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ESI Symposium 2009

Presentations and information market

December 8th
Eindhoven
The Netherlands

Editor: Roland Mathijssen

ESI Report Nr 2009-1
8 December 2009

ESI Reports are available via
http://www.esi.nl/publications/reports
(print)   ISSN: 1876-1607
(online) ISSN: 1876-1615

Programme

Time	Blauwe zaal	Collegezaal 4	Collegezaal 5	Senaatszaal
9.00 - 9.30	Registration, coffee & tea			
9.30 - 9.45	**Welcome & opening** **Boudewijn Havertkort (ESI)**			
9.45 - 10.30	**Keynote presentation** **Rudy Lauwereins, (IMEC)** From 'Counting my Sheep' to 'Recording and Storing my Life'			
10.30 - 11.00	Break, Opening of Information market			Information market
Track	*Robotics*	*Modeling*	*Darwin*	
11.00 - 11.30	**1.1 Stefano Stramigioli (UT)** Variable Impedance Actuators	**2.1 Hristina Moneva (ESI)** Modeling: the holy grail for designing complex systems?	**3.1 Thom van Beek (TUD)** Capture User Requirements using Workflow Scenarios	
11.30 - 12.00	**1.2 Just Herder (TUD)** Balancing variable payload	**2.2 Jan Tretmans (RU / ESI)** Model-Based Testing applied to an Electronic Passport	**3.2 Adam Vanya (VU)** Characterization of Evolutionary Clusters	
12.00 - 13.30	Lunch, Information market			
Track	*ALwEN*	*Octopus*	*Dissemination*	
13.30 - 14.00	**4.2 Frits van de Wateren (Chess / Devlab)** The MyriaNed Wireless Sensor Network	**5.1 Arjan de Roo (UT)** An Architectural Style for Optimizing System Qualities in Adaptive Embedded Systems	**6.1 Joris van den Aker (ESI)** Competence Training & Development for Architects	
14.00 - 14.30	**4.2 Daniela Gavidia (VU)** Epidemic Information Dissemination in Wireless Environments	**5.2 Twan Basten (TU/e / ESI)** Design-Space Exploration of High-Tech Embedded Systems	**6.2 Remko van der Zee (Vanderlande)** Integration & Testing Practices	
14.30 - 14.45	Break			
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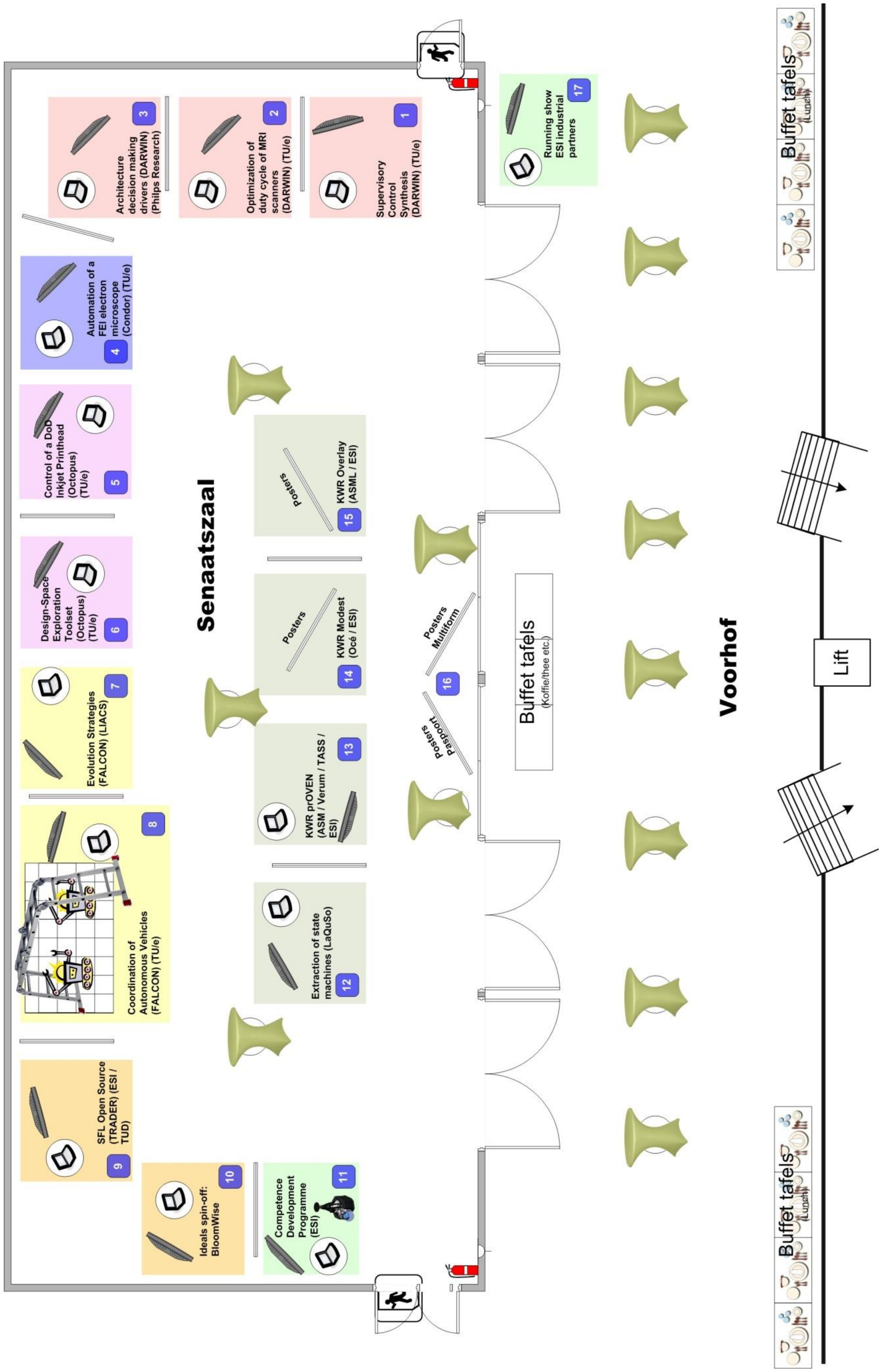
14.45 - 14.55	**7.1 Jeroen Voeten (TU/e / ESI)** Wings: Performance and Flexibility for ASML Execution Platforms	**8.1 Roelof Hamberg (ESI)** **Yang Yang (TU/e)** Octopus: Modeling and Exploration of Printer Data-Paths	**9.1 Maurice Glandrup (Thales)** Introduction of the track	
14.55 - 15.15			**9.2 Arjan Mooij (TU/e)** Run-time integration in dynamic systems-of-systems	
15.15 - 15.45	**7.2 Daniel Borches (UT)** Darwin: Coping with System Evolution	**8.2 Edgar Reehuis (LIACS)** **Thomas Bäck (LIACS)** Design-Space Exploration using Evolution Strategy	**9.3 Alberto Gonzalez (TUD)** Run-time testing in dynamic systems-of-systems	
15.45 - 16.00	Break			
16.00 - 16.45	**Keynote presentation** **Harry Borggreve (ASML)** The world of nanometer precision: stretching system performance and complexity management			
16.45 - 17.00	**Future plans & Closure** **Boudewijn Haverkort (ESI)**			
17.00 - 17.30	Drinks			

Info market room (Senaatszaal)

Information market

	On show	Project / CIP	Demonstrators
1	Supervisory control synthesis	Darwin / Philips Healthcare	Rolf Theunissen
2	Optimization of duty cycle of Magnetic Resonance Imaging scanners	Darwin / Philips Healthcare	Evgeniy Ivanov
3	Architecture decision making drivers	Darwin / Philips Healthcare	Ana Ivanovic
4	Automation of a FEI electron microscope	Condor / FEI	Richard Doornbos
5	Control of a Drop-on-Demand Inkjet Printhead	Octopus / Océ	Amol Khalate Mohammed Ezzeldin
6	Design-Space Exploration Toolset	Octopus / Océ	Jacques Verriet Twan Basten
7	Application Examples of Evolution Strategies	Falcon / Vanderlande Industries	Edgar Reehuis Thomas Baeck
8	Coordination of Autonomous Vehicles	Falcon / Vanderlande Industries	Jurjen Caarls Sisdarmanto Adinandra
9	Open source Spectrum-based Fault Localization	Trader / NXP	Jozef Hooman Hristina Moneva

	On show	Project / CIP	Demonstrators
10	Ideals spin-off: BloomWise	Bloomwise	Gurcan Gulesir Alain le Loux
11	Competence Development Programme	CDP / ESI	Joris van den Aker
12	Extraction of state machines of legacy C code with Cpp2XMI	LaQuSo	Harold Weffers et.al.
13	KWR prOVEN "Reducing Development Costs by Proven Components"	Verum / ASM-Europe / TASS / ESI	Frans Karsmakers
14	KWR Modest "Model Based Design and Testing"	Océ / ESI	Lou Somers
15	KWR Overlay	ASML / ESI	Wouter Tabingh Suermondt
16a	Model-based Testing of Electronic Passports	RU Nijmegen / LaQuSo / ESI	Jan Tretmans
16b	Multiform - Integration Framework	Multiform / ESI	Hristina Moneva
17	Running show CIPs	ESI CIP's	Roland Mathijssen


Senaatszaal
Voorhof
Lift
Buffet tafels
(Koffie/thee etc.)
Buffet tafels
(Lunch)
1 Supervisory Control Synthesis (DARWIN) (TU/e)
2 Optimization of duty cycle of MRI scanners (DARWIN) (TU/e)
3 Architecture decision making drivers (DARWIN) (Philips Research)
4 Automation of a FEI electron microscope (Condor) (TU/e)
5 Control of a DoD Inkjet Printhead (Octopus) (TU/e)
6 Design-Space Exploration Toolset (Octopus) (TU/e)
7 Evolution Strategies (FALCON) (LIACS)
8 Coordination of Autonomous Vehicles (FALCON) (TU/e)
9 SFL Open Source (TRADER) (ESI / TUD)
10 Ideals spin-off: BloomWise
11 Competence Development Programme (ESI)
12 Extraction of state machines (LaQuSo)
13 KWR prOVEN (ASM / Verum / TASS / ESI)
14 KWR Modest (Océ / ESI)
15 KWR Overlay (ASML / ESI)
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Posters
Posters
Posters Multiform
Posters Paspoort
17 Running show ESI industrial partners

Preface

Dear participant,

It is my pleasure to welcome you to the 2009 ESI Symposium!

Last year ESI started a trend by organizing a much larger symposium, addressing its whole research portfolio, rather than covering highlights from only a single project. These larger annual events are much more exciting and give real value to visitors and participants alike.
The true value of ESI, with its broad range of projects and activities, is best seen by following the common themes and approaches that run through all of our projects. A general symposium like today is a perfect opportunity for you to be informed about our important research results but also to network with other professionals like yourselves.

In the programme today you will find presentations from a selection of ESI's national and European research projects together with initial progress from the KWR (KennisWerkersRegeling). In addition to the valuable research results, ESI's consolidation and dissemination activities will also be shown.

Our symposium would not be complete without renowned keynote speakers. I am delighted to inform you that Rudy Lauwereins (Vice president of IMEC & part-time Full Professor at KU Leuven) and Harry Borggreve (Senior Vice President R&D of ASML) have kindly agreed to share their vision of the important developments going on in a leading European research institute, and a world-wide market-leading high-tech company.

In addition to the presentations, there will be an exciting marketplace with demonstrators and posters. These will give you an excellent overview of the results that have been achieved so far.

All in all, I hope that you will find today's programme stimulating and rewarding. It will, I'm sure, provide the inspiration for future collaboration.

I would like to thank all who have contributed in making this symposium a reality: the keynote speakers, the speakers, the demonstrators as well as the ESI staff. And of course, I thank all the researchers that have worked together with us so well over the last years; it is their work that is being presented here!

Finally, I would like to thank you for attending this symposium and I wish you a pleasant, informative and fruitful day.

Sincerely,

Boudewijn Haverkort
Scientific Director and Chair
Embedded Systems Institute

Contents

Presentations

Keynote presentation 1
From "Counting my Sheep" to "Recording and Storing my Life"

A continuous struggle to get the quality balance right

Rudy Lauwereins
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Abstract: The evolution from the early days in history, where calculation corresponded to counting the amount of livestock one possessed, to today, where a pocket sized smart device can virtually record and store one's complete life in real time, is marked by an exponential growth in computation and storage capacity. In this presentation, I will introduce the highlights in this (r)evolution and connect them to the major technical and economic challenges we had to overcome.

In the early days of semiconductor scaling, the challenge was easy: use as many of the additional transistors that fitted on a chip to improve the computation engine by going to wider word widths and more powerful instructions.

When scaling continued, processor clock frequency grew exponentially. Memory access time however hardly decreased. This memory bottleneck got solved by putting lots of memory on the chip thereby building a complicated memory hierarchy. The challenge became to carefully balance memory throughput and latency versus the computational capabilities.

A few years later, another problem joined the memory bottleneck: how to keep the processor cool. Parallelism at various levels has been introduced to overcome this power problem, thereby worsening the memory bottleneck.

Today, process technology variability joined the growing list of problems. Run-time monitoring and control are needed to guarantee a given performance level.

I will end by looking into a crystal ball: (un)reliability of the underlying devices will add another dimension to the already long list of design problems. It will become very challenging to build reliable systems out of unreliable components and still meet all specifications regarding performance and power efficiency. In addition, these systems will become autonomous and hence have to interface directly to the real environment through a plethora of sensors and actuators that are not 100% CMOS compatible.

About the presenter: *Rudy Lauwereins is vice-president of IMEC, Belgium's Interuniversity Micro-Electronic Centre, which performs research and development, ahead of industrial needs by 3 to 10 years, in microelectronics, nano-technology, enabling design methods and technologies for ICT systems. He is Director of IMEC's Smart Systems Technology Office, covering energy efficient radios, (bio)medical and lifestyle electronics as well as wireless autonomous transducer systems. He is also a part-time Full Professor at the Katholieke Universiteit Leuven, Belgium, where he teaches Computer Architectures in the Master of Science in Electrotechnical Engineering program, and a director of the Institute for BroadBand Technologies (IBBT)*

Keynote presentation 2
The world of nanometer precision

Stretching system performance and complexity management

Harry Borggreve
ASML
www.asml.com

Abstract: ASML is the leading supplier of lithography equipment for the semiconductor industry. ASML develops manufactures and services advanced systems that produce semiconductors. In short, ASML makes the machines that print chips.

Lithography is the key process step in semiconductor manufacturing that determines the performance of chips. Increasing performance is realized by shrinking dimensions. The shrink roadmap (Moore's law) translates into unparalleled challenges for ASML equipment development. To be more specific, tighter requirements on Imaging, Overlay, and Productivity.

The increased performance often implies a more than linear increase in system complexity. The solution space for this is limited by expectations concerning development (lead time and cost) and system (reliability and cost). The presentation shows ideas to deal with this dilemma, and it describes performance development up to now and a projection into the future. Finally, the "embedded community" is invited to support the industry with methods, tools, and techniques that solve the system complexity issue.

About the presenter: *Harry Borggreve (1955, The Netherlands) earned an MSc degree in Applied Physics (cum laude) from the University of Groningen. He started in 1980 at Océ (printing systems) in Research and Development. In 1989 he was appointed director of Engineering (photo conductors and print technology) and in 1993 vice president R&D digital printer/copier systems.*
Early 1998 he joined ASML (Lithography equipment Semiconductors) as vice president Development and Engineering. Since 2001 he is senior vice president ASML responsible for Development & Engineering Worldwide: Netherlands (Veldhoven), USA (Wilton CT) and Taiwan (Taipeh). Harry Borggreve is member of Netherlands Academy of Technology and Innovation, member of the supervisory board of the Embedded Systems Institute and member of various advisory boards.

1.1 Variable Impedance Actuators

Why and how

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Raffaella Carloni and Ludo Visser
University of Twente

Abstract: One of the big challenges in robotics is the development of actuators which are energetically efficient, safe and deliver enough power as necessary for different applications, but without increasing the volume too much. Variable Impedance Actuators have great potential to tackle the described projects. They are actuator in which local storage is often present and they behaviour/impedance is tuneable, but intrinsically present even if no further actuation or energy supply is delivered.

A European project in FP7 called VIACTORS (http://www.viactors.org/) is exactly looking at possible new concepts for Variable Impedance Actuation. Within this context new designs are developed. In this talk, a number of concepts will be presented together with some analysis tools that show the advantages of the novel devices.

About the presenter: *Stefano Stramigioli is professor of advance robotics and chair of the CE group of the University of Twente. He is an officer of IEEE, Vice President Elect of the IEEE Robotics and Automation Society and Editor in Chief of the IEEE Robotics and Automation Magazine, the journal with the highest Impact Factor in Robotics (3.0).*

ACKNOWLEDGEMENT
This project has been carried out as part of the VIACTORS project FP7-231554 of the European Commission.

1.2 Balancing variable payload

Energy-neutral adjustment of spring-balanced mechanical systems

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Abstract: Often we are tempted to grab the standard solution, but sometimes the right question opens up a whole unbroken field of new solutions. Lifting weight is one such an example. Of course this takes force, and we are inclined to use actuators running on external power. However, it can be done without an actuator. This talk will discuss mechanical systems for lifting weights with no effort. Typically spring-balancing will be used, and some examples will be shown.

The next challenge is what to do if the payload changes. The spring system will no longer provide full balance, and will need to be adjusted. Naturally, stretching springs takes force, so using an actuator is an obvious choice, but again this can be avoided by a proper system choice. Three different strategies will be presented that can do this. Their working principles will be explained and demonstrated, and physical examples will be shown.

About the presenter: *Just Herder received his M.Sc. in 1992 and his Ph.D. in 2001, both with honours (cum laude), in Mechanical Engineering from TU Delft, where he is now an associate professor Biomechanical Engineering. Recently he was appointed as a part-time full professor in Automation and Control at Twente University.*

He is an associate editor for three international scientific journals, is or has been board member in five international conferences, and programme committee member in over a dozen more. He is a recipient of several personal awards, has published around 90 peer-reviewed full papers in scientific journals and conferences, and holds ten international patents. Three start-up companies have emerged from his research. He has advised around 70 M.Sc. and several Ph.D. students.

ACKNOWLEDGEMENT
This work is partially supported by STW Valorisation Grants.

2.1 Modelling: the holy grail for designing complex systems?

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Abstract: Due to the increasing complexity of today's high-tech systems, there is a growing interest for modelling. Modelling requires structures and abstractions which will be defined pragmatically (e.g., UML, Visio drawing) or more formally (e.g., CIF, Poosl, mCRL2). Introducing these modelling formalisms has an impact on the way how we will develop complex systems with multiple persons in a highly dynamic and often imprecise environment. Our presentation addresses the impact of modelling when designing complex systems and attempts to structure the needs of the support for modelling activities with as little preconceptions as possible.

What does a design process for a complex system look like?
One way of classifying the variety of activities in a design process is according to their level of formality. On the one hand, the more formal activities, that cover aspects like creating, manipulating, and analyzing concrete models, reflect those situations in which relationships between parameters, variables, structure, and actual values, are well defined and well under control. Typically, in such activities many factors are abstracted away in order to be able to study a certain part or aspect of the system. On the other hand, the more informal activities describe all the development steps that are made and the design decisions that are taken to put all models in the context of the desired system. These informal activities can also be further distinguished as activities related to the concrete design process that is being applied or as activities related to the design itself.

At higher abstraction levels of the design process, activities consist of sub-activities such as identifying a number of design options (DO), choosing one of them or, in other words, taking a design decision (DD), and refining the system in the current design step (DS) as a result of such decisions. All these activities can be represented by a graph. This graph will show the design flow as a tree-like progression of steps, the sequence of which aims at achieving the desired system, but which will always comprise a number of dead-end branches as well in reality.

The detailed design activities concern the system components and their interrelations. These are performed in a concrete design step and are the result of all design decisions made till this moment. They may include further system decompositions, modelling parts of the system, analyzing models, etc. Note that different stakeholders with different concerns will probably use different views with different system decompositions. These activities are performed until a coherent set of choices has to be frozen. This choice is used as a basis for new design decisions as well as the analysis results yielded in the current design step.

What might go wrong?
A major risk is to forget or neglect the interdependencies between design decisions. This might be due to lack of insight in the relation between system clusters, e.g., because of 'conflicting views'. Also the implications of changing a design decision (e.g., components involved, theirs actual values, triggered dependencies) are simply not known or forgotten. Yet another reason is that adjusting parameters, which have been input for a specific model, does not automatically result in a re-analysis or re-run of the model in order to have the updated results, which in its turn can impact the inputs to other models. Last but not least, problems are caused by sheer lack of system overview in itself.

Does this sound familiar to you?
If yes, we have something to offer you! A way of tracking all design decisions, connecting heterogeneous models even if they concern different parts of your system, providing you with conflict detection every time you change a parameter value or just analyze a model, or in other words, keeping your design development under control. What we do not offer you is a concrete design process and any guidelines or steps to follow in order to achieve your desired system.

And now: please help us as well! Are we missing something you (think you) may need? We promise you to present our ideas supported by small cases. What can you provide to us?

About the presenter: *Hristina Moneva received her MSc degree in Computer Systems and Technologies (1997-2001) at the Technical University – Varna, Bulgaria and continued her education at Stan Ackermans Institute with the Software Technology programme (2006-2008), where she received her PDEng degree. She is currently working as a Research Assistant at Embedded Systems Institute. Her main interest is in finding the way to combine the academic innovations with the industrial needs and she definitely likes challenging tasks.*

ACKNOWLEDGEMENT
This work has been performed as part of the 'Integrated Multi-formalism Tool Support for the Design of Networked Embedded Control Systems (MULTIFORM)' project, supported by the Seventh Research Framework Programme of the European Commission. Grant agreement number: INFSO-ICT-224249

2.2 Model-Based Testing applied to an Electronic Passport

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Jan Tretmans {1,2} ; Ronny Wichers Schreur {1}
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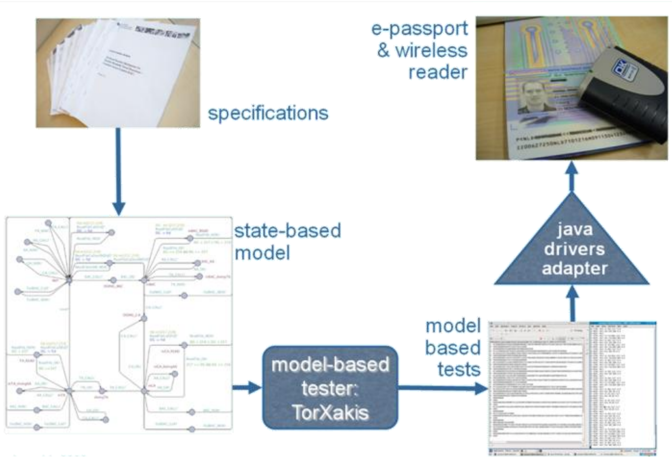
{2} Embedded Systems Institute (ESI), Eindhoven

Abstract: Systematic testing is important for system and software quality, but it is also error-prone, expensive, and time-consuming. Model-based testing is a new technology that can improve the effectiveness and efficiency of the testing process. With model-based testing a system under test is tested against a formal description, or model, of the system's behaviour. Such a model serves as a precise and complete specification of what the system should do, and, consequently, is a good basis for the automatic generation of test cases and analysis of test results. This allows effective test automation beyond the automatic execution of test scripts. And if the model is valid, i.e. expresses precisely what the system should do, then all these tests are valid too.

Electronic passports, or e-passports for short, contain a contactless smartcard which stores digitally-signed data. The second generation of e-passports being introduced in the EU in the autumn of 2009 contains fingerprints, in addition to the holder's name and picture. Access to e-passports involves several protocols defined in standards of the International Civil Aviation Organization (ICAO). To test whether passports correctly implement these protocols we used model-based testing. The first step was to analyse the English-language ICAO specifications and to develop a state-based model. Secondly, we developed a test environment including card reader and passport-terminal software to access the contactless smartcard. Thirdly, we used the model-based testing tool TorXakis to test actual e-passports.



In this presentation we discuss the ideas and principles of model-based testing. Then we show how model-based testing was applied to the new e-passport leading to fully automatically generated tests performing over 1,000,000 protocol steps on an actual passport.

