noted that acceptance testing at the level of modules and functions comes with different challenges. Among other things, so-called legacy software has to be integrated and verified often. In the development process of power-train functions there are project-specific test criteria, so that each project is testing on their own terms.

The aim of the project is to optimize the test quality by means of introducing model-based testing to the development process. On one hand, uniform standards for tests on module and function level should be introduced. On the other hand, the degree of test automation should be increased by a model-based approach.

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Project 9: Model Quality

Project Members
Prof. Dr. Andreas Rausch (Leader)
Dipl.-Wirt.-Inf. Martin Vogel (Project Staff)

Partner
Volkswagen AG, Wolfsburg, Germany

Funding
Volkswagen AG
20,000€ (of 20,000€ total)

Duration
since 01.01.2013

Project Description
Requirements engineering for software development in the automotive domain becomes more pretentious and complex. Functions in this domain are less programmed and more modeled. How good or bad these models are in terms of selected quality factors, e.g. maintainability or extensibility, is often disregarded. Because these models are not used only for one automotive, but on several automotive series, it is necessary to ensure the quality of the models in terms of the selected quality factors. In order to ensure the quality of the models in the long term, it is imperative to check their quality in a durable manner during the development process.
1.1 IPSSE

Research Groups

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Project 10: Module Development

Project Members
Dr. rer. nat. Christoph Knieke (Leader)
All scientific employees (Project Staff)

Partner
Volkswagen AG, Wolfsburg, Germany

Funding
Volkswagen AG
1.115.000€ (of 1.115.000€ total)

Duration
since 01.01.2012

Project Description
Module development is a term used by Volkswagen to describe software development for the engine control unit. The control system engineers of Volkswagen and its suppliers use a model-driven approach to develop the physical models of the requested functions. The software engineering department takes these models and transforms them into C-code, e.g. by adding quantization formulas and using code generators.

IPSSE is handling a part of the load which the software engineering department of Volkswagen has to manage. More concrete, IPSSE is performing the following tasks:
• Integer quantization: The physical models developed by the control systems engineers are by default calculated in floating point arithmetic. Although code generators can automatically transform floating point into fixed point calculations, the results can be significantly improved if meta information like ranges of values or needed resolutions are added to the model.

• Model to C code transformation: The C code is generated from the given physical model by a code generator, which requires a specific configuration of the involved tools and referenced objects.

• Testing: Currently, model in the loop tests are run by the control system engineers. The results of these tests are compared against those of the software in the loop tests, which are performed by the software engineers.

• Analysis: A static code analysis is performed for the generated C code for all models, in order to ensure safety and non-functional requirements.

The purpose of this project is to gain a better understanding of the underlying principles which support the process of software development for engine control units at Volkswagen. Only with a good knowledge of the involved tools and processes can serious support and consulting in the fields of tool support and processes of software development be provided.

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Project 11: MultiCore

Project Members
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Partner
Volkswagen AG, Wolfsburg, Germany

Funding
Volkswagen AG
170.000€ (of 170.000€ total)

Duration
since 01.01.2012
**Project Description**

Multicore electronic control units (ECUs) provide additional computational power and the ability for parallel execution, that can be featured by car manufacturers to enable high scale integration of in-vehicle applications, e.g. engine control. Applications, which were initially executed on a single-core, have to be partitioned for integration on multiple cores. Our goal in this project is to provide techniques for migration of control applications. These techniques ensure that approved critical or non-critical single core applications behave in the same way on multiple cores.

In this project, different migration scenarios have been investigated. One of these is the model enrichment scenario, which enables the migration of behavioral models, e.g. models developed in ASCET. The migration is realized by additionally providing requirements specification on the base of a developed architecture specification language. The language is then used to verify behavioral requirements of model-based applications during model-based software integration.

The second part of the project deals with a timing analysis of the models. At first, models are created which contain information of the supplier and the OEM-code. Then, we analyze the timing properties of these models in order to forecast some of the timing problems that may arise due to the parallel execution of the software applications.
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**Project 12: Poseidon**

**Project Members**
Dr. rer. nat. Christoph Knieke (Leader)
B.Sc. Dirk Herrling (Project Staff)

**Partner**
Volkswagen AG, Wolfsburg, Germany

**Funding**
Volkswagen AG
20,000€ (of 20,000€ total)

**Duration**

**Project Description**
Software engineering for the engine control unit is performed in diverse, non-standard ways by different software developers. This is worth changing in order to have a more predictable quality of the resulting software artifacts and a better understanding of the software development process in general.

Poseidon was one of many steps taken to improve this situation. The idea behind this project was a mixture of tutorial and interactive manual. It was build as a web application to step through the explanation of a specific process (e.g. module testing) and serve as a manual. The name of the project originates from the Greek god with the same name.

