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SOFTWARE TECHNOLOGY

PDEng projects 2017

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SOFTWARE TECHNOLOGY - PDENG PROJECTS 2017

Prof.Dr. M.G.J. van den Brand

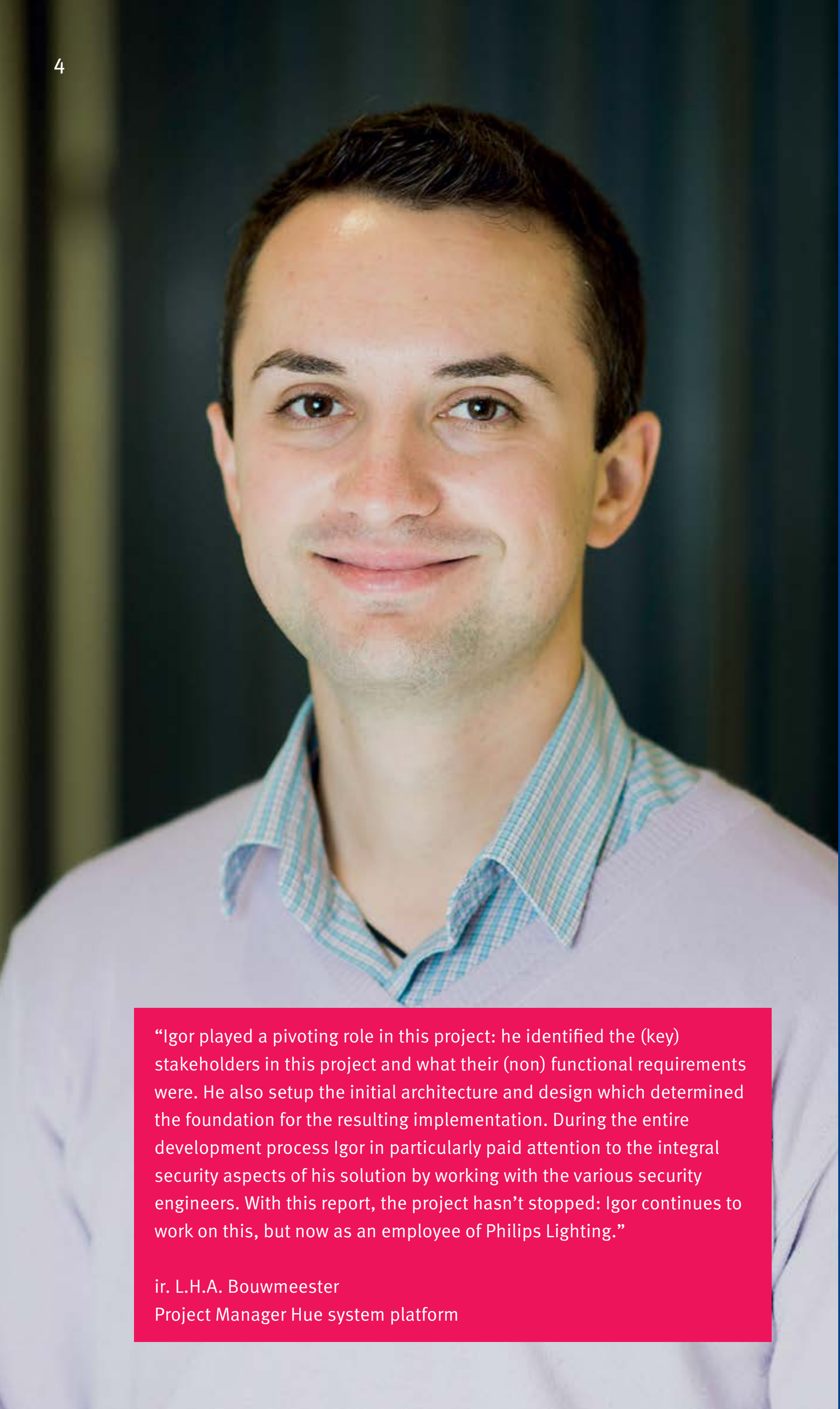
Model-driven software engineering in practice

Software has been one of the driving factors for innovations in our society in the last 25 years. Software creates new ways of transportation, new ways of communication, new ways of production, etc. These innovations, by means of model-driven software engineering and data science, have led to new challenges, such as security, and new opportunities, such as data analytics. The society is more and more depending on software and data that is being produced and analyzed. Next to the still increasing amount of software, the amount of data will increase even faster in the near future. New model-driven development methodologies are explored and rapidly adapted and spreading to other disciplines. This also holds for the area of data analytics and machine learning.