About the presenter: *Jan Tretmans is research fellow at the Embedded Systems Institute (ESI) in Eindhoven, and part-time associate professor in the Model-Based System Development group at the Radboud University, Nijmegen. His research focuses on integration and testing, model-based testing, quality of embedded software, formal methods, and industrial use of verification technology.*

3.1 Capture User Requirements using Workflow Scenarios

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Abstract: Capturing user requirements in the early phase of a systems architecting project is not a trivial task. This approach uses a flowchart model of the expected use of the system to explicitly capture, discuss and develop the use-related requirements for the system in natural language, from very early the design process (Project Preparation Phase).

In this presentation the different shapes, characteristics and benefits of the workflow models (flow chart, Gantt chart and 3D animations) are explained and demonstrated using a case study as an example and the benefits of these models, e.g. early phase user requirements documentation, hierarchical expanding model, customer feedback facilitation, explicit intra and extra design team communication/understanding are shown. The benefits for different stakeholders are explained. With stakeholders being the development organization as a whole, system architects, project design team third parties involved and the customer/user.

After requirements specification, the next step for the system architect is to translate the user requirements into system characteristics, or functionality. It is demonstrated how the workflow models provide a structure to systematically develop a functional model of the system as a start of the conceptual design (see figure 1). This connection can later be used in the system verification phase.

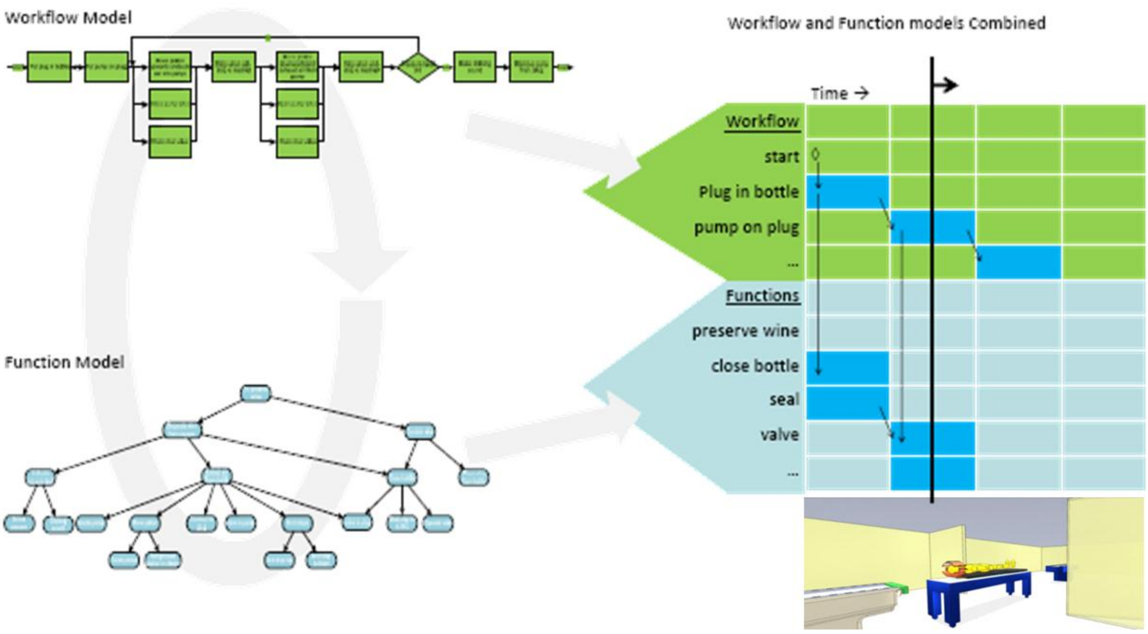

Figure 1: Connecting Workflow to Function Models

About the presenter: *Thom van Beek received his M.Sc. degree Mechanical Engineering from the Delft University of Technology in August 2006. His master thesis, titled: 'Design of a Hydraulic Leg Suspension System for Jack-Up Installations', was runner up in the national Senter Novem competition 'Ontwerpen Ontworpen'. His experience with design started in 2002 when he got involved in the Delft Formula Student race team as the drivetrain- and powertrain-manager. He is currently involved as a Ph.D. student in the Darwin project and tries to increase complex system complexity by introducing abstract level architecture models early in the design process.*

ACKNOWLEDGEMENT
This work has been carried out as a part of the Darwin project with Philips Healthcare Nederland under the responsibilities of the Embedded Systems Institute. This project is partially supported by the Dutch Ministry of Economic Affairs under the BSIK programme.

3.2 Characterization of Evolutionary Clusters

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Steven Klusener, Nico van Rooijen and Hans van Vliet
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Abstract: Software architects regularly have to identify weaknesses in the structure of software systems. Groups of software entities which frequently changed together in the past are one way to help find such structural weaknesses. However, there may be many such groups. Not all of them point to structural weaknesses and even fewer indicate severe issues. During the presentation it will be discussed how a multi-dimensional characterization of evolutionary clusters can help identify severe structural weaknesses.

In addressing this question we describe
(1) properties used for characterizing evolutionary clusters,
(2) an example scenario characterizing severe structural issues, and
(3) the mapping of the scenario to a query on a set of evolutionary clusters, resulting in a subset denoting severe structural issues according to that scenario.

We applied the proposed characterization to the case of the MR software system having a development history of more than a decade. The results are promising since the evolution type structural issues identified are typically acknowledged by the developers and architects of MR.

About the presenter: *Adam Vanya received his M.Sc. degree in Computer Science from the VU University Amsterdam in July 2006. During his master programme, he focused on the codification of architectural patterns in the medical domain. Currently, he participates in the Darwin project, which aims to provide generic methods for the design of highly evolvable systems. He is a member of the Dutch research School for Information and Knowledge Systems (SIKS).*

ACKNOWLEDGEMENT
This work has been carried out as a part of the Darwin project at/with PHILIPS Healthcare under the responsibilities of the Embedded Systems Institute. This project is partially supported by the Dutch Ministry of Economic Affairs under the BSIK programme.

4.1 The MyriaNed Wireless Sensor Network

Research and experiments with a physical network of 1000 nodes

Frits van der Wateren
Chess / Innovation Team
www.chess.nl / www.devlab.nl / www.alwen.nl

Abstract: Today the operation of Large-scale Wireless Sensor Networks (WSN) with a network size of 1000 and higher has almost always been shown by simulation, while the network size of practical experiments is rarely higher than 100 nodes. This is due to a lot of implementation issues, the lack of adequate methodologies to monitor and debug the behaviour of a large network, and the scalability issues of such a network.

The starting point of the project is the Gossip protocol that was originally researched in the Large-scale Distributed Systems group of Prof. Maarten van Steen at the VU, and was initially applied to wired networks. The question is: "Can these protocols also be used in wireless networks".

The ALwEN research project aims to address the above mentioned issues and research questions in a strong consortium with universities, research institutes and industry. A unique project plan in combination with this multi-disciplinary consortium enables us to do a lot of practical experiments. The results are fed back into models, algorithms and design methods. It heavily motivates and guides our research. The experimentation and research interaction is a constant loop in which we gradually scale-up the physical network from 100 nodes now, to 1000 nodes in the second period of the project. This approach is also know as 'Industry as Lab'. The presentation will give you more detailed information about the project, and will show some intermediate results.

About the presenter: *Frits van der Wateren was born in 1950 in Haarlem, the Netherlands. He received his BSc. degree in Electrical Engineering in 1972 at the Polytechnic of Haarlem. He is currently working as a researcher in the Innovation Team of the company Chess. The main research focus of this team is on Wireless Sensor Networks. He is chair of the Technical Committee of DevLab and R&D Leader of the ALwEN project.*

ACKNOWLEDGEMENT
This work is done as a part of the ALwEN project. The partners in the project consortium are: VU, TUD, TU/e, UT, ESI, Philips Research, Holst Centre, Roesssing Research and DevLab. The project is carried out under the responsibilities of DevLab. This project is partially sup-ported by SenterNovem under the PointOne programme.

4.2 Epidemic Information Dissemination in Wireless Environments

Daniela Gavidia
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Abstract: As embedded devices capable of wireless communication become ubiquitous, the possibility of having large-scale wireless ad hoc networks in the near future appears more certain. We can expect that such networks of wireless embedded devices will experience node failures, unreliable radio links and node mobility, resulting in very dynamic network topologies. For this reason, these networks need robust distributed algorithms that can be used to coordinate their operations in the face of topology changes. Epidemic techniques can provide the robustness necessary to overcome the dynamic conditions seen in wireless environments.

In this talk, we will focus on the use of epidemic techniques to solve the problem of information dissemination in wireless networks of small, resource-constrained devices. Epidemic protocols have been successfully used in large-scale wired networks to tackle a variety of problems, such as updating distributed database tables and building peer-to-peer overlays. It has been shown that epidemic protocols, being inherently robust, are able to cope with the dynamic conditions often seen in very large networks. This characteristic makes them very appealing for use in wireless environments, where dynamic network topologies are commonplace. This talk will explore the challenges in applying traditional epidemic techniques in large wireless networks of resource-constrained devices.

About the presenter: *Daniela Gavidia is a post-doc researcher at the Vrije Universiteit Amsterdam. She obtained her Ph.D. degree from the Vrije Universiteit Amsterdam in 2009. Her research focuses on the use of epidemic techniques to achieve robust and reliable communication in large wireless ad hoc networks. She currently works as a researcher in the Ambient Living with Embedded Networks (http://www.alwen.nl) project, where she puts to practice the techniques developed during her Ph.D. research.*

5.1 An Architectural Style for Optimizing System Qualities in Adaptive Embedded Systems

Using Multi-Objective Optimization

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Abstract: Customers of today's complex embedded systems demand the optimization of multiple system qualities under varying operational conditions. For example, in the printing system domain customers demand more productivity while energy consumption must be minimized. Often, this optimization is subject to trade-offs as system qualities might be conflicting and user preferences differing. For example, certain users prefer higher productivity over lower energy consumptions, while others prefer the opposite. In this presentation we will show how multi-objective optimization can be introduced into the architecture of the embedded control software, to control and optimize the qualities of the embedded system.

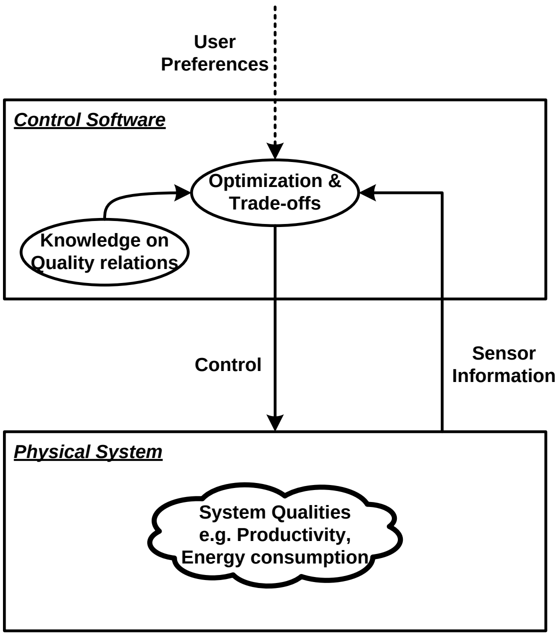

Figure 1: optimization functionality in context of the embedded system

Figure 1 schematically shows the optimization functionality in context of the embedded system. The system is divided into the actual physical system and the control software. The system qualities emerge in the physical system. The control software tries to control the physical system to optimize the system qualities, based on the trade-offs given by user preferences. The optimization algorithm uses sensor information to determine the current state of the machine. It also uses knowledge on the relationships between the different system qualities and the control parameters, to decide how to control the system in an optimal way.

To optimize the system qualities (objectives) of a system, the right value for the control parameters has to be chosen. Examples of parameters are the power given to a component and the speed of the system. The range of possible values is often subject to constraints. For example, a component needs a certain amount of power under a given speed. This is an optimization problem known as multi-objective optimization (MOO). The realization of MOO in the embedded software is usually distributed over several components. The decomposition is based on the controlled hardware and is possibly implemented by different engineers. Therefore, this realization should be documented in the architectural description to support communication, analysis and verification, and to guide design, implementation and reuse. In this presentation we describe an architectural style to introduce MOO in the software architecture and we report on our ongoing work.

About the presenter: *Arjan de Roo received his Master's degree in Computer Science in 2007 at the University of Twente. He is a PhD student at the University of Twente in the Octopus project. His current work is focused on how to manage the increasing software complexity of adaptive embedded systems. His research interests include software architectures, software composition and software language design.*

ACKNOWLEDGEMENT
This work has been carried out as part of the Octopus project with Océ-Technologies B.V. under the responsibility of the Embedded Systems Institute. This project is partially supported by the Netherlands Ministry of Economic Affairs under the Embedded Systems Institute programme.

5.2 Design-Space Exploration of High-Tech Embedded Systems

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Xiaochen Chen {1}, Marc Geilen {1}, Roelof Hamberg {2}, Georgeta Igna {3},
Venkatesh Kannan {1}, Frans Reckers {2}, Sebastian de Smet {4}, Lou Somers {4},
Jacques Verriet {2}, Marc Voorhoeve {1}, Yang Yang {1}, Sander van Zuidam {1}
{1} Eindhoven University of Technology
{2} Embedded Systems Institute
{3} Radboud University Nijmegen
{4} Océ Technologies

Abstract: Embedded-system development trajectories are expected to produce high-quality cost-effective products. A common challenge in many development trajectories is the need to explore extremely large design and configuration spaces. The exploration needs to consider multiple metrics of interest (timing, memory usage, energy usage, communication bandwidth, cost …). The number of design and configuration parameters is typically very large and the relation between parameters and metrics of interest is often difficult to determine. A design-space exploration process may involve multiple designers and take an extended period of time. Many design alternatives are considered and many design decisions are taken. The process is often visualized as a Y-chart:

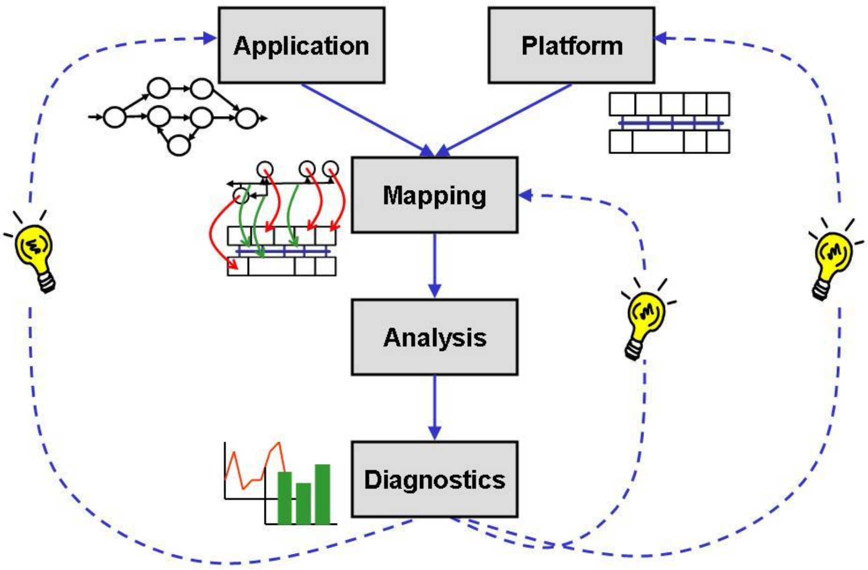

Figure 1: The Y-chart[1]

[1] *The Y-chart: Design-space exploration typically involves the co-development of an application, a platform, and the mapping of the application onto the platform. Diagnostic information is used to (semi-automatically) improve application, platform, and/or mapping.*

Kienhuis et al. A Methodology to Design Programmable Embedded Systems. The Y-Chart Approach. LNCS 2268. Springer. 2002.

The complexity of today's embedded systems and their development trajectories re-quires a systematic, model-driven design approach, supported by tooling wherever possible. Only in this way, development trajectories become manageable, with high-quality, cost-effective results. The Embedded Systems Institute has recently started the development of a toolset to support design-space exploration for high-tech embedded systems. Ultimately, such a toolset may incorporate:

- a design-space exploration kernel to coordinate the exploration process, centred around an intermediate representation for design alternatives;
- domain-specific editors for defining design alternatives, metrics of interest and exploration experiments;
- support for the automatic exploration of parts of the design space (for example via evolutionary algorithms);
- support to interface with analysis tools (model checkers, simulators) to compute metric values for design alternatives;
- support to interface with optimizers and dedicated design-space-exploration tools to determine solutions (schedules, mappings, etc) for sub-problems;
- visualization support for metrics, trade-offs between metrics, trends in metrics over design alternatives, dynamic system behaviour and metric development, design bottlenecks, decision processes, etc;
- decision support and version management for design alternatives and models.

In this presentation, we outline the ongoing development of a toolset for design-space exploration of high-tech embedded systems. The toolset is initially developed for professional printing systems but it is sufficiently generic to be retargetable to other types of systems.

The first version of the toolset is demonstrated during the info market.

About the presenter: *Twan Basten is a research fellow at the Embedded Systems Institute and a professor of computational models at the Eindhoven University of Technology (TU/e). He received his MSc and PhD degrees in Computing Science from TU/e in 1993 and 1998. His research interest is the design of resource-constrained embedded systems, with a special focus on networked and multiprocessor systems and computational models. Twan Basten (co)authored over 100 scientific publications, of which three received a best paper award, and he (co)supervised 8 PhD degrees. He is a senior member of the IEEE and a life member of the ACM.*

ACKNOWLEDGEMENT

This work has been carried out as a part of the Octopus project with Océ Technologies under the responsibilities of the Embedded Systems Institute. This project is partially supported by the Dutch Ministry of Economic Affairs under the BSIK programme.

6.1 Competence Training & Development for Architects

Lessons learned and outlook

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Abstract: In September 2008 the Embedded Systems Institute (ESI) and the High Tech Systems Platform initiated a Competence Development Programme for architects. In this presentation we discuss the issues that turned out to be crucial for successful training and development of architects. Furthermore a summary of the new development programmes for designers and architects will be given. These programmes will start in 2010.

During the presentation we address the following issues:

Lessons learned

1. Competence development of architects requires a close cooperation between the participant, the company and ESI. How to integrate the needs from these three stakeholders into a balanced programme.
2. How to combine content and activity to create a high-impact learning programme.
3. Architects are expected to have the ambition and professional qualities to act and lead on a higher system level. What are the associated personal and professional skills that need to be developed.
4. Companies address architecture and architecting in different ways. How can these differences contribute in a positive way within the context of the programme.

New Development Programmes 2010

In 2010 ESI will start competence development programmes on three different levels (designer level, domain architect level and system architect level). A short introduction will be given to the content and way of working of each of these programmes.

About the presenter: *Joris van den Aker is working as a knowledge manager at the Embedded Systems Institute. He is responsible for the development and introduction of the Competence Development Programmes and other training activities from ESI.*

ACKNOWLEDGEMENT

This project is partially supported by the Dutch Ministry of Economic Affairs, Province of Noord-Brabant, Province of Limburg and the 'SRE-Stimuleringsfonds' under the Pieken in de Delta programme.

6.2 Integration & Testing Practices

Experiences of Vanderlande Industries

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Abstract: Integration & testing is a topic that addresses processes, management and skills of developing embedded systems. Integration is about bringing system parts together. It is the counterpart of decomposition. Testing concerns the verification and validation of a system. Integration and testing are related. Integration is about identifying the upcoming and most important problems in the system design by integrating components into subsystems and these into entities with the system as a final result. Testing addresses the same levels, e.g., component-, subsystem and system testing.

Integration & testing is a challenge for embedded systems development. This is because the problems in integration might result into problems like: system delivery delay, little system reliability and projects that exceed their budgets. The Special Interest Group 'Integration and Test' has discussed this topic for a while. In this SIG system integrators and test managers of seven Dutch OEMs in the embedded systems branch are participating: ASML, Assembléon, FEI Company, Philips Healthcare, Thales, Panalytical and Vanderlande Industries. ESI is organizing the SIG and moderates the discussions.

In this presentation, outcomes of the SIG discussions are presented. The focus will be on the experiences of one of the SIG members, namely: Vanderlande Industries. The base practices that we discuss are, amongst others:

- **Define integration plan**: this plan is to ensure that the system parts will be delivered in the right order. In the presentation we will present some guidelines on defining a plan. These guidelines relate e.g., to risk management as well as to the need of looking from different views, e.g., functional, component and availability of test environment.
- **Integration strategy**: strategy triggers the sequence of activities in an integration plan. Development can be leading for integration and vice versa. In the presentation we illustrate both practices and unveil Vanderlande's preference.
- **Roles & responsibilities**: a variety of responsibilities exist in integration & testing. For example, who is in charge of defining the integration plan and maintains it as well as who has the authority to stop? We have observed that allocating those roles and responsibilities is not that simple. In the presentation we focus on some lessons learned.
- **Tools used by Integration & Test teams**: tools used for planning and monitoring progress. Integration of tools for requirements, change and test management.

About the presenter: *Remko van der Zee (B.ICT 1988, University of Applied Sciences Eindhoven) worked from 1990 to 2004 as an Embedded Systems engineer for a Software house. During this period he gained experience with software integration and testing in several major embedded systems companies in the Netherlands and Germany.*
Since 2004 Remko is working for Vanderlande Industries as Sr. Integration Manager. As such he was involved in the building and delivery of the T5 baggage handling system at London Heathrow airport. In this project multidisciplinary aspects of system integration and testing where a particular challenge. Currently he is responsible for deploying the lessons learned from T5 in the 70MB program at Schiphol Airport Amsterdam.

7.1 Wings

Performance and Flexibility for ASML Execution Platforms

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Abstract: Embedded control is a key product technology differentiator for many of the Dutch high-tech industries. The strong increase in complexity of embedded control systems combined with the occurrence of late changes in control requirements, results in many timing performance problems showing up only during the integration phase. This results in extremely costly design iterations, severely threatening the time-to-market and time-to-quality constraints.

In the Wings project this integration problem is attacked systematically through the construction of executable models. The key approach is to separate the logic of the embedded control application from the execution platform on which it is deployed. The resulting models yield an overview and a system-wide insight in the timing bottlenecks. They further allow one to rapidly explore alternatives to optimize the timing performance, by adapting the application, the execution platform or the mapping.

The Wings project has demonstrated the effectiveness of the performance prediction and optimization method by applying it to a complex performance-critical subsystem of a wafer scanner. The application of the method within ASML has resulted in more than a dozen improvement proposals with an expected overall timing performance gain of more than 50%.

About the presenter: *Jeroen Voeten received his master's degree in Mathematics and Computing Science and his Ph.D. in Electrical Engineering from the Eindhoven University of Technology, the Netherlands. He is a senior research fellow at the Embedded Systems Institute in Eindhoven. He is also an associate professor in the Electronic Systems group at the faculty of Electrical Engineering. His research interests include system-level design methodology and performance modelling for embedded systems.*

7.2 Coping with System Evolution

A3 Architecture Overviews as a means to support evolution of complex systems

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Abstract: System requirements change over time; consequently, companies need to systematically evolve their products to cope with those changes. Since developing a system from scratch is time consuming and costly, new systems are often created by evolving an existing system. The knowledge that the company has about the system and the consequences of introducing changes determines its ability to effectively cope with system evolution.

Even in large companies, complex systems are typically poorly documented. The main architecture knowledge resides in the expert's minds, and only part of that knowledge is documented. Some key knowledge regarding the system architecture and design decisions may be lost, especially in long-lived systems, due to experts leaving the company, design decisions not documented and so on.