During the execution of the project, several goals have been achieved:

- Documenting the process for different tasks during software development for engine control software, e.g. module testing, quantization, build processes, etc,
- Providing an interactive step-by-step process for the explanation of various software processes,
- Providing every step in the process with texts and graphics,
- Full text search function through the descriptions of the process steps.
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Project 13: Quicar Elektrisch - eMobility Car Sharing

Project Members
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Partners
Volkswagen AG, Wolfsburg, Germany
Niedersächsisches Forschungszentrum Fahrzeugtechnik, Braunschweig, Germany
Ostfalia Hochschule für angewandte Wissenschaften, Wolfenbüttel, Germany
Hochschule Hannover, Germany
Technische Universität Braunschweig, Germany
Leibniz Universität Hannover, Germany

Funding
Federal Ministry for Economic Affairs and Energy (BMWi)
120.000€ (of 2.600.000€ total)

Duration
01.01.2012 – 30.12.2015
Project Description

The successful marketing of e-car-sharing is still pending against a number of unresolved challenges. Heavy investments in vehicles and in their customized software are necessary. At the same time, there is a lack of knowledge with regard to customer expectations and market development. Further problems arise from the dimensioning and operation of the electric vehicles and the necessary infrastructure. These issues include the optimization of vehicle components, such as control and driver assist systems for short-term use. Another issue is the establishment of appropriate charging infrastructures in the (semi-)public space, ensuring correct charging interface and on-demand charging strategy, while dealing with range restrictions.

New (vehicle) technical solutions adapted to the boundary conditions of the car-sharing are therefore required. In this context, the IPSSE team focused on the optimization of vehicle functions and drive efficiency.

In order to determine a usage- and profile-optimized operating strategy of the entire vehicle, it is necessary to determine and display the energy consumption of the engine and power train as well as the single energy consumption of ancillary components, as these contribute significantly to the total energy expenditure.

Thus, the goal of this project is to identify significant improvement potentials. This is targeted by evaluation and further processing of the CAN data through analog measurement technology. For this purpose, basic usage scenarios were defined and a data logger at an E-Golf was put in operation. A first series of measurements was performed for the defined scenarios. In a further step, these data will be evaluated and determined to what extent the incorporation of analog measuring technology is necessary and whether the energy consumption of the ancillary components can be accurately estimated by a suitable simulation model.
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Project 14:  Algorithms for Model Optimization with TurboProp

Project Members
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- M.Sc. Arthur Strasser (Project Staff)

Partner
Volkswagen AG, Wolfsburg, Germany

Funding
Volkswagen AG
100.000€ (of 100.000€ total)

Duration
since 01.01.2012

Project Description
TurboProp is a software application that provides developers with an environment for the unified implementation of software models. It reduces significantly the development time and supports optimization of code, precision and performance. The software helps in analyzing software models via the user interface and indicates possible errors and overflows in the model. Based on this analysis, it corrects the model by automatically choosing suitable data types and quantization, such that 32-bit overflows and precision losses are minimized or, if possible, avoided. The selections are made with the help of an algorithm based on affine arithmetic. The algorithm also suggests changes to the existing model on grounds of precision, performance and also memory usage as required by the user. The project is a collaboration between Volkswagen and IPSSE, in which IPSSE is responsible for the development and implementation of the analysis and optimization algorithm.


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Project 15: UseBox - Unified Software Engineering Toolbox

Project Members
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Dipl-Inf. Henrik Peters (Project Staff)
B.Sc. Dirk Herrling (Project Staff)

Partner
Volkswagen AG, Wolfsburg, Germany

Funding
Volkswagen AG
75,000€ (of 75,000€ total)

Duration
since 01.01.2012

Project Description
The Unified Software Engineering Toolbox (UseBox) is a unified, yet flexible platform for plugin-applications, which automatize certain activities of the development process for automotive software in the engine control unit at Volkswagen AG. The UseBox is currently developed and maintained by the Institute for Applied Software Systems Engineering and frequently used by control system engineers and software developers at the engine unit of Volkswagen AG.

The research group at IPSSE has developed a versatile set of plug-ins:
1.1 IPSSE

- ADD Container-Fix Checker
- Tool-Chain Checker
- Makelog-Analyzer
- Sandbox-Creator
- Dataspace Name Checker
- DDX Exporter
- Documentation Assistant
- Query Analyzer
- Build-Environment
- MDA-Auto-Differ
- Task-Controlling
- Test Analyse Tool
- DDX Processor
- Docu Label Assistant

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Project 16: ZEUSS - Centralized Development Environment for Control Unit Software

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- Dipl.-Inf. Christian Ristig (Project Staff)
- B.Sc. Dirk Herrling (Project Staff)
- M.Sc. Inform. Malte Mauritz (Project Staff)

Partner
Volkswagen AG, Wolfsburg, Germany

Funding
Volkswagen AG
70,000€ (of 70,000€ total)

Duration
since 01.01.2012
**Project Description**

There are a large number of manual processing steps included in the software development process for engine control units. Many of these steps can be automated, with the help of various tools which provide application programming interfaces (APIs). Over the last years dozens of small scripts and programs have been created independently by software developers to improve their everyday work.

ZEUSS (Zentrale Entwicklungsumgebung für Steuergeräte Software, English: centralized development environment for control unit software) aims at the automation of as many process steps during software creation as possible and making the small scripts of the software developers obsolete. This project is lead by Volkswagen, in which IPSSE is providing development support and valuable know-how in software engineering.

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1.1.5 **Highlights**

- **In 2013**
  - January 2013: Dirk Herrling visited the University of Auckland, New Zealand, and held a talk titled *Iterative Development of a Requirements Model with Integrated Feedback Loops*. While on site, he laid the basis for supervising a master project with the title *Development of a Time Management Software* and a seminar paper titled *Comparison of PHP Frameworks*. The student projects were coordinated from TU Clausthal, whereas the final presentations took place at the University of Auckland.
2.1 Refereed Conference and Workshop Publications (1)


2.2 Diploma Theses (1)


2.3 Bachelor’s Theses (2)


2.4 Master’s theses (5)