In this booklet you will find examples of how model-driven software development techniques are used in the high-tech industry to speed up the development process, to ensure trustworthy software, and to connect legacy software with verified software on one hand. On the other hand you will also learn how traditional engineering disciplines are exploring model-driven techniques to design their products, for instance chemical plants. Other projects are related to data analytics to improve the way that students learn and challenges of ensuring security of medical data. Finally, sound and robust architectures are still challenging, so a number of our graduates have worked on innovations in the area of software architecture, for instance have developed new ways of ensuring the safety for automated driving, or worked on new ways to model architecture.

Our trainees have once again shown that they are able to tackle tough problems and are able come up with innovative solutions that are eagerly adapted by our industrial partners. I wish you a lot of fun when reading this booklet and use it as a source of inspiration. I would like to congratulate our trainees with their results and wish them a bright and challenging career.

Mark van den Brand
Scientific Director PDEng Software Technology programme
Eindhoven University of Technology



“Igor played a pivoting role in this project: he identified the (key) stakeholders in this project and what their (non) functional requirements were. He also setup the initial architecture and design which determined the foundation for the resulting implementation. During the entire development process Igor in particularly paid attention to the integral security aspects of his solution by working with the various security engineers. With this report, the project hasn’t stopped: Igor continues to work on this, but now as an employee of Philips Lighting.”

ir. L.H.A. Bouwmeester
Project Manager Hue system platform

Challenges

The Hue software stack consists of several device specific software applications. Each of these applications need to be securely signed, before they are deployed on the end-devices. However, diverse ways of signing existed, depending of the device type the software is developed for. Finding a unified way for software signing and integrating it in the system under development was one of the main challenges of this project.

Results

A complete release management tool dedicated to the engineers at the Home Systems department was delivered. It visualizes workflows in a simple user interface and automates the core activities in the SDLC. The system provides a traceability about each step executed in the process. Finally, the system is highly configurable, which makes it easy to be extended and adjusted to support different device types with different release workflows.

Benefits

Engineers can sign software with a few clicks on the user interface. What is important is that this signing is executed in a secure environment. This not only saves a lot of time, but also reduces the risk of a human error. The same benefits are gained through an automation of other activities, such as distributing the signed software to the Hue factories, and deploying the software on the cloud.

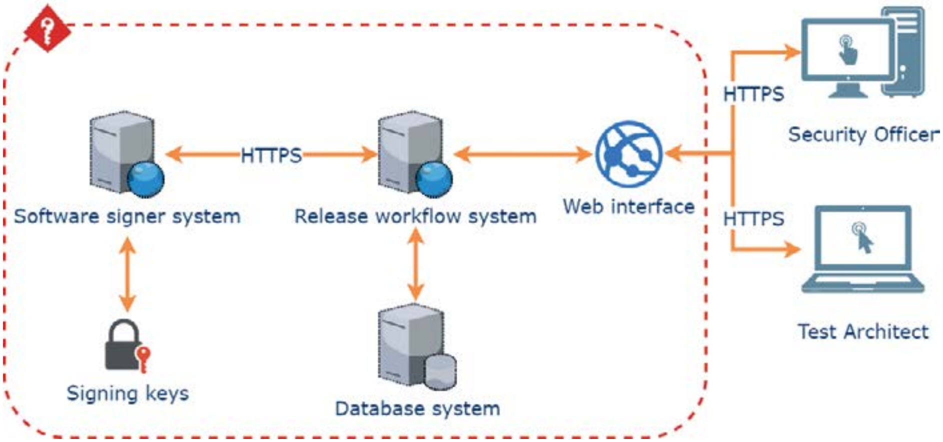
Igor Anastasov PDEng

Signing and security of Hue software

Philips Lighting provides lighting solutions and applications for professional and consumer markets. In 2012, they launched the Philips Hue System. The Hue is a completely connected home lighting system of linked bulbs that can be controlled by a smartphone or tablet. The Hue system consists of various products, such as the Hue cloud, the mobile apps, the bridges, various lamps and luminaires, sensors, and switches. Several of these devices contain software.

Developing software applications for these devices poses plenty of challenges that arise at each stage of the Software Development Life-Cycle (SDLC). Improvement of this SDLC is of immense importance to Philips Lighting. Engineers there aim for continuous integration, deployment, and delivery processes in each aspect of the SDLC. They tend to make the SDLC as automated as possible, without compromising security aspects of the systems.

The project was part of this global movement and its successful delivery made a step further in reaching these objectives. First goal of the project was to automate the software release workflow, with main emphasis on the code signing process. Second goal was to improve the security in these processes, such as storing and operating the highly sensitive software signing keys. The end-result solved many challenges. Core activities in the SDLC are fully automated and the security is improved by implementing advanced security mechanisms for critical aspects.