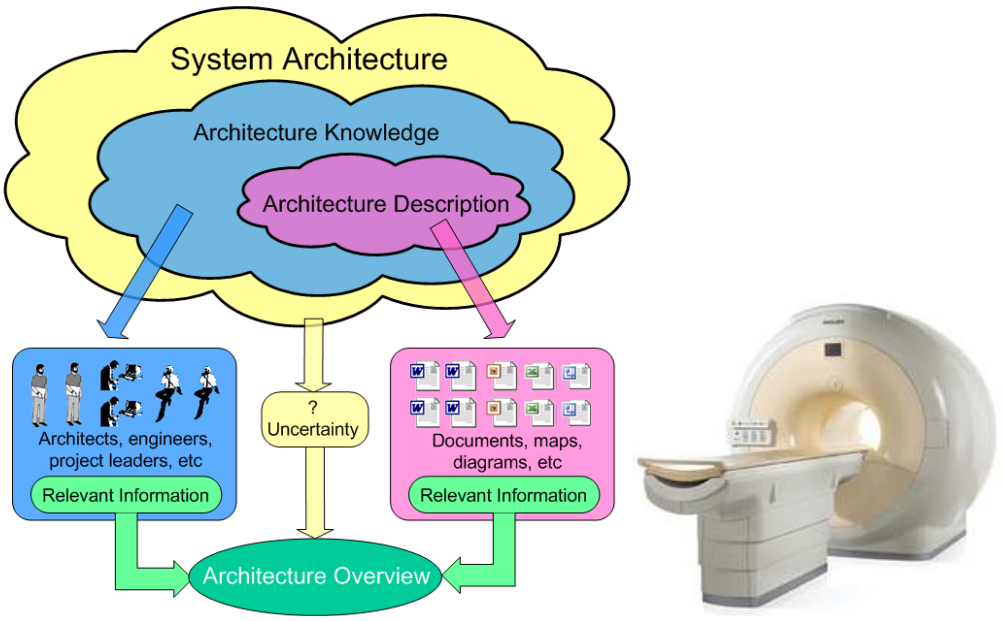

Figure 1: Sources of architecture information

An MRI system requires a multidisciplinary design team with competences in areas such as mechanics, electronics, physics, material science, software and clinical science. Typically people are specialized in a single discipline, and each discipline uses its own vocabulary. Besides this, all the disciplines have to work together on different aspects of the design. Therefore effective communication across disciplines and departments is essential. The consequences of missing information or misunderstandings can cause serious problems and delays in the development process.

As shown in Figure 1, to cope with those problems we present an approach to **collect**, **abstract** and **present** architectural information in a fashion that can be understood and used by a broad set of stakeholders.

For the abstraction and presentation phase, the concept of an **A3 architecture overview** is introduced. The main goal of an A3 architecture overview is to have a manageable architectural representation of a system aspect that enables system architects and designers to reason and communicate the consequences of system changes. An architecture overview helps to provide a broad, comprehensive and easy to handle view of the system aspect under study.

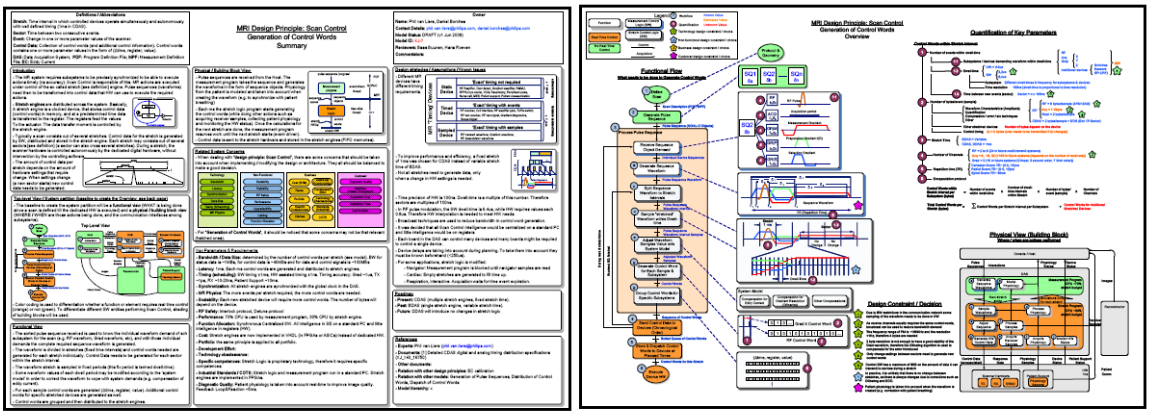

Figure 2 : A3 Architecture Overview Example a) Summary b) Overview

The A3 Architecture Overview is a set of two A3 sheet of paper. The A3 format has been chosen as it is the maximum unit of information that people are willing to read. The A3 Overview provides a model-based description of the system aspect, consisting on a functional view (supported with visual aids) a physical view and a quantification of key parameters view. Annotations of design constraints and design decisions are also present. The views are interlinked together by allocating functions into the physical view, pointers from views to other views, etc. The A3 Summary provides a compact text-based description to support the overview, structured for efficiency.
A3 Architecture Overviews can be used individually, or in a group for deeper understanding, as the overviews provide references to other sources of information and other A3 Architecture Overviews.

About the presenter: *P. Daniel Borches received his Master's degree in Telecommunication Engineering from the University of Madrid Carlos III in 2004. He has worked several years in companies such as Telefónica R&D and Nokia. From 2006 he is doing his Ph.D. at the University of Twente while working at Philips Healthcare Nederland. The main focus of his research is Systems Engineering and Systems Architecting applied in the industrial sector.*

ACKNOWLEDGEMENT

This work has been carried out as a part of the Darwin project at/with Philips Healthcare Nederland under the responsibilities of the Embedded Systems Institute. This project is partially supported by the Dutch Ministry of Economic Affairs under the BSIK programme.

8.1 Octopus: Modeling and Exploration of Printer Data-Paths

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Lou Somers [3], Paul Verhelst [3], Marc Voorhoeve [1]
[1] Eindhoven University of Technology
[2] Embedded Systems Institute
[3] Océ-Technologies B.V.

Abstract: In the context of digital document printers, data-path design deals with the path of documents through several types of image processing steps (such as from network or scanner to the print head). The Octopus project develops support for design decisions during early development of printers using modelling formalisms, providing insights into the behaviour of the system, and trade-off analysis among different design alternatives. The first steps to research the possibilities for architecting of adaptive systems consist of understanding and predicting the system behaviour of current systems under development. The content of this presentation is based on one such printer system at Océ.

Given a hardware architecture, there are different use-cases that achieve certain print functionalities such as copying, scanning, remote printing, and other types of image processing tasks. The design engineers at Océ have various challenges: dimensioning the resources (like number and speed of CPUs and GPUs, system buses, FPGAs and memory components) in the architecture, mapping tasks to these resources, scheduling policies, and resource arbitration to mention a few. Further, for any given design the performance of the system has to be evaluated, analysing bottlenecks, dependencies between tasks, resource dependencies, and scalability being a few of the critical performance-influencing characteristics.

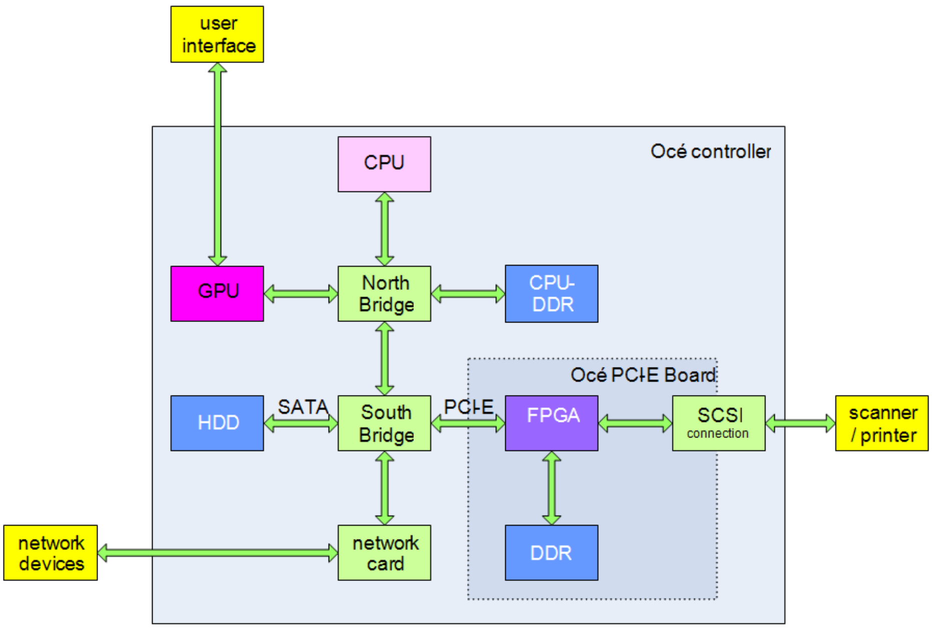
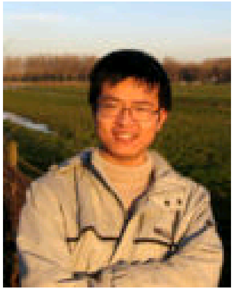


Figure 1 : Architecture Diagram of a professional printer

In this case study, Coloured Petri Nets (CPN) and Synchronous Dataflow Graphs (SDF) are used to model the behaviour of the system and analyze its performance, exploring different design alternatives to support the development process. The case study also serves to advance the modelling patterns and techniques for professional printers and high-tech embedded systems in general.

In this presentation, we give an overview of the printer design challenges, the modelling process using CPN and SDF, model calibration challenges, and the insights gained into the behaviour and performance of the printer system.

About the presenters:



Yang Yang *is a PhD student at the Department of Electrical Engineering at the Eindhoven University of Technology (TU/e) since October 2008. He received his BSc degree in 2004 from Beijing Normal University in China. He received his MSc in Electrical Engineering in 2007, from Tsinghua University in China, His current research interests include Model of Computation and Communication (MoCC), Design Space Exploration and topics related to Embedded system design.*

Roelof Hamberg *received his MSc and PhD degrees in Theoretical Physics from the Universities of Utrecht and Leiden, respectively. He joined Philips Research in 1992 to work on perceptual image quality modeling and evaluation methods. In 1998 he joined Océ as a developer of in-product control software, shifting his role via digital system architect to department manager. In 2006, he joined ESI as research fellow. His research areas of interest are easy specification, exploration, simulation, and formal reasoning of system behavior, and systems architecting in general.*

ACKNOWLEDGEMENT

This work has been carried out as a part of the Octopus project with Océ Technologies under the responsibilities of the Embedded Systems Institute. This project is partially supported by the Dutch Ministry of Economic Affairs under the BSIK programme.

8.2 Design-Space Exploration using Evolution Strategy

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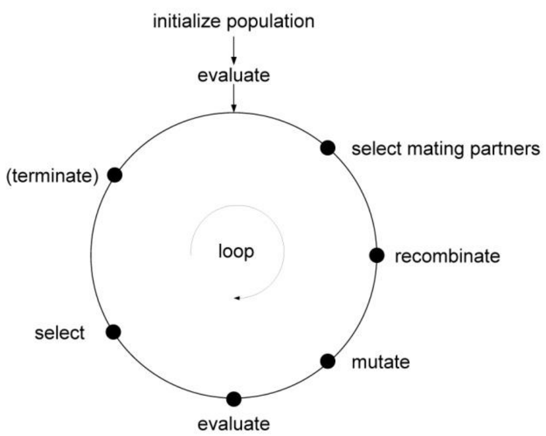
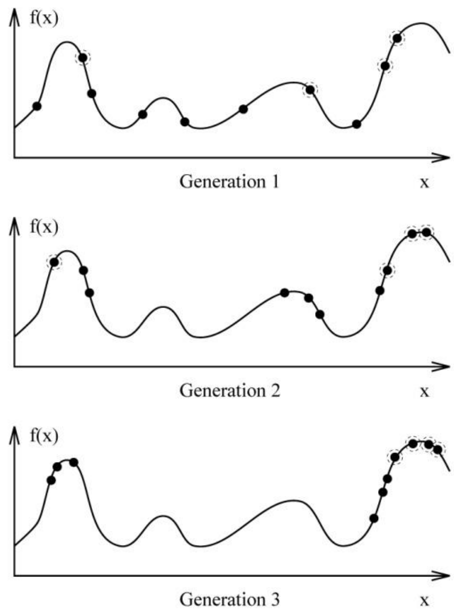
Abstract: Currently the design trajectory of embedded systems involves multiple decisions by human designers. Using a specific type of evolutionary algorithm called *Evolution Strategy* (ES), this task can be alleviated by automating parts of the design process in what could be termed as *directed random search* through the design space. We demonstrate the applicability of ES as an automatic optimization method with respect to high-dimensional mixed-integer design spaces by applying it to a representative warehouse design problem. The problem consists of designing an *item picking system* with a high degree of automation. The simulator implemented for this problem by ESI encompasses several input parameters of different types (i.e., *integer, nominal*), as well as multiple output scores or *performance measures* (e.g., cost, time, latency). Using ES it becomes easier to traverse the design space as compared to doing optimization by hand, which ideally leads to finding superior solutions.

Evolutionary algorithms (EAs), a class of algorithms of which the Evolution Strategy is a member, find their way through the design space using abstractions of the principles of Darwinian evolution: parent individuals *recombine* into offspring individuals, and this process is prone to *mutation*, i.e., introduction of random changes into the combined genetic code.





The Evolution Loop in an Evolutionary Algorithm **Optimizing towards the Maximum**

In an EA the individuals are represented by a set of input parameters for the problem that is under design, where the evolution is governed by their relative fitness, i.e., the output scores of the individuals (*survival of the fittest*). Compared to other types of EAs, the Evolution Strategy stands out by using *endogenous* mutation parameters included in each individual. Instead of using exogenous mutation control, globally for all individuals, this allows the population in ES to *self-adapt* in the direction of the optimal solution(s).

In this presentation we elaborate on the applicability of ES to high-dimensional problems by focusing on the trade-off between computation time and quality of the results. As the simulator produces multiple output scores, we will visualize the results and compare the *Pareto optimality* between test runs. Furthermore, *ease-of-use* is an important aspect, i.e., the effort that is required to configure ES for a new problem. Ideally this research will give rise to integration of ES in a future toolkit developed by ESI aimed at automating (parts of) the embedded systems design process.

About the presenters:

Thomas Bäck *is head of the Natural Computing Group at LIACS, Leiden University and professor of computer science. Thomas Bäck has more than 130 publications on natural computing technologies, and is author of a book on evolutionary algorithms, entitled Evolutionary Algorithms in Theory and Practice. He is editorial board member and associate editor of a number of journals on evolutionary and natural computation (Journal of Natural Computing, Theoretical Computer Science C, Evolutionary Computation), co-editor of the Natural Computation Book Series, and has served as program chair for all major conferences in evolutionary computation. His expertise lies in adaptive technologies for optimization and data-driven modelling, predictive analytics, and bioinformatics. He received the best dissertation award from the Gesellschaft für Informatik (GI) in 1995 and is an elected fellow of the International Society for Genetic and Evolutionary Computation for his contributions to the field. He has ample experience in applying evolutionary computation to industrial problems, working with companies such as Air Liquide, Beiersdorf, BMW, Daimler, Pepsi, Unilever, RWE, TUI, and many others.*

Edgar Reehuis *is a master's student in computer science at LIACS, Leiden University and has an interest in natural computing and multi-objective optimization. Currently he is doing a project on the optimization of a warehouse simulation using an advanced type of Evolution Strategy, the Mixed-Integer ES, which is prepared to optimize solutions comprising real-valued, integer, and nominal variables. He has extended this technique with multi-objective selection as implemented in the NSGA-II algorithm by Deb. This project is supervised by Thomas Bäck and done in conjunction with Jacques Verriet at ESI, who implemented the simulator of the warehouse concept.*

ACKNOWLEDGEMENT

This work has been carried out as a part of the Falcon project with Vanderlande Industries under the responsibilities of the Embedded Systems Institute. This project is partially supported by the Dutch Ministry of Economic Affairs under the BSIK programme.

9.1 Run-time integration and testing in dynamic systems-of-systems

Poseidon track (3 presentations)

Maurice Glandrup
Thales Netherlands

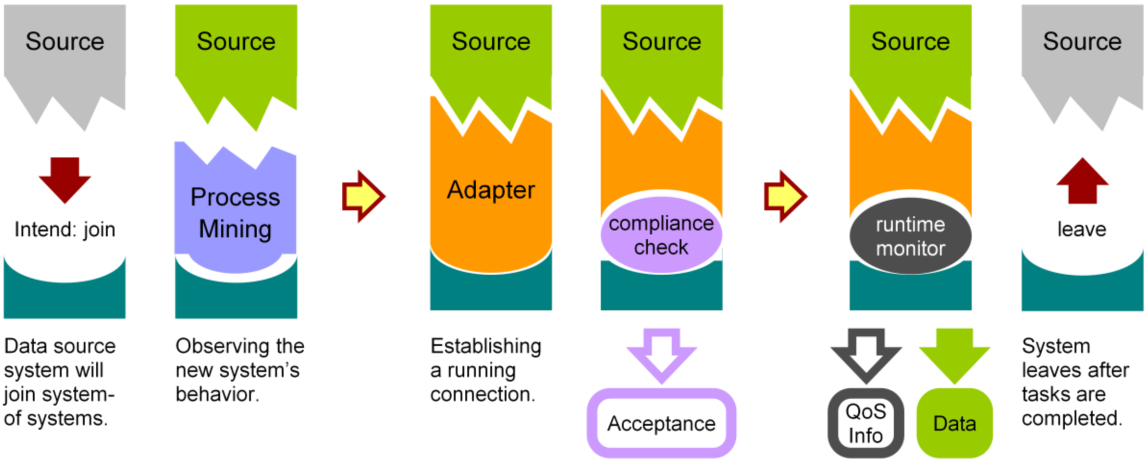
Arjan Mooij
Eindhoven University of Technology – AIS

Alberto Gonzalez
Delft University of Technology – SERG

Marc Voorhoeve (Eindhoven University of Technology –AIS)
Éric Piel (Delft University of Technology – SERG)
Gerd Gross (Delft University of Technology – SERG)
Michael Borth (Embedded Systems Institute)
Jan Tretmans (Embedded Systems Institute)

Abstract:
The Poseidon project (Maurice Glandrup)
The Poseidon project aims to discover new ways to build dynamic information-centric systems-of-systems. The Poseidon research statement is derived from the maritime safety and security domain of its carrying industrial partner Thales. Here, as in many other domains, future systems-of-systems will collaborate across former system boundaries in order to support decision making and situation awareness based upon a variety of heterogeneous information sources. The challenges are to gain flexibility, adaptability, and evolvability at runtime, whilst retaining reliability, so that changes in a system-of-systems configuration can be achieved in minimal time and with minimal effort while the system remains operational and reliable, even in the context of unforeseen events or scenarios. In this presentation we will highlight two aspects of these challenges.

First, we discuss adapter generation; second, we will address runtime testability.



Adapter generation (Arjan Mooij).
The development of systems-of-systems requires the integration of existing systems. Although the knowledge about these systems is limited, the integration should be fast. Often the integration of two systems requires the development of a custom-made adapter (mediator, glue-logic). Such an adapter should be able to deal with both the data conversion between the two systems, and with the behavioural aspects of the two systems. We will show how such adapters can be structured, how the behaviour of the individual systems can be explored using process mining, and how these explorations can be used to automatically construct large parts of the adapter.

Runtime testability (Alberto Gonzalez).
The integration of multiple systems, developed by different teams, according to different standards and even different interpretations of the same standard, requires systematic and extensive testing. If the systems that form these systems-of-systems are already operational and can neither be brought offline nor duplicated, runtime testing is the preferred way of testing. One of the problems of runtime testing is the interference that will occur between tests and normal system operations, e.g., a test that empties a real bank account. Runtime testability studies the influence that runtime testing has on the system-of-systems-under-test. The possible causes of bad runtime testability will be discussed, leading to a measure for runtime testability that relates to the reliability of the integrated system-of-systems. Moreover, we show how this measure can help engineers to identify which components are most vulnerable to interference problems, and, consequently, lead to the largest reliability improvement when modified.

About the presenters:
Maurice Glandrup *is Principal System Engineer for Thales Naval Netherlands. He is technical responsible for the domain of Small Systems. In this work he acts as point-of-contact for the research project Poseidon.*

Arjan Mooij *is a researcher in the Architecture of Information Systems group of the Technische Universiteit Eindhoven. His research interests are in formal techniques for constructing and reasoning about concurrent systems.*

Alberto Gonzalez *received his BSc and MSc in Informatics Engineering from the University of Valladolid, Spain in 2005 and 2007 respectively. He performed his Master's Thesis while visiting the Embedded Software Lab at the TU Delft. Since the end of 2007 he has been with the Software Engineering Research Group in the same university. His research topics include (runtime) testing, testability and diagnosis.*

ACKNOWLEDGEMENT
This work has been carried out as a part of the Poseidon project with Thales Netherlands under the responsibilities of the Embedded Systems Institute. This project is partially supported by the Dutch Ministry of Economic Affairs under the BSIK programme.

Information Market

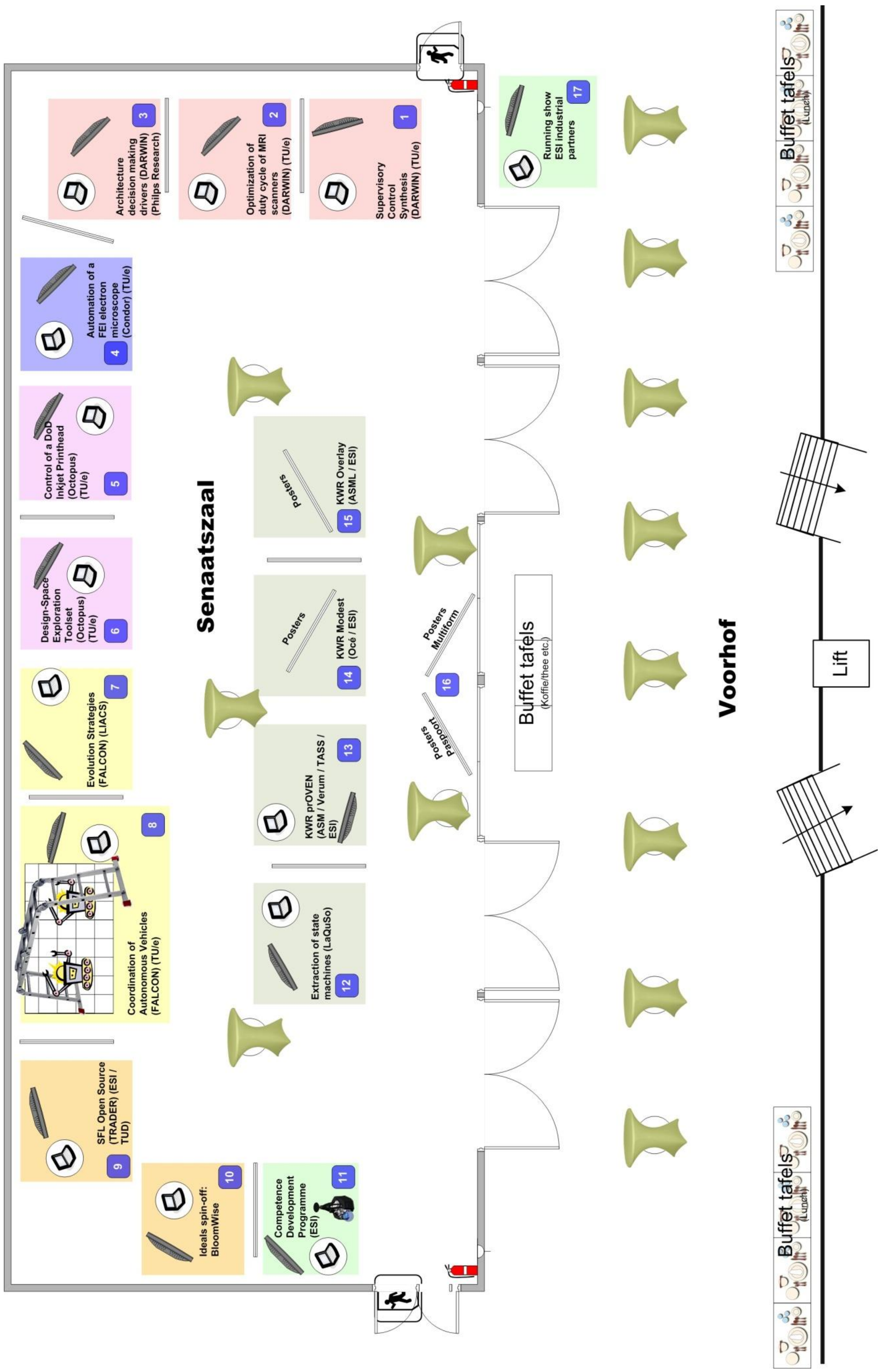
Section numbers are also booth numbers.
(see plan of Auditorium)

Info market room (Senaatszaal)

Information market

#	On show	Project / CIP	Demonstrators
1	Supervisory control synthesis	Darwin / Philips Healthcare	Rolf Theunissen
2	Optimization of duty cycle of Magnetic Resonance Imaging scanners	Darwin / Philips Healthcare	Evgeniy Ivanov
3	Architecture decision making drivers	Darwin / Philips Healthcare	Ana Ivanovic
4	Automation of a FEI electron microscope	Condor / FEI	Richard Doornbos
5	Control of a Drop-on-Demand Inkjet Printhead	Octopus / Océ	Amol Khalate Mohammed Ezzeldin
6	Design-Space Exploration Toolset	Octopus / Océ	Jacques Verriet Twan Basten
7	Application Examples of Evolution Strategies	Falcon / Vanderlande Industries	Edgar Reehuis Thomas Baeck
8	Coordination of Autonomous Vehicles	Falcon / Vanderlande Industries	Jurjen Caarls Sisdarmanto Adinandra
9	Open source Spectrum-based Fault Localization	Trader / NXP	Jozef Hooman Hristina Moneva

#	On show	Project / CIP	Demonstrators
10	Ideals spin-off: BloomWise	Bloomwise	Gurcan Gulesir Alain le Loux
11	Competence Development Programme	CDP / ESI	Joris van den Aker
12	Extraction of state machines of legacy C code with Cpp2XMI	LaQuSo	Harold Weffers et.al.
13	KWR prOVEN "Reducing Development Costs by Proven Components"	Verum / ASM-Europe / TASS / ESI	Frans Karsmakers
14	KWR Modest "Model Based Design and Testing"	Océ / ESI	Lou Somers
15	KWR Overlay	ASML / ESI	Wouter Tabingh Suermondt
16a	Model-based Testing of Electronic Passports	RU Nijmegen / LaQuSo / ESI	Jan Tretmans
16b	Multiform - Integration Framework	Multiform / ESI	Hristina Moneva
17	Running show CIPs	ESI CIP's	Roland Mathijssen



Senaatszaal
Voorhof
1 Supervisory Control Synthesis (DARWIN) (TU/e)
2 Optimization of duty cycle of MRI scanners (DARWIN) (TU/e)
3 Architecture decision making drivers (DARWIN) (Philips Research)
4 Automation of a FEI electron microscope (Condor) (TU/e)
5 Control of a DoD Inkjet Printhead (Octopus) (TU/e)
6 Design-Space Exploration Toolset (Octopus) (TU/e)
7 Evolution Strategies (FALCON) (LIACS)
8 Coordination of Autonomous Vehicles (FALCON) (TU/e)
9 SFL Open Source (TRADER) (ESI / TUD)
10 Ideals spin-off: BloomWise
11 Competence Development Programme (ESI)
12 Extraction of state machines (LaQuSo)
13 KWR prOVEN (ASM / Verum / TASS / ESI)
Posters
14 KWR Modest (Océ / ESI)
Posters
15 KWR Overlay (ASML / ESI)
Posters Multiform
16
Posters Paspoort
17 Running show ESI industrial partners
Buffet tafels (Koffie/thee etc.)
Lift
Buffet tafels (Lunch)
Buffet tafels (Lunch)

D 1 Supervisory control synthesis

Technische Universiteit Eindhoven University of Technology

Applied to the MRI patient communication subsystem

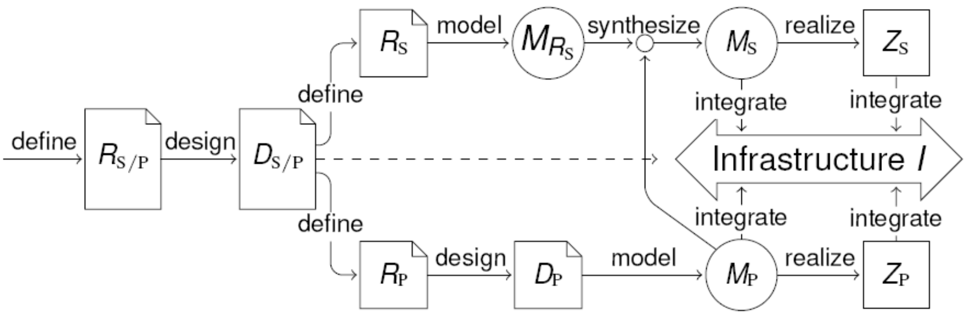
Overview

Due to market demands and increasing competition, the number of features, and thus the complexity of systems increase, while the time-to-market of systems should be decreased. This necessitates the need for methods to maximize reuse and to minimize the effort to design new generations of a system. In the context of redesigning the MRI patient communication system, this project aims at improving the evolvability of high-tech systems by using supervisory control theory.

High-tech machines consist of physical components (hardware) and control systems. The control system can be divided into multiple subsystems. In this case we focus on the supervisory control subsystem. This subsystem is responsible for the coordination of the individual machine components, and for the interpretation of user input.

Method

In a nutshell, supervisory control theory allows for automatic generation of correct-by-design control software. As inputs, it requires a formal model of the uncontrolled system (plant), and the formal specification of the desired behaviour of the controlled system (control requirements).



Supervisory control is one of the many activities within the model based engineering (MBE) methodology. Other activities, such as (hardware-in-the-loop) simulation, can be used to supplement this approach. Simulation is used to validate the correctness of the models and requirements. Code generation is used to obtain the final implementation.

Benefits

Major advantages of this approach are correctness of the synthesized supervisory controller (supervisor) by construction. As a consequence, the design process of a supervisory controller changes from implementing and debugging controller code to designing and debugging control requirements. The latter allows for a faster incorporation of requirement modifications into the control design. In turn, this leads to a reduction in the number of design-test-redesign loops.

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DARWIN: Supervisory Control Synthesis

Eindhoven University of Technology

Embedded Systems INSTITUTE

Market key performance indicators

The key performance indicators (KPI) of a system in relation with the market are (F, Q, T, C):

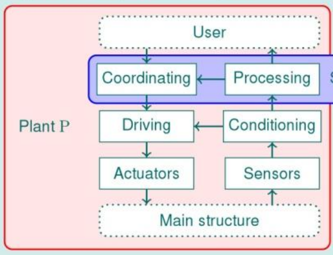
- F - functionality
- Q - quality
- T - time to market
- C - cost

In principle for a new system generation holds:

$$F_{\text{new}} \geqslant F_{\text{old}}$$

System view

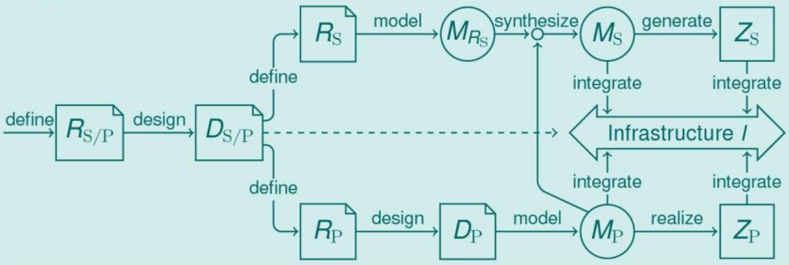
A system can be divided in (uncontrolled) plant P and supervisor (controller) S:



Synthesis-based engineering

The method consists of:

- Model (uncontrolled) plant $\Longrightarrow$ M_{P} (discrete-event model)
- Model control requirements R_{S} $\Longrightarrow$ $M_{R_{\mathrm{S}}}$ (formal requirements)
- Synthesize the supervisor $\Longrightarrow$ M_{S} (discrete-event model)



Result

The supervisor is:

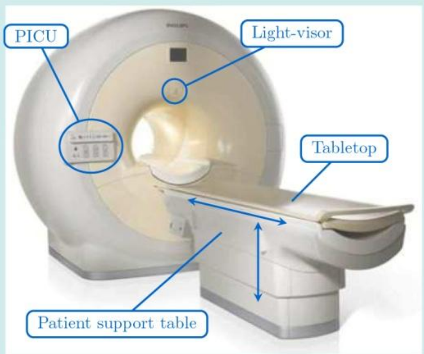
- by construction mathematically correct w.r.t. $M_{R_{\mathrm{S}}}$
- non-blocking (deadlock and livelock free)
- maximally permissive, allowing selection of 'optimal' sequence of events

Benefits

The design process changes from implementing and debugging controller code to designing and debugging control requirements:

- Quick generation of supervisor
- Reduction of design-test-redesign loops

Philips MRI scanner



Cases

Patient support table:

- Event-based and State-based
- Uncontrolled system consists of 6.3 billion states

Patient communication system:

- Communication between the patient and the operators
- Distributed
- State-based

More information

Team:

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- Ramon Schiffelers
- Bert van Beek
- Koos Rooda

Website:

- www.se.wtb.tue.nl

TU/e Technische Universiteit Eindhoven University of Technology

D 2 Optimization of duty cycle of Magnetic Resonance Imaging scanners

TU/e Technische Universiteit Eindhoven University of Technology

Overview

Each Magnetic Resonance Imaging (MRI) examination consists of several different scans. During execution these scans impose limitations on different parts of the MRI system (temperature of gradient amplifies and coils, SAR level, etc.) that sometimes results in prolongation of the MRI examination time. The MRI scanners duty cycle can be optimized by dividing scans into segments and processing them in parallel, by switching between segments of different scans by means of special multi-parameter scheduling algorithm.

We will demonstrate work of the algorithms we have designed to reduce the time of routine MRI examinations.

Method

The scheduling algorithm for scan segments is based on modelling of restricting physical properties such as SAR, amplifiers duty cycles and gradient coil temperature.

The algorithm we have designed optimizes the examination time against multiple limitations simultaneously. That implies in up to 20% reduction of the total MRI examination time.

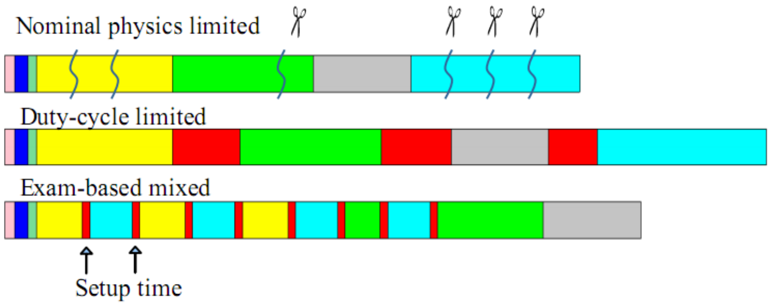

Figure 1 : MRI examination scan segments rescheduling (scans are denoted by different colors, red color denotes 'dead time' due to duty-cycle limitations)

Benefits

The MR examination time reduction is up to 20% (in average it is about 10%).
Hospitals can handle more patients per day (about 1-2 patients). That is sufficient, because in some hospitals the queues for the MR examinations are up-to 2 weeks.

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DARWIN: Optimization of duty cycle of MRI scanners

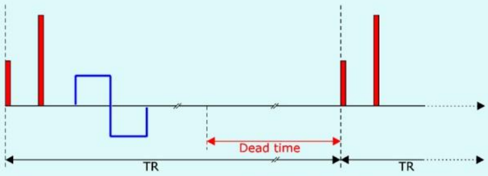
Partner: TU Eindhoven (E. Ivanov, A.Y. Pogromsky, J.E. Rooda)

Embedded Systems INSTITUTE

Problem

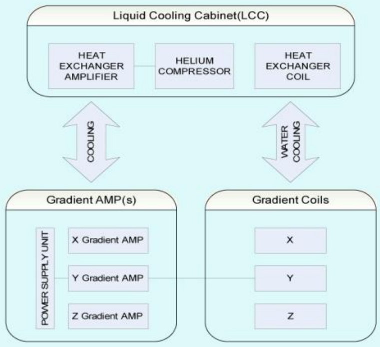
How to reduce MRI examination time without image quality compromising?

SAR-limited scans



Some scans are SAR-limited. TRs of such scans include dead time in order not to exceed the SAR constraints

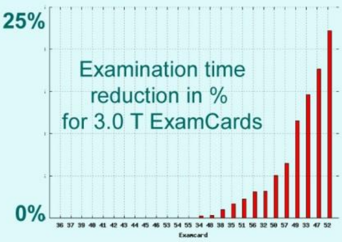
Gradient AMPs/coils heating



Method

New scan segments scheduling algorithm

Split the scans into segments and mix them to comply the duty cycle limitations of the SAR-level, amplifiers and coils temperature.



Benefits

Time reduction up to 20%

Hositals can diagnose more patients per day

Needed effort

~ 1 FTE

TU/e

D 3 Architecture decision making drivers

PHILIPS

Online survey worldwide

Overview
Architecture decision making in an organization and business context is a very complex process. The decisions are made based not only on technological properties of the system or on economic benefits for the organization but on several aspects considered jointly. At the same time the social profile and personal preferences of a business decision maker considerably impact decisions. Thus, to better understand architecture decision making, we need to analyze technological, business, and psychological aspects of decisions jointly to sharpen a holistic picture of the architecture decision drivers in industrial practice.
Recently Philips Research conducted in total 19 interviews with managers and architects in one of leading businesses in Philips Healthcare in the Netherlands to better understand architecture decision making. The findings of the interviews were insightful. The economic drivers (investment, cash flow, sales) are predominant for managers while technology drivers (quality attribute trade-off and future proof) are predominant for architects to make their decisions. They equally agree that time-to-market and upside potential enabled by architecture are very important in decision making.
With these facts, we decided to design an online survey to validate our insights with the worldwide population.

Method
We set up an online survey aiming to identify how architecture decision making depends on the respondent's profile and information available for decision making. The survey is primarily focused on architects and decision makers who actively participate in the architecture investment decision making process. In contrast to the standard questionnaire, this survey is designed to ask participants to take role of a decision maker in three realistic anonymized cases from the automotive, healthcare, and consumer electronics domains.

With the premise that decisions are based on several factors considered jointly, we use conjoint analysis to design the survey and analyze the results. A conjoint analysis is used to understand the importance of different information and people's profile, as well as to determine how decisions are likely to be influenced by the inclusion, exclusion, or degree of that information.

The data collection is performed online worldwide in a timeframe of a month starting from the end of October 2009.

In the demonstrator we will present our findings about architecture decision making drivers as the results of this survey.

Benefits
We think that understanding architecture decision drivers will help us in proposing approaches that will improve the architecture decision making process in industrial practice.

For more information

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DARWIN: Architecture decision making drivers

Partner: Philips Research

Embedded Systems INSTITUTE

Finding common ground for architects and managers

Research Question: What information do managers and architects need to effectively take decisions?

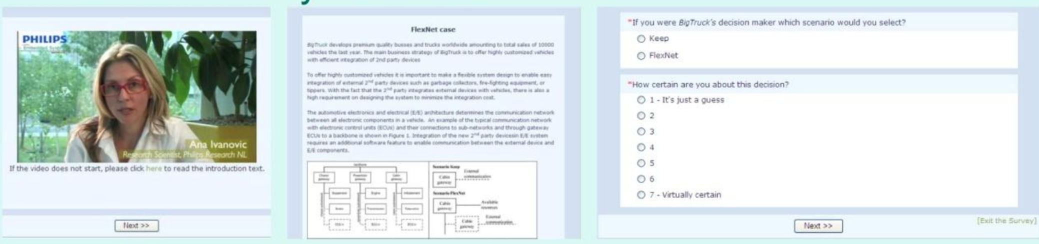
Input: Interviews in MRI, Philips Healthcare

Information used for architecture decision making

		Gut feeling	Investment	Cash flow, NPV, IRR	Sales	Market uncertainty	Customer segment benefits	Time-to-market	Upside potential	Customer satisfaction	Quality attribute trade-off	Future proof	Downside effect	Resources	Technology risk	Cost savings	Capabilities
Total	19	◕	◑	◔	◑	◑	◑	●	◕	◑	◑	◑	◑	◑	●	◕	◑
Architects	10	●	◔	○	◑	◔	◔	●	◕	◑	●	◕	◔	◑	●	◕	◑
Managers	9	◔	●	◕	◕	◕	◑	●	◕	◕	○	◔	◕	◑	◕	◑	◑

Icon	When value is
○	<=20 %
◔	20-40 %
◑	40-60 %
◕	60-80 %
●	=>80%

Validation: Survey worldwide



Survey: Participants take the role of decision maker
Psychometrics method: Conjoint analysis

Results: Decisions are likely to be influenced by personal profiles and given information

PHILIPS

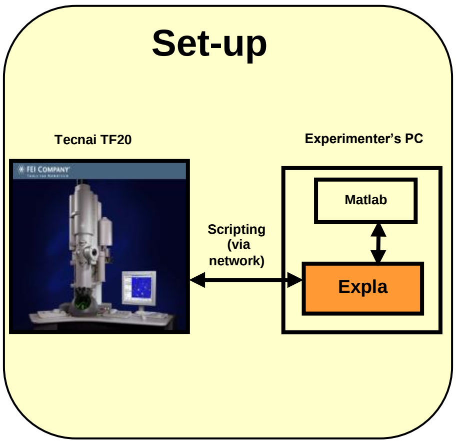
D 4 Automation of a FEI electron microscope

Concept Car 1: size analysis of nanoparticles on a FEI Tecnai

Overview

Current electron microscopes are very complex scientific instruments that require highly skilled personnel for operation. For enabling routine applications on these machines we investigate the options to support the operator and especially to automate microscope operations.

Unattended routine measurements require a stable and robust system, e.g. with capabilities to align itself, and a robust toolset for a variety of applications. To investigate this we have built an experimental platform that currently allows us to create a first routine application: size analysis of nano particles.



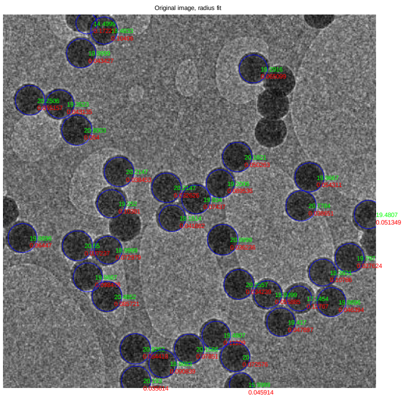


Figure 1 : Platform set-up and intermediate sizing result.

Method

The demonstrator shows an automated alignment procedure to optimize the focus, and the magnetic lens stigmation in two directions. The procedure is based on the image variance, which is applied as an image quality measure. The variance is optimized in a three parameter space with the Nelder-Mead simplex method. Furthermore, we show a sizing application based on a linear image formation model for annular dark field scanning transmission electron microscopy (ADF STEM), which determines diameters and positions of spherical particles.

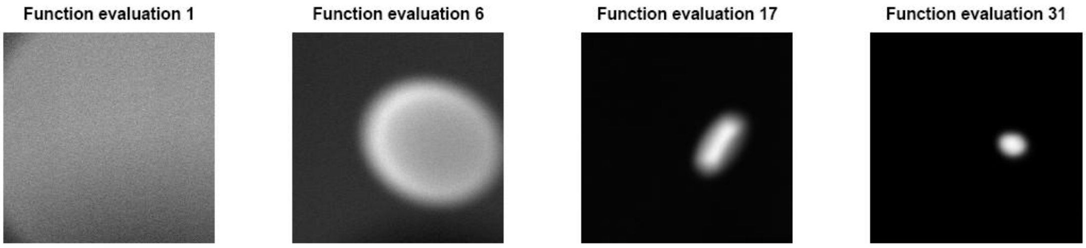


Figure 2 : Images of 20 nm gold particles in the optimization of focus and x- and y-astigmatism

Benefits

The developed experimental platform helps us to find the key issues that arise when extending a very complex scientific instrument for routine applications.

For more information

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Condor

Automation of a FEI electron microscope

FEI COMPANY, Universiteit Antwerpen, TU/e, Embedded Systems Institute, TU Delft, Technolution, Katholieke Universiteit Leuven

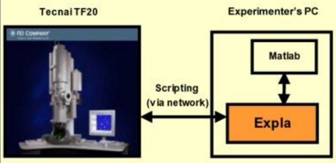
Objectives

- Make routine type applications easier for the user
- Run measurements without the user present

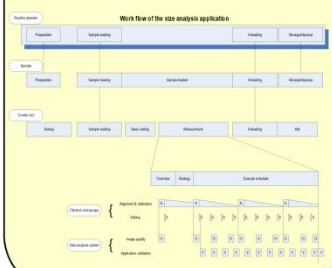
Concept Car I: size analysis

- 1000 particles of ~50 nm
- 5 samples per hour
- Size accuracy 1 %
- STEM
- Challenges:
  - Automation
  - Alignment optimization
  - Throughput

Set-up

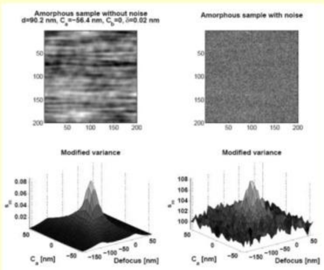


Work flow



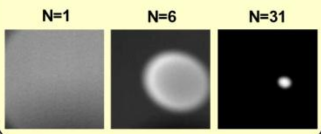
Optimization in 3D space

- Focus, x- and y-stigmation
- Local optima due to noise



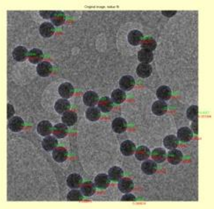
Preliminary results

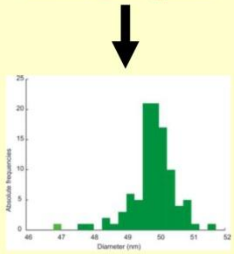
The Nelder-Mead method converges in 30-50 function evaluations.



Automated size analysis

- Classical image processing for particle location determination
- Image formation model for STEM used for accurate diameter determination





Results

- Automated size analysis of nano particles with good throughput
- Platform with auto-optimization

Next steps

- Expanding the set of applications
- Add continuous control
- Stability and robustness analysis

Embedded Systems INSTITUTE

R. Doornbos (ESI), M. Rudnaya (TUE), W. van den Broek (U Antwerp), D. Langsweirdt (KU Leuven), N. Venema (Technolution)

D 5 Control of a Drop-on-Demand (DoD) Inkjet Printhead

The Octopus Project

Overview

Inkjet is an important technology in document printing and many new industrial applications. Inkjet developments move towards higher productivity and quality, requiring adjustable small droplet sizes fired at high repetition rates. Inkjet printers are now widely used to form conductive traces for circuits, and colour filters in LCD and plasma displays. That make the printing quality is an important issue.

For printing applications at Océ, accuracy in terms of microseconds, micrometers and picoliters is desired. It is expected that for future applications these criteria become even tighter. Here, main targets are a high resolution, a constant quality and a high print speed. These demands can directly be translated into small droplets with constant properties and high jetting frequencies of the printhead.

After a drop is jetted, the fluid-mechanics within an ink channel are not at rest immediately: apparently travelling pressure waves are still present. These are referred to as residual vibrations. A second phenomenon which is encountered during jetting is interaction between different channels, called cross-talk. The cross-talk happens due to the fact that the pressure waves within one channel influence other channels. Both the residual vibrations and cross-talk result in degradation of the printing quality.

The main objective is to improve the performance of the DoD inkjet printhead by reducing the speed variations for each nozzle at each jetting frequency, reducing the speed variations over all the jetting frequencies, and reducing the effects of the cross-talk.

Method

Feedback control depends mainly on measuring the controlled variable. In the inkjet printer, there are no sensors available to measure the drop speed. Although residual vibration and cross-talk effects are large, they are very predictable and reproducible. Hence, a feed forward controller can be appropriate for this case. Two approaches are proposed:

- Optimization based feed-forward control
- Online optimization based control

For more information

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Mohammed Ezzeldin	Eindhoven University of Technology	m.ezz @ tue.nl

Control of a Drop-on-Demand (DoD) Inkjet Printhead

Amol Khalate and Mohammed Ezzeldin

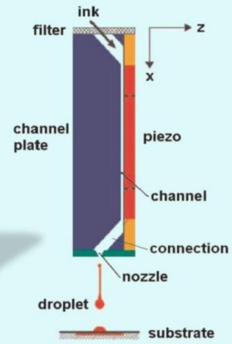
Embedded Systems INSTITUTE

Octopus Project

Objectives

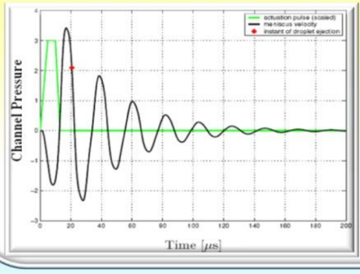
Improve the performance of a DoD Inkjet Printhead by

- Reducing the drop speed variations for each nozzle at each frequency.
- Reducing the drop speed variations over all the frequencies.
- Reducing the effects of the cross- talk.

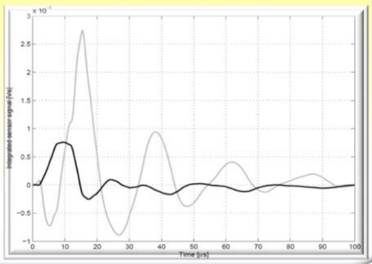


Sources of performance degradation

1. Residual Oscillation

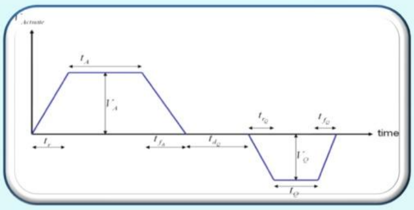


2. Cross Talk



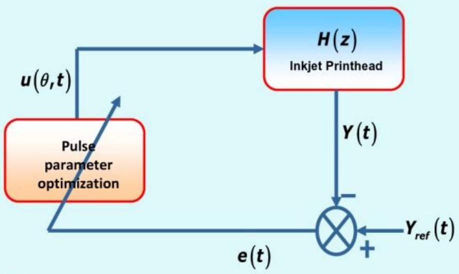
Control limitations

- There are no sensors, no feedback control
- Actuation pulses are restricted to trapezoidal shape

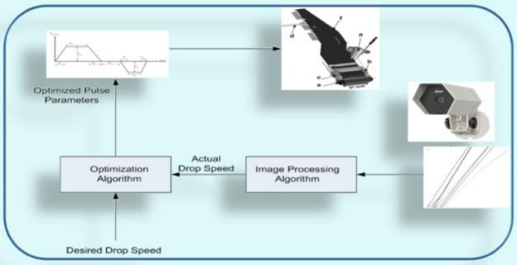


Proposed approaches

1. Optimization based feed-forward control



2. Online optimization based control



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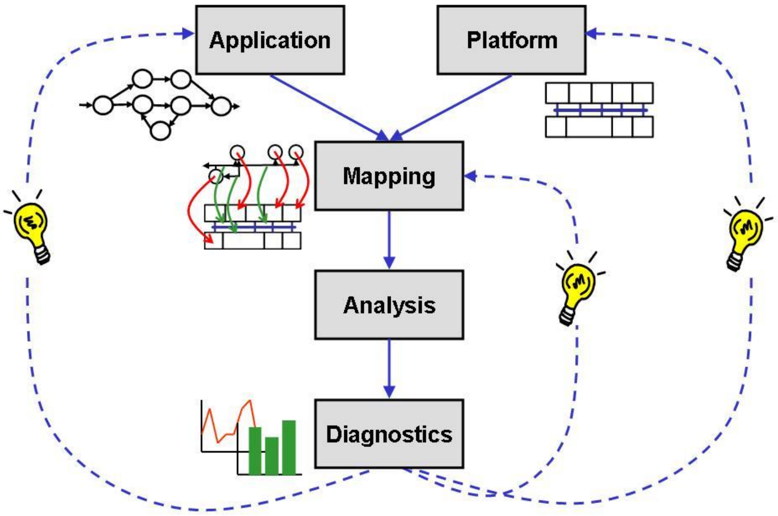
TU/e Technische Universiteit Eindhoven University of Technology

D 6 Design-Space Exploration Toolset

The Octopus Project

Objective
A flexible toolset supporting design-space exploration of high-tech embedded systems. The toolset is initially developed for professional printing systems but it is sufficiently generic to be retargetable to other types of systems.

The Y-chart
Design-space exploration typically involves the co-development of an application, a platform, and the mapping of the application onto the platform. Diagnostic information is used to (semi-automatically) improve application, platform, and/or mapping. [Kienhuis et al. LNCS 2268, 2002]



The Toolset
The complexity of today's embedded systems and their development trajectories re-quires a systematic, model-driven design approach, supported by tooling wherever possible. Only in this way, development trajectories become manageable, with high-quality, cost-effective results. The Embedded Systems Institute has recently started the development of a toolset to support design-space exploration for high-tech embedded systems. Ultimately, such a toolset may incorporate:

- a design-space exploration kernel to coordinate the exploration process, centred around an intermediate representation for design alternatives;
- domain-specific editors for defining design alternatives, metrics of interest and exploration experiments;
- support for the automatic exploration of parts of the design space (via for example evolutionary algorithms);
- support to interface with analysis tools (model checkers, simulators) to compute metric values for design alternatives;
- support to interface with optimizers and dedicated design-space-exploration tools to determine solutions (schedules, mappings, etc) for sub-problems;
- visualization support for metrics, trade-offs between metrics, trends in metrics over design alternatives, dynamic system behaviour and metric development, de-sign bottlenecks, decision processes, etc;
- decision support and version management for design alternatives and models.

The demo shows the first version of the toolset.

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Design-Space Exploration Toolset
Octopus project

Embedded Systems INSTITUTE

Objective

Design-space exploration support for high-tech embedded systems

- Flexible set of tools
- Prototype for professional printers
- Retargetable to other systems

Domain-specific scenario editor
- UI for the system designer*
- Specification of design alternatives*
- Specification of experiments, metrics

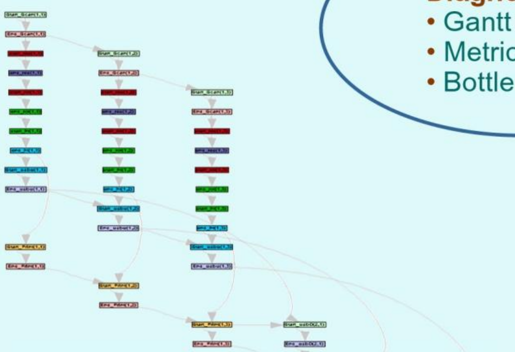
- Database
- Versioning
- Decision support

Analysis
- CPNTools*
- Point analysis tools
- Automated exploration

The kernel
- Central engine*
- Intermediate representation*
- Default analyses*

* supported in current prototype

Diagnostics & Visualization
- Gantt charts*
- Metric values, trade offs
- Bottlenecks, trends



Intermediate representation
Parameterized Event Partial Orders

More Information

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D 7 Application Examples of Evolution Strategies

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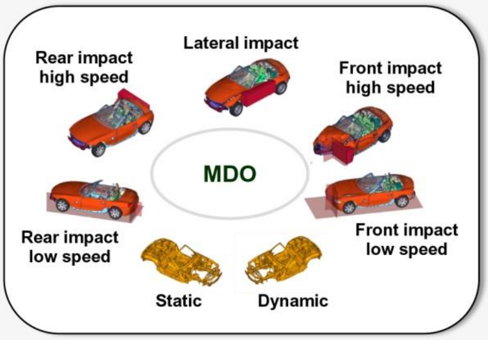
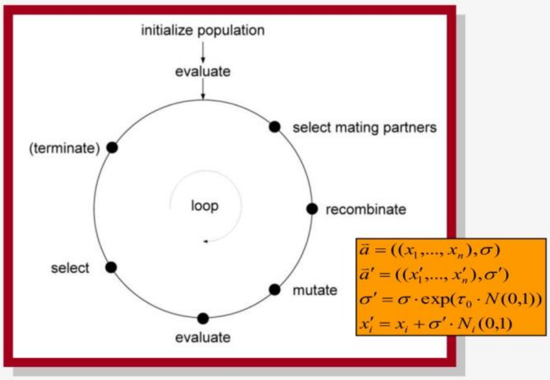
Application Examples of Evolution Strategies

Prof. Dr. Thomas Bäck, LIACS, Leiden University

Multidisciplinary Optimization

The Task | **The Algorithm**





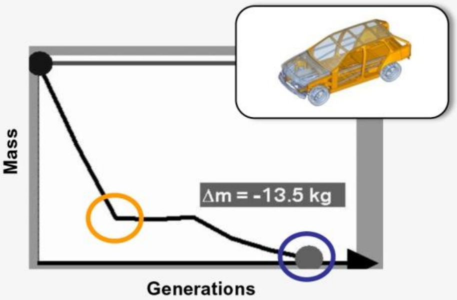
- Very demanding simulations (multiple CPUs, many hours).
- Large number of design parameters and constraints.
- Very few evaluations (shots) possible (often < 300).

- Based on principles of organic evolution.
- Self-adaptive mutation, constantly learning.
- Very different from Genetic Algorithms!

Application Examples

Example 1:

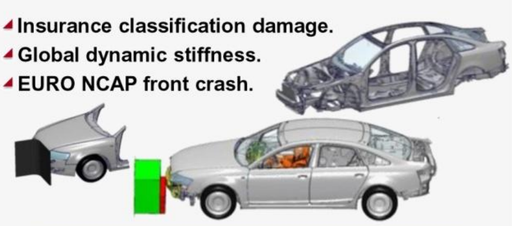
- Thickness parameters: 136, constraints: 47.
- 180 (10 x 18) evaluations: ~ 12 days.
- Crash: ~ 1,000,000 elements, NVH: ~ 300,000

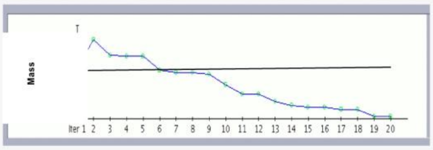


- 13,5 kg weight reduction by Evolution Strategy.
- Reduced development time from 5 to 2 weeks.

Example 2:

- Insurance classification damage.
- Global dynamic stiffness.
- EURO NCAP front crash.





- 376 simulator evaluations.
- Feasible solution found.
- Weight significantly decreased.

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D 8 Coordination of Autonomous Vehicles

Technische Universiteit Eindhoven University of Technology

Overview

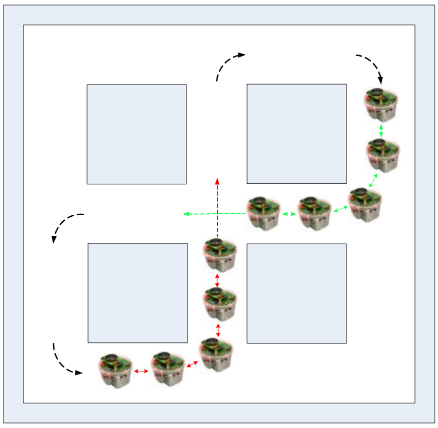
To increase the scale of and automation in distribution centres (DC), flexible, cost effective and robust transportation systems are needed. One possibility is to use autonomous vehicles to transport goods instead of using the traditional conveyor systems. Most available systems use a central control method in which a single controller takes all decisions. Using all information, tasks can be distributed optimally to the vehicles, their optimal paths can be calculated and collisions avoided. The problem is that re-planning and rescheduling - in case of disturbances/failures - might take too long in large systems and the total system may suffer from this.

More hierarchical and distributed control methods are being developed to be robust against disturbances while being efficient when the system scales up.

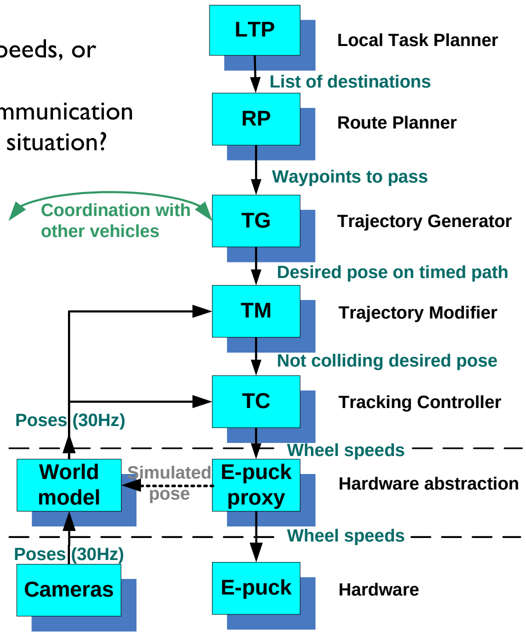
In our demo, collision avoidance is used as an example of something that has to be coordinated among vehicles. The questions to deal with are:

1) At what level of abstraction should they coordinate? At the lowest level where actual positions are known, or, at a higher level where the path to be followed is determined?
2) What information is needed? Only positions, or also speeds, or even the desired paths up to a certain horizon?

Each solution has its own trade-off between robustness, communication effort and optimality. What solution works best in a certain situation?



Demo layout with desired paths



Control Architecture

Method

In our demo ten robots are shown that follow an 8-shaped path. Two groups of five robots start at different places, and the ordering within each group should be kept. A path following controller is developed to keep each vehicle on a timed path with minimal error. In addition, two solutions for collision avoidance are implemented. One at the level where the path is being followed and one at the level where the desired paths are generated. Both methods have decentralized control, but use different information and work at different update rates.

Further reading

D. Kostic, S. Adinandra, J. Caarls, N. van de Wouw, H. Nijmeijer, Collision-free Tracking Control of Unicycle Mobile Robots, in 48th IEEE Conference on Decision and Control; Shanghai, China, 2009

For more information

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Dr. H. Nijmeijer	Eindhoven University of Technology	Department of Mechanical Engineering

Technische Universiteit Eindhoven University of Technology

Coordinating Autonomous Vehicles

S. Adinandra, J. Caarls, D. Kostić, H. Nijmeijer

falcon Flexible Automated Logistics CONcepts

Embedded Systems INSTITUTE

Problem statement

Each vehicle should transport goods via waypoints on a timed path. The problem is to follow the path with minimal error, while avoiding collisions with other vehicles.

Goal: coordination on multiple abstraction levels, using different amounts of information.

Focus: collision avoidance

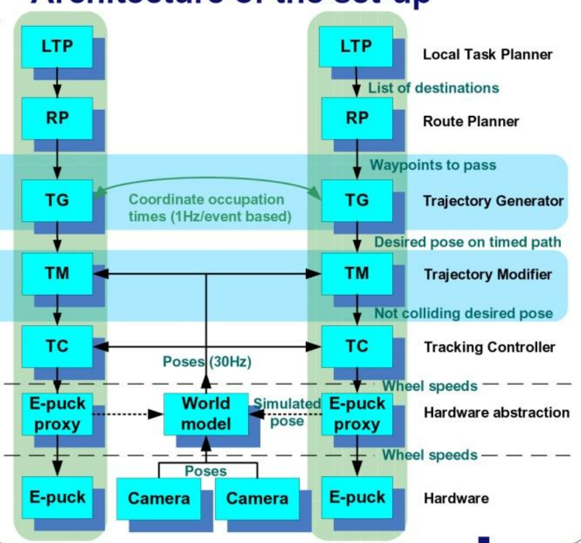
Two solutions

Available information:
High-level: desired paths
Low-level: actual positions

High-level (1Hz)
Coordinate occupation times

Low-level (30Hz)
Repulsed by nearby objects

Architecture of the set-up



Evaluation

- Maximum travel time
- Robustness to perturbations
- Keeping the sequence

Results/Conclusion

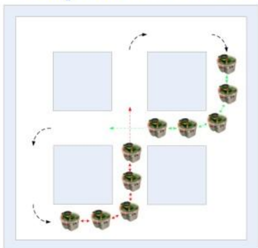
Low-level

- slow to recover
- very robust to perturbations

High-level

- efficient
- less robust to perturbations

Experimental layout



Task:

Transport ten products in two ordered groups

Situation:

Without adaptation, the groups will collide

/ Dynamics and Control, Department of Mechanical Engineering

Technische Universiteit Eindhoven University of Technology

falcon Flexible Automated Logistics CONcepts

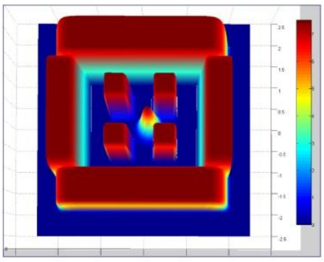
Embedded Systems INSTITUTE

Collosion Avoidance of Autonomous Vehicles

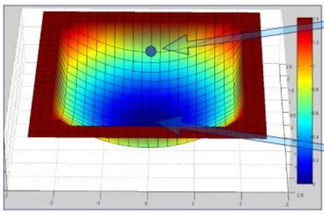
S. Adinandra, J. Caarls, D. Kostić, H. Nijmeijer

Locally override trajectory using Artificial Potential Fields

- Activate APF when an object comes too close
- Generate a repulsive field for that object and an attractive field for the desired position
- The field can be seen as a virtual landscape with an artificial gravity force
- The robot will move in the direction of the steepest descent



Top view of the virtual landscape of the walls and one vehicle



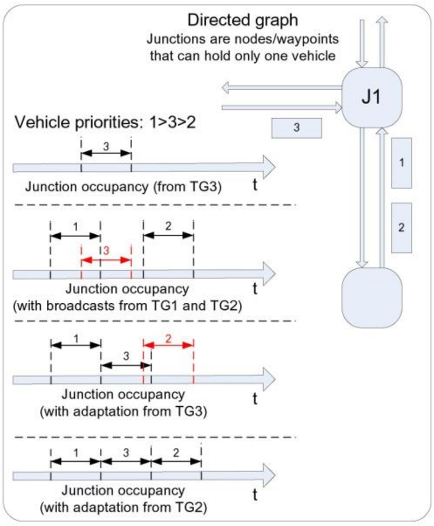
current position

desired position

High-level coordination of waypoint arrival times

Given: Waypoints from route planner

- Trajectory Generator (TG) determines desired timed path through the waypoints
- All vehicles headed for Waypoint J1 start a “conference call”, and @ 1Hz broadcast their occupation interval
- If overlap is detected
  - The TG of the lower priority vehicle adapts its speed and broadcasts its new occupation interval
  - The higher priority vehicle re-broadcasts its occupation interval



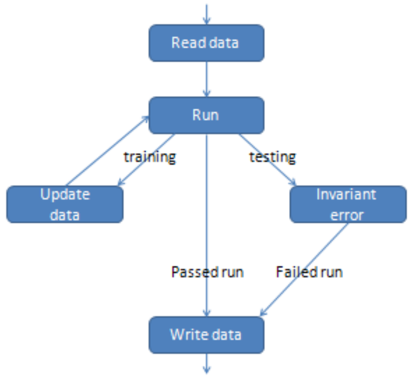
/ Dynamics and Control, Department of Mechanical Engineering

D 9 Spectrum-based Fault Localization

Find errors without explicit domain knowledge

Overview

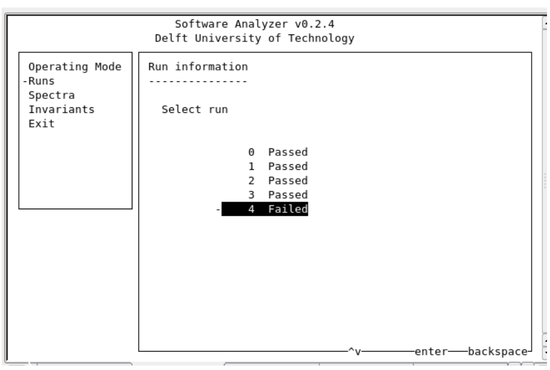
Debugging is an important part of software development. Several debugging tools exist which are based on stepping through the execution of the program. These tools require the user to have knowledge about the code that is executed and about the inner workings and dependencies in the program which can be very difficult for one person to comprehend.

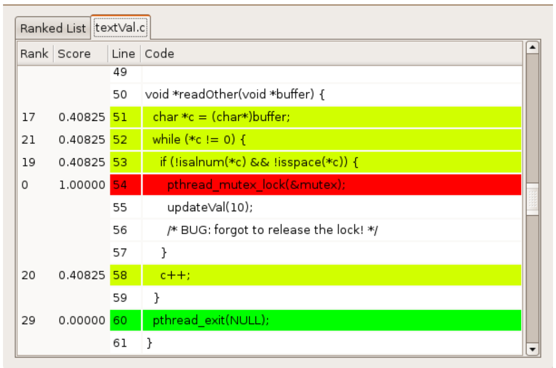


In practice, a large test set usually exists against which the program under development is tested. Some tests will fail, some will pass, and this information can indicate what is going wrong when unexpected behavior occurs. However, in many cases, especially for large programs, a tester needs extensive knowledge about the program to be able to map a certain output or behavior to a point in the source code.

Method

A solution to these issues would be a black box method which takes a program and available test cases and returns the most probable location of the fault in case a number of these tests fail. In this demo a toolset is introduced that implements a technique called Spectrum-based Fault Localization. SFL is based on instrumenting a program and keeping track of executed parts of the code after which the spectrum-based fault localization technique is applied to return a list of source code locations ordered by the probability of it containing the fault. Furthermore, the tool set enables a program to be trained with expected behaviour and to automatically detect an error if it encounters unexpected behaviour. The fact that no knowledge is needed of the program to acquire possible fault locations would make this set of tools a useful extension to currently applied methods of testing and debugging.





Benefits

Spectrum-based fault localization quickly determines the most probable locations of the root cause of observed system failures. A specific advantage of the approach is that it can be applied relatively easily, also by developers who do not have a thorough understanding of the architecture. Practical experience with SFL has indicated that in real-life development scenarios, debugging times can be reduced from weeks to days or even hours.

For more information

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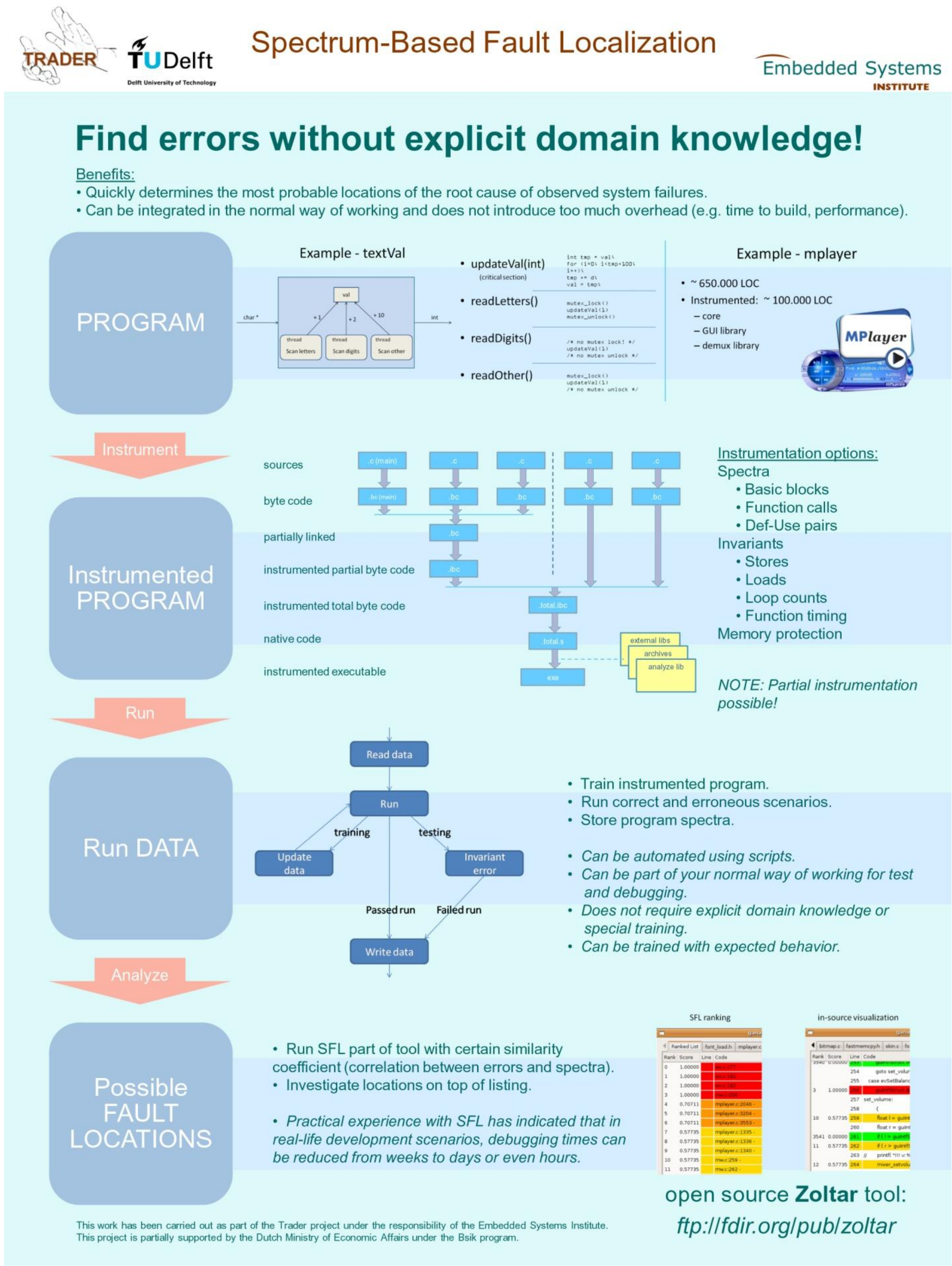

TRADER
TU Delft
Delft University of Technology
Spectrum-Based Fault Localization
Embedded Systems INSTITUTE
Find errors without explicit domain knowledge!
Benefits:
• Quickly determines the most probable locations of the root cause of observed system failures.
• Can be integrated in the normal way of working and does not introduce too much overhead (e.g. time to build, performance).
PROGRAM
Example - textVal
• updateVal(int)
(critical section)
• readLetters()
• readDigits()
• readOther()
Example - mplayer
• ~ 650.000 LOC
• Instrumented: ~ 100.000 LOC
– core
– GUI library
– demux library
MPlayer
Instrument
Instrumented PROGRAM
sources
byte code
partially linked
instrumented partial byte code
instrumented total byte code
native code
instrumented executable
external libs
archives
analyze lib
exe
Instrumentation options:
Spectra
• Basic blocks
• Function calls
• Def-Use pairs
Invariants
• Stores
• Loads
• Loop counts
• Function timing
Memory protection
NOTE: Partial instrumentation possible!
Run
Run DATA
Read data
Run
training
testing
Update data
Invariant error
Passed run
Failed run
Write data
• Train instrumented program.
• Run correct and erroneous scenarios.
• Store program spectra.
• Can be automated using scripts.
• Can be part of your normal way of working for test and debugging.
• Does not require explicit domain knowledge or special training.
• Can be trained with expected behavior.
Analyze
Possible FAULT LOCATIONS
• Run SFL part of tool with certain similarity coefficient (correlation between errors and spectra).
• Investigate locations on top of listing.
• Practical experience with SFL has indicated that in real-life development scenarios, debugging times can be reduced from weeks to days or even hours.
SFL ranking
in-source visualization
open source Zoltar tool:
ftp://fdir.org/pub/zoltar
This work has been carried out as part of the Trader project under the responsibility of the Embedded Systems Institute.
This project is partially supported by the Dutch Ministry of Economic Affairs under the Bsik program.

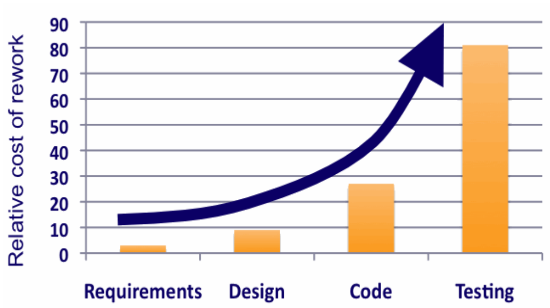
D 10 Ideals spin-off: BloomWise

Engineering high-quality behavioural requirements for embedded software

BLOOM WISE
Software Engineering Solutions

Context: ***Behavioural requirements engineering (BRE) in embedded software***
In today's industrial practice, behavioural requirements of embedded software systems are often imprecisely documented as plain text in a natural language (e.g., English), supplemented with ad-hoc and free form diagrams. Therefore, requirements documents are often difficult to read, analyze, and maintain.

Problem: ***Up to 100 times more costly rework due to inconsistent requirements***



Because behavioural requirements are often imprecisely documented, manual reviews and inspections cannot reveal inconsistent requirements, during the requirements engineering phase of a software project. Consequently, such inconsistencies cause expensive rework during a later phase, for instance, during testing and integration. According to well-known statistics, such rework can be up to 100 times more costly than detecting and resolving the inconsistency during the requirements engineering phase, in the first place.

Solution: ***A tool-supported method for resolving inconsistencies during BRE***
BloomWise offers a unique solution that enables system engineers and software architects to detect and resolve inconsistent behavioural requirements as early as possible during the behavioural requirements engineering phase of a software project. This solution consists of

- **Vibes** (Visual BEhaviour Specifications): A graphical, easy-to-use language to precisely and incrementally document the behavioural requirements,
- **CheckSpecs**: A software tool that automatically detects and reports inconsistent requirements documented as Vibes diagrams, and
- **Engines**: A set of software tools that automatically transform, generate, and simplify Vibes diagrams.

Benefit: ***9 to 21% reduction of overall software development cost***

Using the solution explained above, one can incrementally engineer precise, unambiguous, human-readable, and consistent requirements that can easily be kept up-to-date during the complete lifecycle of an embedded software project. Consequently, one can find and fix inconsistent behavioural requirements 76% faster and 90 to 99% cheaper, according to the results of the controlled experiments with 24 software professionals. Based on these results, we estimate that the cost of overall software development can be reduced by 9 to 21%; if 2 to 5% of the overall engineering effort is invested in creating Vibes diagrams.

For more information

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Ideals spin-off: BloomWise

Engineering high-quality behavioral requirements for embedded software

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BLOOM WISE Software Engineering Solutions

Embedded Systems INSTITUTE

MOTIVATION

CONTEXT

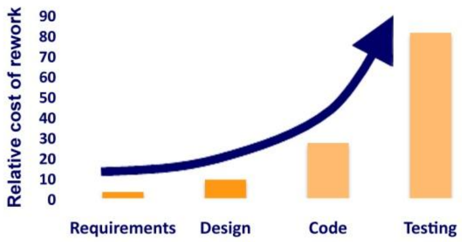
Requirements documents in practice

- Content:
  - Plain text
  - Ad-hoc diagrams
- Nature:
  - Unclear
  - Imprecise
  - Ambiguous
  - Difficult to read, analyze, maintain

PROBLEM

Reviews do not reveal inconsistent reqs.

- This causes up to 100 x more costly rework:

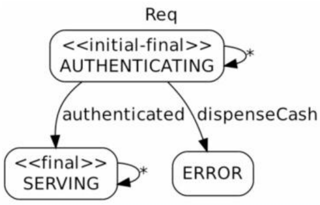


SOLUTION

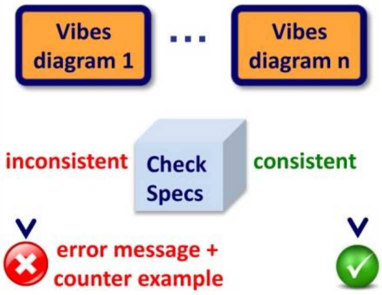
LANGUAGE: Vibes

VIsual BEhavior Specifications

- Req: ATM should not dispense cash before the user is authenticated.



VERIFIER: CheckSpecs



ENGINES

- Operators:
  - negate
  - and
  - or
  - if
  - ...
- Simplifiers:
  - minimize
  - cleanup

BENEFITS

QUALITATIVE

- Precise and common understanding of behavioral requirements
- Up-to-date behavioral reqs.
- Consistent behavioral reqs.
- Unambiguous behavioral reqs.
- Traceability between behavioral design and behavioral requirements

QUANTITATIVE

- Find & fix inconsistent behavioral requirements
  - 76% faster
  - 90 to 99% cheaper

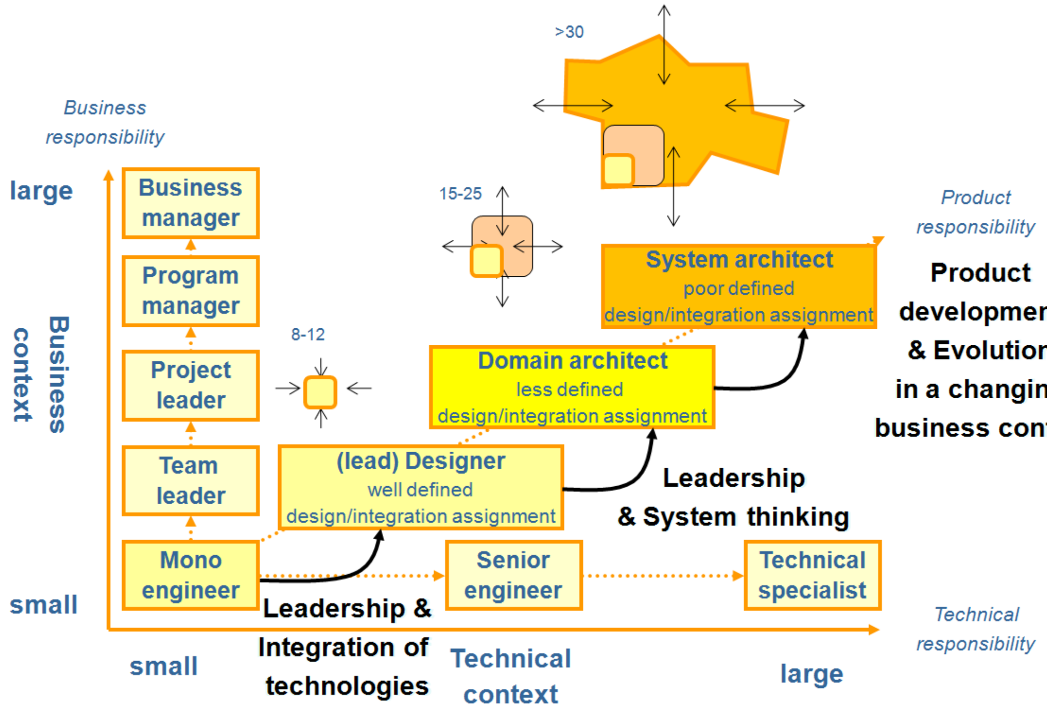
- Reduce the overall development cost by 9 to 21%
  - If 2 to 5% of the development effort is invested in creating Vibes diagrams

D 11 Competence Development Programme

For those who want to lead technology without leaving technology

Overview
In September 2008 the Embedded Systems Institute (ESI) and the High Tech Systems Platform initiated a Competence Development Programme for architects. The programme consists of three different competence levels.

In 2010 ESI will start a new programme cycle. A short introduction will be given to the content and way of working of each of these programmes.



The programme is offered on three different levels:
1. Lead designer
2. Domain architect
3. System architect

In all three programmes explicit attention is paid to:

1. Broadening technology scope and system thinking
2. Personal skills and technological leadership.
3. Dealing with uncertainties on a technological and system level

For more information
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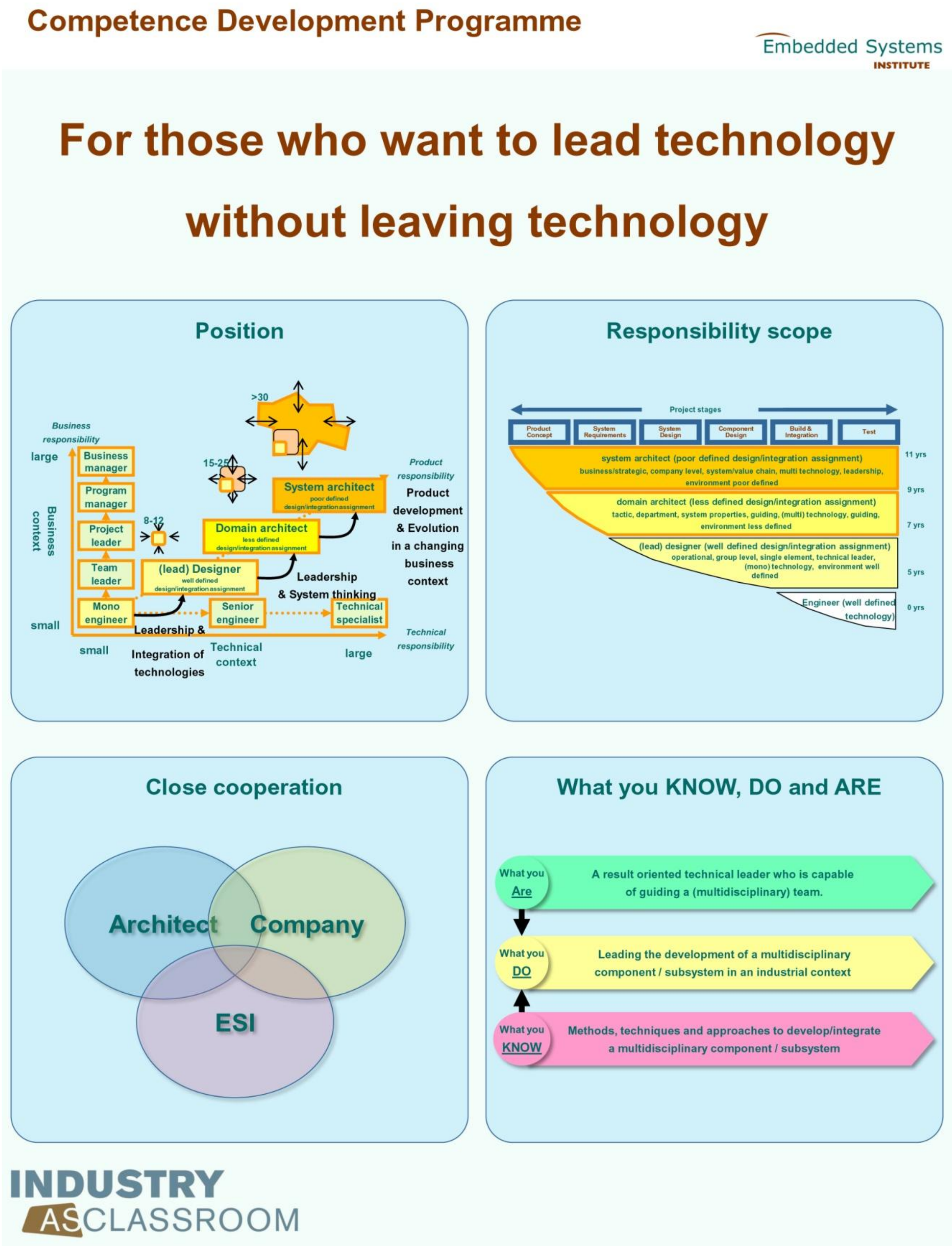

Competence Development Programme
Embedded Systems INSTITUTE
For those who want to lead technology without leaving technology
Position
Business responsibility
large
small
Business context
Business manager
Program manager
Project leader
Team leader
Mono engineer
>30
15-25
8-12
System architect
Domain architect
(lead) Designer
Senior engineer
Technical specialist
Leadership & Integration of technologies
Leadership & System thinking
Technical context
Product responsibility
Product development & Evolution in a changing business context
Technical responsibility
Responsibility scope
Project stages
Product Concept
System Requirements
System Design
Component Design
Build & Integration
Test
system architect (poor defined design/integration assignment)
business/strategic, company level, system/value chain, multi technology, leadership, environment poor defined
domain architect (less defined design/integration assignment)
tactic, department, system properties, guiding, (multi) technology, guiding, environment less defined
(lead) designer (well defined design/integration assignment)
operational, group level, single element, technical leader, (mono) technology, environment well defined
Engineer (well defined technology)
11 yrs
9 yrs
7 yrs
5 yrs
0 yrs
Close cooperation
Architect
Company
ESI
What you KNOW, DO and ARE
What you Are
A result oriented technical leader who is capable of guiding a (multidisciplinary) team.
What you DO
Leading the development of a multidisciplinary component / subsystem in an industrial context
What you KNOW
Methods, techniques and approaches to develop/integrate a multidisciplinary component / subsystem
INDUSTRY AS CLASSROOM

D 12 Extraction of state machines of legacy C code with Cpp2XMI

Technische Universiteit Eindhoven University of Technology

LaQuSo Laboratory for Quality Software

Overview

Analysis of legacy code is often focussed on extracting either metrics or relations, e.g. call relations or structure relations. For object-oriented programs, e.g. Java or C++ code, such relations are commonly represented as UML diagrams: e.g., such tools as Columbus [1] and Cpp2XMI [2] are capable of extracting from the C++ code UML class, and UML class, sequence and activity diagrams, respectively.

New challenges in UML diagram extraction arise when
a) additional UML diagrams and
b) non-object-oriented programs are considered.

In this paper we present an ongoing work on extracting state machines from the legacy C code, motivated by the popularity of state machine models in embedded software [3].

To validate the approach we consider an approximately ten-year old embedded system provided by the industrial partner. The system lacks up-to-date documentation and is reportedly hard to maintain.

[1] Rudolf Ferenc, Árpád Beszédes, Mikko Tarkiainen, and Tibor Gyimóthy. Columbus – reverse engineering tool and schema for C++. In ICSM, pages 172–181. IEEE Computer Society, 2002.

[2] E. Korshunova, M. Petkovic,M. G. J. van den Brand, and M. R.Mousavi. Cpp2XMI: Reverse Engineering of UML Class, Sequence, and Activity Diagrams from C++ Source Code. In WCRE, pages 297–298. IEEE Computer Society, 2006.

[3] Jürgen Mottok, Frank Schiller, Thomas Völkl, and Thomas Zeitler. A concept for a safe realization of a state machine in embedded automotive applications. In Francesca Saglietti and Norbert Oster, editors, SAFECOMP, volume 4680 of Lecture Notes in Computer Science, pages 283–288. Springer, 2007.

See also: http://alexandria.tue.nl/openaccess/Metis221595.pdf

For more information

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D 13 prOVEN Reducing Development Costs by Proven Components

Overview

In the ‘Kenniswerkers’ (knowledge workers) project prOVEN, TASS, ASM, Verum and ESI collaborate to reduce software development time and to improve software quality. Often, long realization times are caused by the integration and test phase, which is difficult to control and to predict. In this phase often major problems have to be solved, sometimes leading to large architectural changes and a further increase of the testing time. This leads to large costs and long development times, conflicting with the need for fast innovations. An important problem during integration is the occurrence of unexpected interactions between the behaviour of components. For example, an unanticipated sequence of function calls between components might lead to system failures.
A promising solution for these problems is the Analytical Software Design (ASD) method of Verum. ASD is based on the formal specification of component interfaces, model checking techniques to prove correctness of component compositions and conformance of a design model with respect to an interface specification. Scalability is achieved by a methodology of writing complete component interfaces, gradually composing and verifying components, and hiding irrelevant details. By generating software from the design models, manual coding errors are avoided.

Project goal

The main goal of this project is to develop guidelines for the migration from a system developed without ASD technology to a design which is based on this technology. In addition, the aim is to get additional evidence concerning the proposed benefits for the test and integration phase and to assess the impact on other system qualities. The research will address two main issues:

1. how to incorporate the ASD method in the development process, e.g., what is the precise relation with system analysis and requirements capture, and
2. how to integrate software which is generated with the ASD tools into the system.

Approach

The main approach of this project is a close interaction between research activities and an immediate evaluation of research results on an industrial case study provided by ASM. This case study concerns the temperature control of a furnace of ASM which is used in the semiconductor industry to process wafers. The complexity of this particular kind of equipment is determined by the combination of real time control requirements, the internal logistics requirements, the external logistics requirements and the growing amount of diagnostic requirements.

For more information

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Kenniswerkers project
prOVEN

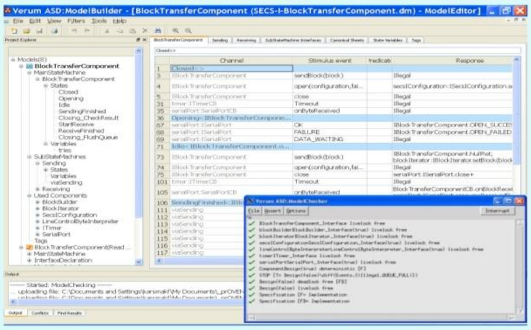
Reducing Development Costs by Proven Components

Partners: TASS, ASM, VERUM, ESI

Embedded Systems INSTITUTE

Aim

- Reduce software development time
- Improve software quality



ASM TASS Embedded Systems INSTITUTE

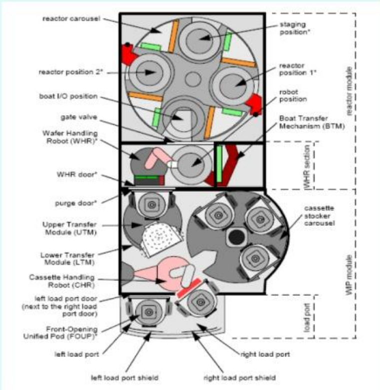
Approach

Apply Verum's Analytical Software Design (ASD) method and, when required, adapt and extend it.

- Complete, state-based interface specifications
- Mathematically verified design specifications
- Code generation from design specifications

Research Questions

- How to incorporate ASD in existing development process?
- How to migrate from existing system to system developed with ASD?
- How to identify most suitable parts for ASD, where to start?
- How to integrate generated software in existing system, especially in system with mixture of languages such as C and Java?



Activities

- Develop guidelines to include ASD in an existing system and development process
- Improve ASD technology, especially to generate Java code
- Evaluate approach on case study of ASM; temperature control of furnace for wafers
  Interesting aspects:
  - combination discrete / continuous part
  - distributed on two HW boards, one without OS
  - includes complex Matlab algorithm
  - uses both C and Java

D 14 The Modest project

Model Based Design and Testing

Overview

The aim of the MoDesT project (model-based design and testing) is to significantly enforce model-based product development within Océ and to share the achieved results in the network of high-tech companies in the region around Eindhoven. Multidisciplinary, model-based design methods constitute a sound scientific foundation for making products and their development process more effective, more efficient, and more responsive to societal needs.

The application of models implies a sharp reduction in the number of necessary physical prototypes, thereby accelerating the development process and simultaneously reducing the use of resources. Another good example of the advantages of model-based design is the optimal use of available energy during the process of printing through which the equipment becomes more energy savvy.

It is important to extend the competences that are necessary for the development of future printer systems generations with innovative capabilities. In the project, two groups of research areas and required results have been identified, respectively centred around design and around testing.

The first group can best be described as the left side of the V-cycle. Here techniques and tools are being developed to aid in the development of new products and functions. The work packages include the following topics:

- Model smart system behaviour, extend the multidisciplinary model base, and improve the software synthesis capabilities.
- Develop models in cooperation with the mechanical engineers for paper handling designs and analyze and simulate these models to improve the design in an iterative way. The models will contain the layout of the paper handling as well as the mechatronic control subsystems.
- Enable product platform development by reusing mechatronic systems and subsystems. Part of these systems and subsystems is the functional control software.

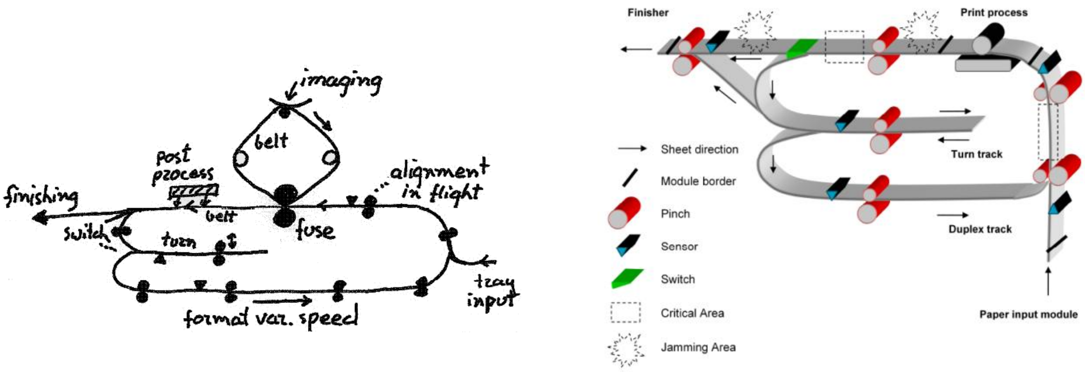


Figure 1: A paper path design sketch and its mock-up.

The second group of activities provides tools to test and validate new products and functions. The goal is to test the engine software as soon as possible (in the development environment, on a target platform with simulated mechanics, and on a real engine) in an efficient way, both automatically and manually. The work packages target the following topics:

- Realize one Software-In-the-Loop test environment that will be suitable for all Océ printers.
- Develop automatic test tools and share test methods, scripts, and tooling over multiple product development projects. The scope is tests in a simulated environment as well as tests on a real engine.
- Define and share methods and guidelines for creating test cases and reporting.

The results of the project will be visible in a more efficient and shorter product development cycle inspired by improvements and extensions of the tools that support the model-based way of working. A second benefit is the knowledge sharing and dissemination among professionals in the Dutch industrial network.

For more information

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D 15 Overlay

Performance modelling and design space exploration for embedded mechatronic control systems

Overview

In the high-tech industry, there is a trend towards the use of general-purpose platform resources such as CPUs, operating systems and (wireless) communication networks. These resources are typically optimized for average throughput, at the expense of unpredictable and highly variable latencies. In the past this was not a major issue, but current mechatronic applications require very small predictable latencies. Satisfying these latency requirements, by using these general purpose resources, is increasingly difficult since it involves many low-level optimizations. In addition, there is another key problem. Instead of scaling up clock-frequencies, platform performance is now boosted by multi-core and hyper-threading techniques.

As a consequence, the straight forward 'free performance lunch' is over, implying that application programs do not automatically benefit anymore from the improved raw platform performance. Only by increasing the grain of application concurrency and by applying sophisticated model-based design-space exploration techniques, increased raw platform performance can be utilized effectively.

Goal

The goal of the Overlay project is to investigate such techniques and explore how they can be applied to the real time performance-critical embedded control systems, developed within ASML. It will be shown that the application of such techniques can lead to a tremendous improvement in application performance.

For more information

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D 16 Other posters

Embedded Systems INSTITUTE

Model-based Testing of Electronic Passports

Wojciech Mostowski, Erik Poll, Julien Schmaltz,
Jan Tretmans, Ronny Wichers Schreur

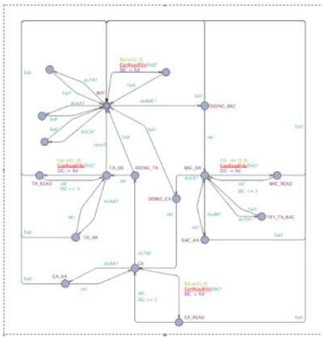
Electronic Passports

Electronic passports contain a contactless smartcard with a picture and personal data of the holder. New European passports will also contain fingerprints. Several security mechanisms are in place to safeguard the authenticity and confidentiallity of this data. We were involved in a project to test the security in a real-world implementation of the electronic passport.

The Specs

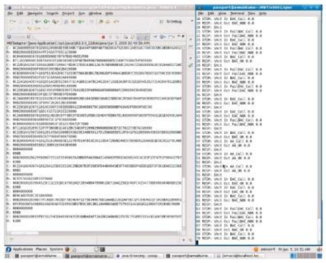
The basic protocols are specified in an ICAO standard. This standard references many other standards. Implementators of the standard have various options in their choice of protocols. Also, the standard is underspecified, in particular for error conditions.

The Model



After scrutinising the specifications we constructed a formal model of the passport's behaviour. This model takes the form of a labelled-transition system. The model contains explicit transitions for error conditions.

The Tools



The model was fed to the testing tool TorXakis (based on TorX) that automatically generates and executes test cases on the fly. The JMRTD framework provided the Java implementations of the protocols. Also jUnit was employed for *ad-hoc* testing.

Experiences

Understanding the specifications and constructing the model was most of the work. After that using TorXakis to automatically run test cases was quick and easy. We started with a coarse model, which allowed us to run tests early on in the project. The model was then subsequently refined. In this project model-based testing has clearly proven its value.

Radboud Universiteit Nijmegen

LaQuSo Laboratory for Quality Software

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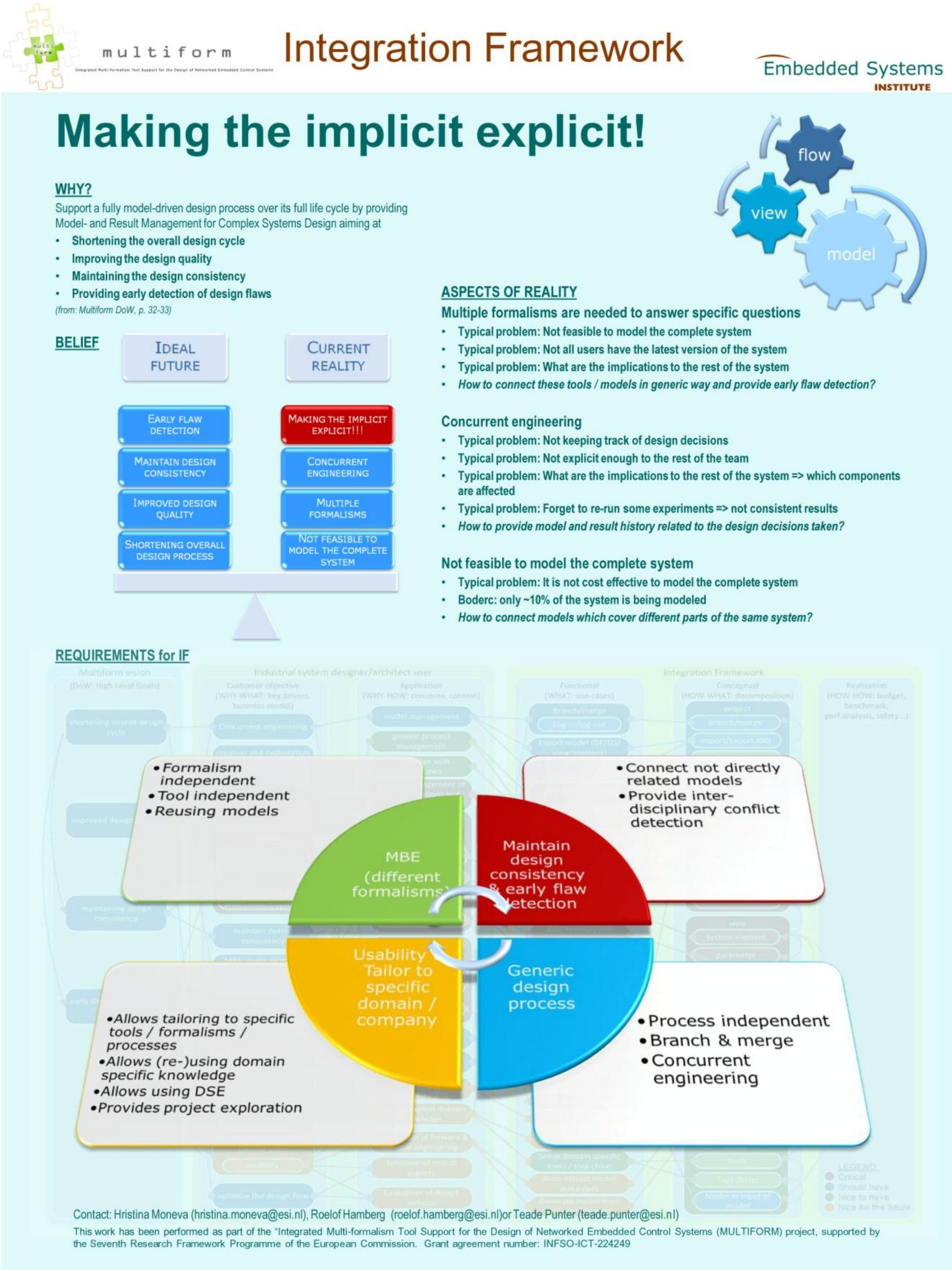
multiform
Integration Framework
Embedded Systems INSTITUTE
Making the implicit explicit!
flow
view
model
WHY?
Support a fully model-driven design process over its full life cycle by providing Model- and Result Management for Complex Systems Design aiming at
• Shortening the overall design cycle
• Improving the design quality
• Maintaining the design consistency
• Providing early detection of design flaws
(from: Multiform DoW, p. 32-33)
BELIEF
IDEAL FUTURE
CURRENT REALITY
EARLY FLAW DETECTION
MAINTAIN DESIGN CONSISTENCY
IMPROVED DESIGN QUALITY
SHORTENING OVERALL DESIGN PROCESS
MAKING THE IMPLICIT EXPLICIT!!!
CONCURRENT ENGINEERING
MULTIPLE FORMALISMS
NOT FEASIBLE TO MODEL THE COMPLETE SYSTEM
ASPECTS OF REALITY
Multiple formalisms are needed to answer specific questions
• Typical problem: Not feasible to model the complete system
• Typical problem: Not all users have the latest version of the system
• Typical problem: What are the implications to the rest of the system
• How to connect these tools / models in generic way and provide early flaw detection?
Concurrent engineering
• Typical problem: Not keeping track of design decisions
• Typical problem: Not explicit enough to the rest of the team
• Typical problem: What are the implications to the rest of the system => which components are affected
• Typical problem: Forget to re-run some experiments => not consistent results
• How to provide model and result history related to the design decisions taken?
Not feasible to model the complete system
• Typical problem: It is not cost effective to model the complete system
• Boderc: only ~10% of the system is being modeled
• How to connect models which cover different parts of the same system?
REQUIREMENTS for IF
•Formalism independent
•Tool independent
•Reusing models
•Connect not directly related models
•Provide inter-disciplinary conflict detection
MBE (different formalisms)
Maintain design consistency & early flaw detection
Usability Tailor to specific domain / company
Generic design process
•Allows tailoring to specific tools / formalisms / processes
•Allows (re-)using domain specific knowledge
•Allows using DSE
•Provides project exploration
•Process independent
•Branch & merge
•Concurrent engineering
Contact: Hristina Moneva (hristina.moneva@esi.nl), Roelof Hamberg (roelof.hamberg@esi.nl)or Teade Punter (teade.punter@esi.nl)
This work has been performed as part of the "Integrated Multi-formalism Tool Support for the Design of Networked Embedded Control Systems (MULTIFORM) project, supported by the Seventh Research Framework Programme of the European Commission. Grant agreement number: INFSO-ICT-224249

multiform

Integrated Multi-formalism Tool Support for the Design of Networked Embedded Control Systems

Integration Framework

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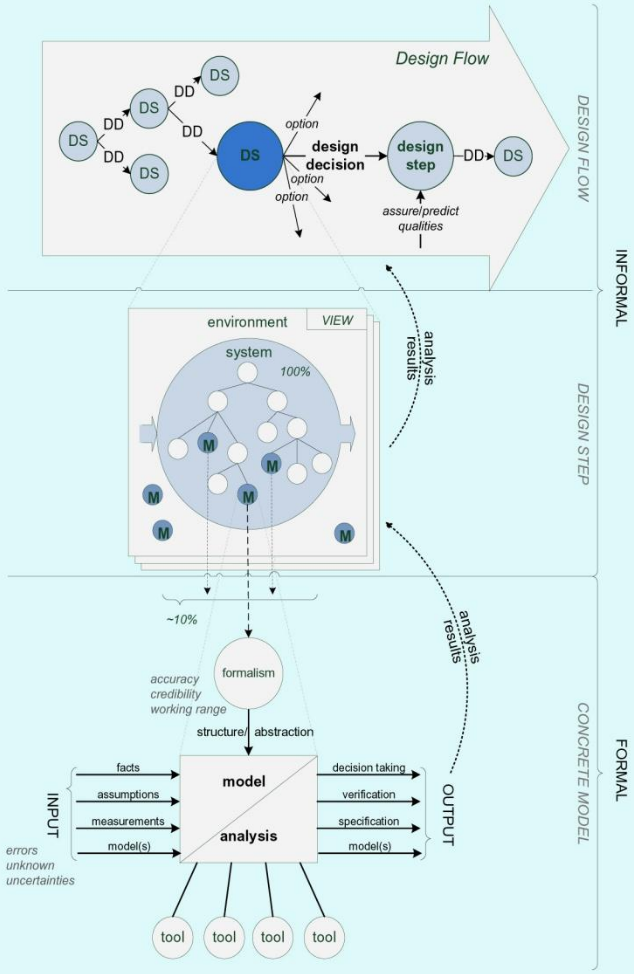
Making the implicit explicit!



Process independent:
- Keeps track of design decisions
- Provides model / result management

Completeness of modeling:
- "Boderc" project
  - ~10% of the entire system is being modeled

Design flow:
- Decisions
  - Design decision
  - Design options (alternatives)
- Refinement
  - Design step

Design step:
- Multiple views
- Hierarchy of components

View:
- Representation of an aspect at system level
- System decomposition & parameter dependencies
- Multiple models per component
- Multiple experiments per model

Parameters:
- May have range, type, unit
- Represent:
  - Assumptions
  - Measurements
  - Requirements
  - Etc.
- May have dependencies

Model:
- From "drawing on a napkin" to "model to model transformations"
- May be part of multiple components / views
- May be used for analysis

Tool/formalism independent:
- Designed to be generic
- Allows domain-tailoring, support for tool-chains, etc.

STRENGTHS: "Making the implicit explicit"
- Know the exact implication of each design decision
- Reuse models (resume from previous design steps, do not start from the scratch)
- Continuous integration at model/design level (not only during realization)
- Keep dependencies in control
  - Dealing with heterogeneous models
  - Continuous conflict detection
- Better / easier communication within design team

WEAKNESSES:
- Too generic approach (does not support concrete methods and tools)
- Requires discipline and introduces overhead
- Introduces other way of working

NOTE:

SHOULD
- Be invisible and seamless
- Support the typical activities
- Provide help

SHOULD NOT
- Restrict process choice
- Restrict tool choice
- Restrict formalism choice

Contact: Hristina Moneva (hristina.moneva@esi.nl), Roelof Hamberg (roelof.hamberg@esi.nl) or Teade Punter (teade.punter@esi.nl)

This work has been performed as part of the "Integrated Multi-formalism Tool Support for the Design of Networked Embedded Control Systems (MULTIFORM) project, supported by the Seventh Research Framework Programme of the European Commission. Grant agreement number: INFSO-ICT-224249

D 17 Running show ESI Industrial partners

For more information

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ASML

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océ

PHILIPS

THALES

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Innovation programmes and ESI

Our network partners

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rijksuniversiteit groningen
NXP founded by Philips
IfM Management Technology Policy University of Cambridge
BeteoR
PHILIPS
HighTech Systems Platform
BUSKERUD University College
CE/T Center for Embedded Software Technology
DEVLAB Development Laboratories
TNO
TASS software professionals
Technolution Automation Technology
Universiteit Twente de ondernemende universiteit
THALES
VanDerLande Industries
N.V. Brabantse Ontwikkelings Maatschappij BOM
Point-One Pole of innovative technology on nanoelectronics and embedded systems
LIOF
SRE Samenwerkingsverband Regio Eindhoven
SenterNovem
Ministerie van Economische Zaken

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research

Reliability by Design

PROJECT FACTS

Partners: NXP Semiconductors, NXP Research, IMEC, Philips Consumer Electronics, TASS Software Professionals, Delft University of Technology, Eindhoven University of Technology, University of Leiden, University of Twente, Embedded Systems Institute

Period: October 2004 - September 2009

Capacity: 20 fte/year, 7 PhDs, 2 Postdocs

INDUSTRIAL CHALLENGE

Modern high-tech systems such as digital television, mobile phones, medical imaging equipment, and advanced automobiles, are becoming increasingly dependant on the software content. Future system reliability is a prime concern.

A major challenge being faced by many technology driven companies is how to bring new high-quality products to market faster and with less resource. The cost to develop each new generation is increasing fast and is driven by the following trends:

- **Complexity** Over the last decade the software content of many products has grown exponentially. This is caused by the increase in required functionality and the migration of control from hardware to software. One of the undesirable side effects of this is unpredictable feature interaction and the large number of possible use cases.
- **Development life-cycle** Market competition dictates that the innovation rate of high-tech products must continuously improve, resulting in increased feature integration and shorter time-to-market. This places significant pressure on all phases of the product creation process.
- **Open Systems** Many high-tech systems are no longer *stand alone* appliances. They have become a components in a wider networked environment. After integration system behavior may be provoked that was not foreseen during the original product concept.

The Trader project will address this industrial challenge by developing generic methods and tools that improve system level reliability, and by using specific industrial study cases in the area of digital entertainment systems as identified by NXP Semiconductors.

RESEARCH OBJECTIVES

Taking into account the above constraints, the Trader project aims to develop techniques to optimize the customer experience by: (1) detecting potentially undesirable system behavior, (2) developing strategies to correct the situation. The results are expected to be applicable not only to consumer style products but also to embedded systems in general. The project focuses on three main research topics:

- **Behavioral awareness** Complex consumer products have little awareness that their behavior is acceptable or not. The project aims to provide a high level 'user centric' executable model of correct behavior.
- **Run time error correction** Based on an understanding of how customers perceive system failures, develop a strategy and architecture to correct a system that is showing or will show functional failures or performance degradation.
- **Non domain specific test and fault diagnosis** The complexity of testing a system increases at a faster rate than the increase in its functional complexity. To simply test all combinations of events over all possible use cases becomes an unbounded task.

EXPECTED RESULTS

Architectures, methods and tools that can be used during all stages of the product creation process to design in enhanced reliability:

- Techniques to measure and analyze user perception of failures;
- Executable models to explore system behavior during the product concept phase;
- Architectural constructs to create behavioral awareness, detect errors and the ability to perform local recovery;
- Test and fault diagnosis techniques to be used during the test and integration phase;
- Run time monitoring and control to prevent resource overloads causing customer visible failures.

INFORMATION

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research

Architecting for Evolvability

PROJECT FACTS

Partners: Philips Healthcare
Philips Research
University of Groningen
Delft University of Technology
Eindhoven University of Technology
University of Twente
Free University of Amsterdam
Embedded Systems Institute

Period: October 2005 - September 2010

Capacity: 20 fte/year, 10 PhDs, 2 Postdocs

INDUSTRIAL CHALLENGE

The field of medical imaging is changing rapidly. New and improved imaging and diagnostic techniques are being developed and imaging is increasingly being deployed during therapeutic intervention procedures. System integrators strive to incorporate new features effectively into their designs. With the high cost and long life time of imaging equipment, customers also expect that their installed systems can *evolve* i.e. can be progressively upgraded to take advantage of the constant advances being made.

System evolvability can therefore be characterized as a system's ability to efficiently cater for the addition of new functionality and capabilities as well as for changes in implementation technologies, system components and configurations. Driven by the need to provide field upgradability, short time to market, and optimized development costs, improved system evolvability is increasingly being recognized as a critical success factor in high-tech system design.

In the absence of any formal methods for evaluating and enhancing the level of evolvability for computer based systems, the Darwin project aims to provide generic methods that will enable architects to optimize this important system quality.

RESEARCH OBJECTIVES

The challenge of Darwin is to develop an approach that can be used to represent and analyse existing system architectures and to provide improvements that will enhance the ability to respond to the ever-increasing demand for change. Changes need to be incorporated into the system architecture without compromising the key factors of safety, performance, reliability, and cost.

To achieve this, the architecture of the Philips Healthcare MRI product family is used as a case study. Analytical methods are being developed and evaluated on this large complex system to demonstrate effectiveness and scalability. Results of this work will be generalized and used to form part of a reference architecture paving the way for new efficient designs.

EXPECTED RESULTS

The Darwin project focuses on the key aspects of the existing architecture of a state-of-the-art MRI system, allowing its structure to be exposed and recommending improvements that facilitate change:

- Extraction & visualization of existing system structures highlighting areas preventing ease of change;
- Requirements driven design methodology to synthesize and validate deadlock free control systems;
- Reference Architectural views with a focus on key system drivers, e.g. image quality, performance, and independent development of key functions;
- Methodology to assist architectural decision making by the use of economical modeling;
- Algorithmic methods to optimize system performance by the scheduling of events.

INFORMATION

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Embedded Systems INSTITUTE

research

From Research Instrument to Industrial Tool

PROJECT FACTS

Partners: FEI Company
Delft University of Technology
Eindhoven University of Technology
University of Antwerp
Catholic University Leuven
Technolution B.V.
Embedded Systems Institute

Period: February 2008 – January 2012

Capacity: 23 fte/year, 6 PhDs, 5PostDocs

INDUSTRIAL CHALLENGE

Recent developments in nano-technology applications strongly promote the need for ever more accurate nano-scale measurement- and characterization techniques. The electron microscope is one of the few instruments capable of imaging, measuring and characterizing very small structures in a broad range of nano-technology domains. New applications continuously emerge, such as for semiconductor and data-storage technology, the chemical industry and biotech/pharma. Not only do these new applications require the highest-possible precision imaging, they also rely on robust and repeatable device behavior at the lowest cost-of-ownership.

The operational behavior of a precision critical instruments such as a high-end electron microscope, is governed by its intricate physics characteristics, and therefore by the subtleties and interrelations of physical phenomena, such as for electron optics and electron-beam sample interaction. Furthermore, the more widespread practical technological and human limitations in engineering, such as for mechanical, electronic and software design, play a critical role.

It is an important industrial challenge to manage the complexity of this technology and application domain, through new design and engineering approaches. Special attention must be paid to the development of cross-disciplinary approaches, ranging from device physics to software engineering, by which a new generation of precision critical instruments can be developed.

RESEARCH OBJECTIVE

The main objective of the Condor project is to develop a cross-disciplinary model-based approach towards the design of precision critical instruments. The project is based on a challenging industrial application, by using a high-end STEM electron microscope from FEI Technologies (The Netherlands) as an industrial case. Special attention is paid to the fact that these precision instruments are required to combine the flexibility and basic performance of a research 'instrument' with the robustness (operational stability), ease-of-use and throughput of an industrial 'tool'.

In more detail the objectives of the Condor project are as follows:

- Devise a method to create multi-disciplinary behavior models for key system design parameters sufficiently capturing the relevant physical phenomena and external disturbances;
- Develop new robust concepts for the integral system functional behavior, including key system design parameters such as focus, position and calibration;
- Develop an architectural application framework that exposes the system as a generalized, calibrated, flexible measurement tool towards the application developer;
- Build demonstrator prototypes that serve to validate the new concepts and techniques, and prove the validity of the proposed methods by an experimental set-up.

EXPECTED RESULTS

- A system design approach applicable for complex physical systems based on multi-disciplinary modeling providing reduced realization time and effort;
- Explicitly described and validated concepts for an architectural framework of the embedded compute system;
- Proof-of-concept demonstrator prototypes based on FEI Electron Microscopes.

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research

'System-of-Systems' Performance and Reliability in Logistics

PROJECT FACTS

Partners: Vanderlande Industries
Delft University of Technology
Eindhoven University of Technology
University of Twente
Embedded Systems Institute
Demcon

Period: October 2006 – September 2010

Capacity: 21 fte/year, 9 PhDs, 2 PostDocs

INDUSTRIAL CHALLENGE

Logistics systems in distribution centers and warehouses support the transport, rearrangement and storage of a large variety of goods under strict constraints for throughput, storage and costs. Depending on application and use, the operational settings between logistic warehouses can vary significantly. However, a common denominator is that throughput and response time need be highly reliable, ensuring effective and efficient operations, often on a 24/7 basis.

A state-of-the-art logistic warehouse represents a complex 'system-of-systems', integrating a variety of technology sub-systems and components. Even for the latest generation of logistic warehouses, human activity is still an essential part of the operation. Automation systems have yet to conquer the versatility of humans with respect to complex functions, exception handling and error resolution. By deploying highly advanced system components, future warehouses will be able to reduce their reliance on human activity. However, the introduction of these latest technologies must ensure that the required levels of performance and reliability are maintained.

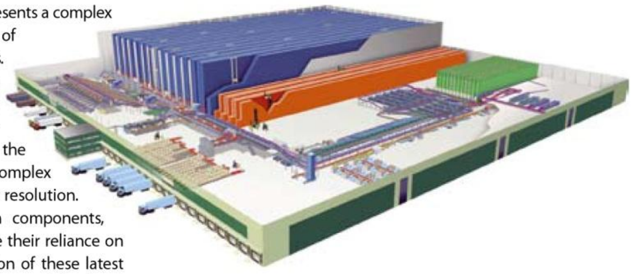
The Falcon project is a collaborative research project of the Embedded Systems Institute that rises to the challenge of developing new ways of distribution center design modeling and innovative approaches to automated item picking. An advanced distribution center of Vanderlande Industries is taken as the 'industry-as-laboratory' case. This industrial laboratory setting is used to provide hard evidence of measurable performance- and reliability levels.

RESEARCH OBJECTIVES

The challenge to develop a fully integrated and automated logistics warehouse as a complex 'system-of-systems', is to increase performance under stochastic conditions whilst maintaining reliability. Basically the research projects comprises of three lines of attention:

1. Through high-level simulation, system-level requirements can be decomposed and propagated to the component level.
2. Developing specific mechatronic components, as well as the redesign and evaluation of both the overall system- and component architectures.
3. Reliable integration of components into systems requires a system-level control approach that involves the appropriate sensors and actuators, as well as relevant information architectures to synchronize the virtual world with the real world.

In addition to these research topics, the integrity of the relationship between the conceptual design and its actual implementation is addressed as a crucial condition for achieving the correct level of dependability of the resulting system-of-systems.



EXPECTED RESULTS

The expected results comprise a number of key aspects for performance and reliability in logistics system-of-systems:

- Architectures optimized for reliable and high performance automated operation;
- Methods for system and component design, and their integration into associated control systems and software architectures;
- Mechatronic components that enable automated item picking in the context of distribution centers and warehouses;
- Demonstrator prototypes of selected subsystems.

INFORMATION

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Embedded Systems INSTITUTE

research

Dynamic Information-centric Systems-of-Systems

PROJECT FACTS

Partners: Thales Naval Netherlands
Noldus Information Technology
Delft University of Technology
Eindhoven University of Technology
Free University of Amsterdam
University of Amsterdam
University of Maastricht
Embedded Systems Institute

Period: June 2007 – May 2011

Capacity: 22 fte/year, 6 PhDs, 7 PostDocs

INDUSTRIAL CHALLENGE

The ever increasing capabilities for system interconnection and sharing of information, processes and resources, provides unparalleled opportunities to configure systems into more capable aggregate systems, called systems-of-systems, that open up more and more application areas. Future systems-of-systems will collaborate across former boundaries, be robust to configuration changes, and cope with unexpected changes in their environment.

The Poseidon project is a collaborative research project by the Embedded Systems Institute that rises to this challenge. Working with the industrial partner Thales, it aims to discover new ways to build dynamic information-centric systems-of-systems, deriving its research statement from the maritime safety and security domain.

Maritime safety and security systems support decision making and situation awareness in coastal areas. They are highly dynamic, provide a wide range of functions, use a variety of information sources for various purposes, and must be able to deal with elements of surprise.

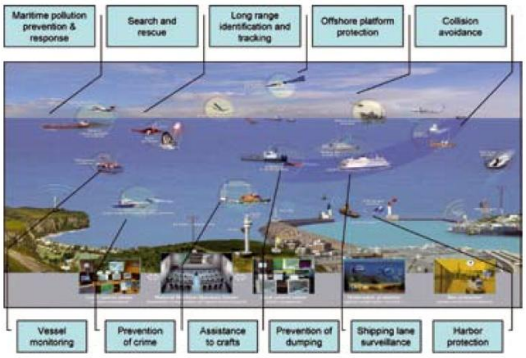
RESEARCH OBJECTIVES

The challenge of developing advanced systems-of-systems is to gain flexibility, adaptability, and evolvability whilst retaining reliability. Changes in a system-of-systems' configuration need to be achievable with minimal efforts and the system should always remain operational and reliable, even in the context of unforeseen events or scenarios.

To achieve this, multi-disciplinary combinations of analytic, modeling, and implementation techniques need to be developed, especially for integration, information analysis and visualization, and trustworthy information interoperability.

Altogether, these data-based operations require an information-centric approach to both system-of-systems design and also to operations that support the individual systems in achieving their principal goals.

This approach is a key factor for the emergence of higher level capabilities from lower-level interactions. Consequently, the needed higher-level information models and dynamic processes are also addressed as research objectives.



EXPECTED RESULTS

The Poseidon project partners will address the key aspects of design, integration, and information-processing required for dynamic systems-of-systems:

- System-of-systems information processing architectures beneficial to adaptability and evolvability;
- Run-time methodologies for the diagnosis, integration, and acceptance of dynamic systems-of-systems;
- Trustworthy fusion and processing of information originating from a variety of sources that differ in role, type, security level, syntax, and semantics;
- Intelligent information analysis and visualization for tasks within the maritime safety and security domain, especially for anomaly detection.

INFORMATION

For further information, please visit the website **www.esi.nl**

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research

Smart System Adaptability

PROJECT FACTS

Partners: Océ-Technologies B.V.
Delft University of Technology
Eindhoven University of Technology
Radboud University Nijmegen
University of Twente
Embedded Systems Institute

Period: July 2007 – June 2011

Capacity: 20 fte/year, 8 PhDs, 4 PostDocs

INDUSTRIAL CHALLENGE

Today's high-tech systems industry operates in a complex and highly dynamic business environment. In order to ensure a successful product range, a well chosen trade-off between market position, functionality and technological capabilities is required. In addition to this, time-to-market, cost engineering, and life-cycle management considerations can also be considered critical factors to a product's success.

As an example, consider professional color printing systems. Current systems are designed to operate in a confined and well-defined context, in which system interactions are well known and understood. Future systems will be expected to deal with a much more dynamic operating context, with continuously changing requirements for application, function and technology. In order to ensure the competitive positioning of such system in this dynamic market and to effectively deploy the required development investments, it has become of paramount importance to design-in the correct level of system 'evolvability' and 'adaptability'.

The Octopus project is a collaborative research project of the Embedded Systems Institute, where a professional high-volume color printing system from Océ Technologies is taken as an 'industry-as-laboratory' case to research new ways to design-in system evolvability and -adaptability. To illustrate this principle, consider the consistency of 'image quality of color prints'. Quality results are expected whilst using a wide variety of media formats and types (even new ones), under environmental conditions that can widely vary. This involves adaptability and consistency of both the digital processing of images and control of the printing-on-paper process.

The challenge of runtime adaptability in systems design is widespread in industry. This project aims to create new adaptability concepts and patterns that can be used across a broad range of industrial applications. Central to these concepts is the transparent coordination of system control over different technology domains, supported by adequate, multi-disciplinary models.

RESEARCH OBJECTIVES

The challenge of developing adaptable high-tech systems is to find a mixed set of relatively simple first-principles models and heuristic approaches that can be used to design system level control. For the industrial case of Océ Technologies this comprises the improvement of system adaptability by:

- Model-based sensory analysis and innovative actuation of the system. This should be supported by a system architecture that intrinsically facilitates adaptability;
- Model-based trade-off analyses to develop control strategies of the chain of software components that are used in the digital image processing.

EXPECTED RESULTS

The Octopus project partners will address a number of key technology aspects for adaptability of complex embedded systems:

- Concepts, methods, and tooling for design-for-adaptability;
- Model-based system interpretation techniques to analyze, develop, and optimize adaptability strategies;
- Digital signal processing control and adaptability concepts;
- Physical layer control and adaptability concepts;
- Proof-of-concept demonstrators based on Océ printers.

INFORMATION

For further information, please visit the website **www.esi.nl**

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Embedded Systems INSTITUTE

services

Educating our future High-Tech System Architects

EMBEDDED SYSTEMS INSTITUTE

Today's high-tech systems, from mobile phones and cars to complex, highly automated mechatronic systems in industry, rely heavily on embedded technology to make them more powerful, flexible, and intelligent. The need to develop highly performant and dependable embedded systems efficiently and effectively has become a major issue for the industry, creating a strong demand for innovative embedded systems design and engineering capabilities as well as know-how.

The Embedded Systems Institute (ESI) aims to meet precisely this demand. Its mission is 'to advance industrial innovation and academic excellence in embedded system engineering for high tech systems'. Within this general mission, it is a key objective of ESI to raise embedded system design from a craft to a scientifically based engineering discipline.

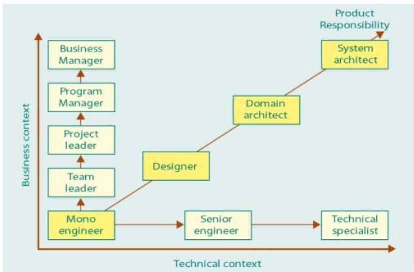
OPEN-INNOVATION RESEARCH NETWORK

As an innovation leader in its domain, ESI operates world-class research programmes in embedded system engineering, based on an open-innovation research network with participation of leading industries and universities, both national and international. Through its 'Industry-as-Laboratory' approach, ESI combines academic excellence with industrial applicability, creating value for all participants in its network.

CAREER DEVELOPMENT OF SENIOR ARCHITECTS

A main problem within the high-tech industry today is the shortage of highly qualified and experienced system designers. ESI works towards its solution by offering a Competence Development Programme to accelerate the development of professional engineers into top-class system architects. ESI has created a thorough and balanced educational and coaching programme following the 'Industry-as-Classroom' format. Part of the programme is carried out in cooperation with the Stevens Institute of Technology in New Jersey (USA).

INDUSTRY AS CLASSROOM



A top-class system architect requires a well-balanced understanding of multi-disciplinary design and engineering, combined with an in-depth knowledge of product, market and business drivers.

ESI COMPETENCE DEVELOPMENT PROGRAMME

The ESI Competence Development Programme focuses on three key concerns in professional development: (1) multi-disciplinary technological knowledge and understanding, (2) broadening of capabilities for integral system design and engineering, i.e. beyond the responsibility for individual system aspects, (3) professional capabilities to align technology- and design choices with product, market, and business drivers. The programme contains a number of special educational components, such as on-the-job coaching by senior system architects, temporary job rotation between participating industrial partners, a programme of courses and on-the-job assignments.

The programme has been developed in cooperation with the High-tech Systems Platform, a professional network of high-tech industries in the Netherlands.

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people

PhD Positions at ESI

Interview with Gürcan Güleşir, PhD at the Ideals project

Gürcan Güleşir studied Computer Engineering at Bilkent University in Turkey. He received his Bachelor's degree in 2001 and his Master's degree in 2003.

Following his graduation he came to the Netherlands to work as a PhD candidate at the Software Engineering Group at the University of Twente. His research was part of the Ideals project, a project of the Embedded Systems Institute (ESI) in which ASML was the industrial partner. Güleşir received his PhD degree in March 2008.
Upon completing his PhD, he co-founded BloomWise to commercialize his research results. In addition, he works as a postdoctoral fellow at the Electrical Engineering, Mathematics and Computer Science department of the University of Twente. His research is part of the ESI project Darwin, in which Philips Medical Systems is the industrial partner.

Why did you choose to do a PhD at ESI?

'I studied Computer Engineering at Bilkent University in Ankara and I was looking for an opportunity to go abroad. I wanted to gain international research experience. There was a visiting professor from the University of Twente at Bilkent. He told us about a PhD project at the University of Twente in cooperation with ESI. I was interested in this particular project because I wanted to do applied research in Software Engineering. I wasn't interested in purely theoretical research, but wanted to do research that is validated in industry. That's why the ESI project appealed to me.'

What are the benefits of doing a PhD project at ESI?

'If you have the ambition to see your research applied in real life, in industry, then ESI is a good place to work. ESI has very good contacts with many companies, so you don't just get academic feedback about your research and ideas, but practical feedback as well. I did not want to spend four years sitting behind a desk writing a thesis, so for me the ESI project was ideal.'

What did your research entail?

'As part of the Ideals project I identified where there was room for improvement in the software development and maintenance processes at ASML. I developed software tools and techniques to make the development and maintenance of software more efficient and effective. One area where there was room for improvement was the lack of consistency in the design documentation and the implementation. I developed a design language and a software tool to keep design and implementation consistent, with less effort and errors. I spent two days a week at ASML in Veldhoven. I worked with a team of software engineers, monitoring their progress. I was basically trying to make their work easier. This involved a lot of collaboration and getting feedback. So communicating was an important part of my job. I received my PhD in March 2008 and my committee members were very positive about my research. They acknowledged that I struck a good balance between theory, practice, and empirical validation. They said that a dissertation that combines all of these components is rare.'

What are you doing now that you've received your PhD?

'I co-founded a new company, BloomWise, together with my supervisor Lodewijk Bergmans. We want to commercialize the results of my research. What we have now is a prototype. We are collecting feedback from potential customers before we start developing commercial-grade products.
I am also working as a part-time postdoctoral fellow at the University of Twente, on another ESI project, Darwin. The aim is to develop architectures, methods and tools for optimizing the ability of a system to evolve in response to changing requirements. We are working closely together with Philips Medical Systems.'

Do you have any advise for engineers who would like to do a PhD at ESI?

'If they like to collaborate with practitioners in real-life situations, then they should definitely apply for a PhD at ESI. They should also enjoy a dynamic lifestyle. Working on an ESI project can be very demanding and involves a lot of travel. I wrote half of my thesis on the train. I like to joke that the train is my second office. I not only travelled from Enschede to Veldhoven two days a week, but also to many international conferences.'

Interview by Elke van Cassel, Communicatiebureau Corine Legdeur, May 2008

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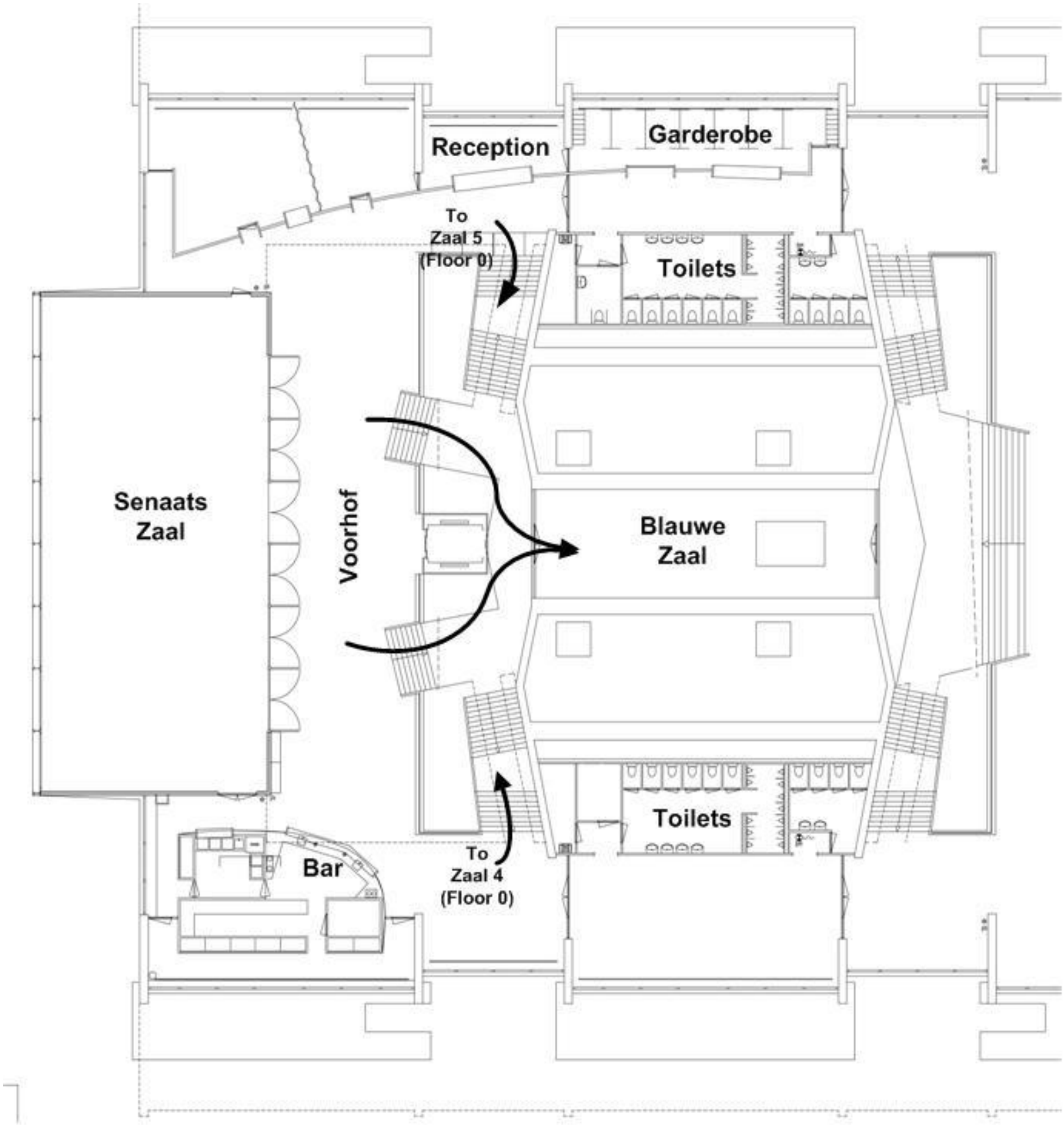
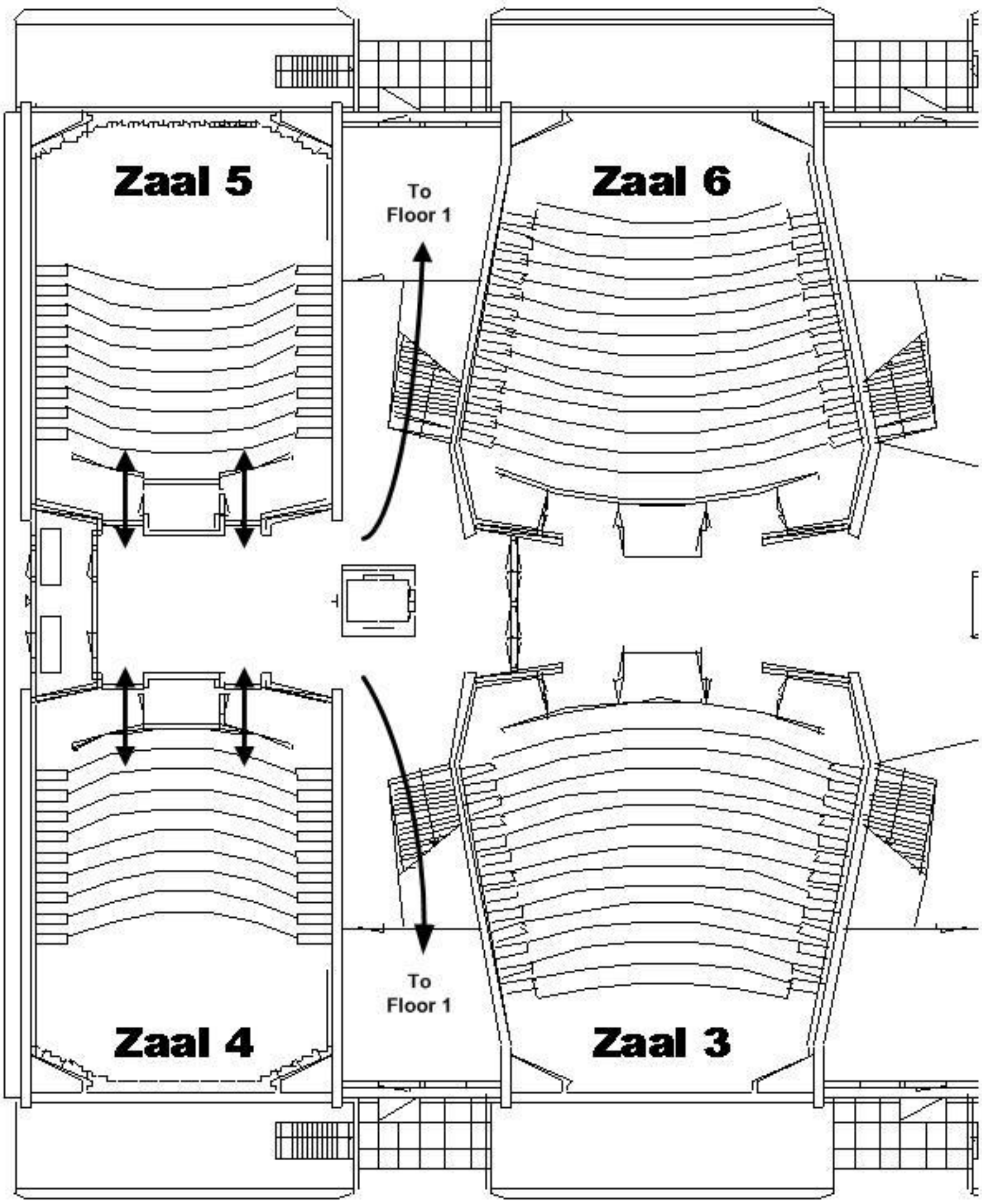
Auditorium plan

Main floor

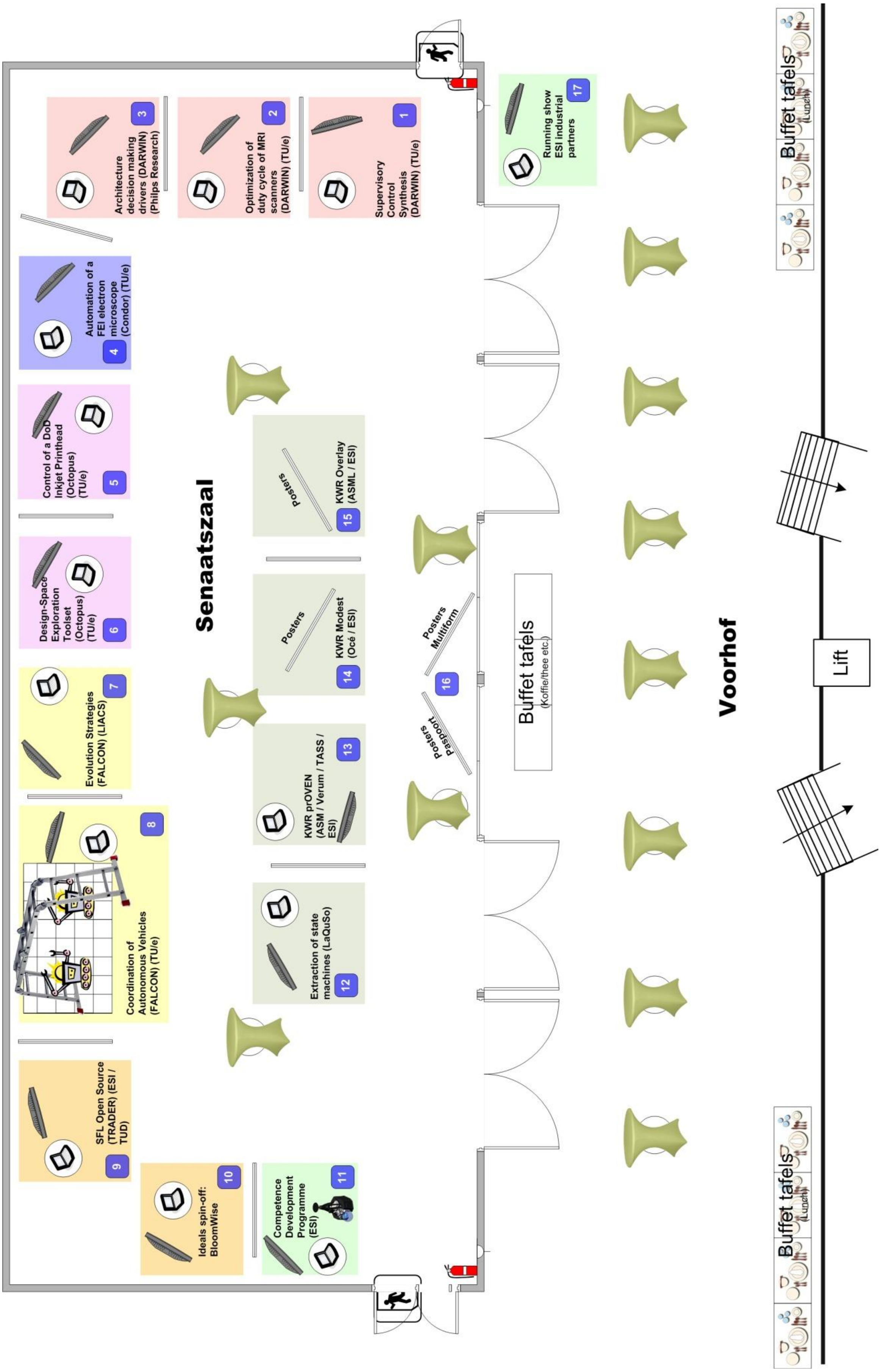


TU/e Auditorium
Floor 1

Presentation rooms



TU/e Auditorium
Floor 0


Senaatszaal
Voorhof
1
Supervisory Control Synthesis (DARWIN) (TU/e)
2
Optimization of duty cycle of MRI scanners (DARWIN) (TU/e)
3
Architecture decision making drivers (DARWIN) (Philips Research)
4
Automation of a FEI electron microscope (Condor) (TU/e)
5
Control of a DoD Inkjet Printhead (Octopus) (TU/e)
6
Design-Space Exploration Toolset (Octopus) (TU/e)
7
Evolution Strategies (FALCON) (LIACS)
8
Coordination of Autonomous Vehicles (FALCON) (TU/e)
9
SFL Open Source (TRADER) (ESI / TUD)
10
Ideals spin-off: BloomWise
11
Competence Development Programme (ESI)
12
Extraction of state machines (LaQuSo)
13
KWR prOVEN (ASM / Verum / TASS / ESI)
14
KWR Modest (Océ / ESI)
Posters
15
KWR Overlay (ASML / ESI)
Posters
16
Posters Multiform
Posters Paspoort
17
Running show ESI industrial partners
Buffet tafels
(Koffie/thee etc.)
Buffet tafels
(Lunch)
Buffet tafels
(Lunch)
Lift

Notes

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