Challenges

The two main challenges in this project were to choose the right input for modeling and to draw the important conclusion from the models created in the project.

Results

The comparison methodology implemented in two subsystems Point and Train Detection System led to creating additional SysML models based on EULYNX documents. This helps ProRail understand in detail the documents created by EULYNX and give feedback more effectively to EULYNX. The implementation of traceability has indicated that the requirements specification of EULYNX cannot be traced back to INESS. The implementation of simulation methodologies has shown the advantages of models over the textual way of specification to ProRail.

Benefits

Via this project, ProRail has grounded reasons to support its conclusion that although EULYNX potentially shows its benefit in modeling to ProRail, it is still too soon to decide whether or not EULYNX is mature. Before that, ProRail needs to make sure that its interface requirements are aligned with EULYNX specifications. The active involvement of ProRail in the verification and validation process of EULYNX is one of the factors. The traceability to its requirements is also crucial. Moreover, a better working process between EULYNX and the Infra Managers is needed.

"With her report in our hands we can conclude that Linh's approach has added value to determine the future of modeling in the signaling domain within ProRail. Combining these two signaling and modeling domains knowledge will lead ProRail to a future with a robust and unambiguous way of specifying signaling interfaces. For ProRail it became clear after Linh's project that more effort is still needed to make this new form of specification understood by more signaling experts."

M.H. van der Werff
ProRail B.V

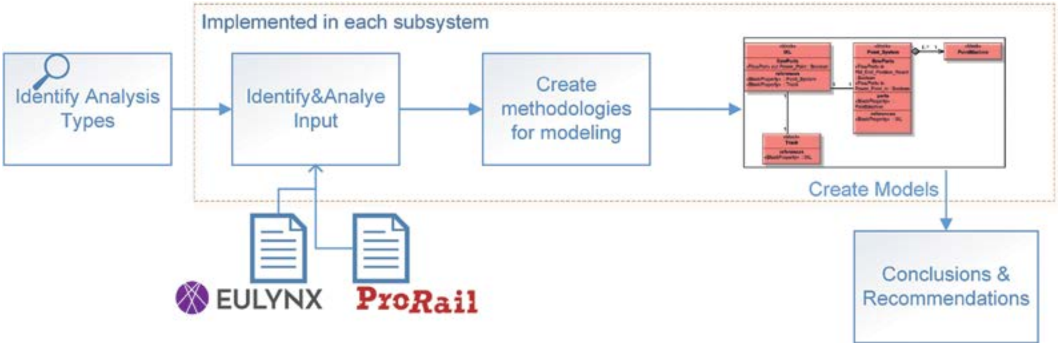
Linh Ngoc Bui PDEng

An analysis of the benefits of EULYNX-style requirements modeling for ProRail

ProRail B.V. a company that is responsible for the Dutch railway infrastructure. In contrary to legacy systems, for the future with modern technology, ProRail has to consider to apply state-of-the-art specification methods, such as modeling. ProRail is currently participating in the EULYNX project to standardize technical interfaces of the signaling system. In EULYNX, the model is the main container of the functional requirements.

ProRail desires to investigate the benefit of EULYNX requirements to its organization. Therefore, this project's main focus is to analyze SysML modeling from EULYNX and ProRail's contexts in order to answer questions and to give recommendations to ProRail from the modeling perspective.

This project conducted a research on the current EULYNX models and ProRail specifications. It also included reviewing the modeling domain. All these investigations led to the conclusion that modeling can be useful for ProRail for three types of analysis: comparison, traceability, and simulation. Three modeling methodologies are developed to serve these analysis types: the methodology for comparison the ProRail and EULYNX subsystems, the methodology for implementing traceability, and the methodology for implementing simulation.


Implemented in each subsystem
Identify Analysis Types
Identify&Analye Input
Create methodologies for modeling
Create Models
Conclusions & Recommendations
EULYNX
ProRail

“Vera managed to design and implement a national data warehouse infrastructure for the medical field addressing the privacy and security challenges head-on. She created a solid base for further integration into the regional solution. We thank Vera for her outstanding contribution to make this first step from the regional to the national level.”

Freek van Keulen
Medworq

Challenges

The main challenge of the system design was a trade-off between keeping data utility while preserving privacy of individuals. Other challenges are connected with data aggregation process: duplicated data and different identifiers related to one particular patient in the collected data from different regions. Handling these two challenges allows avoiding wrong outcomes from medical research.

Results

The end result of the project is a Java Enterprise application that provides an opportunity to conduct medical research at a national level. The system was verified based on data exported from two regional Population Databases. To show the added value of the system, data for medical research on Chronic kidney disease was exported from the system.

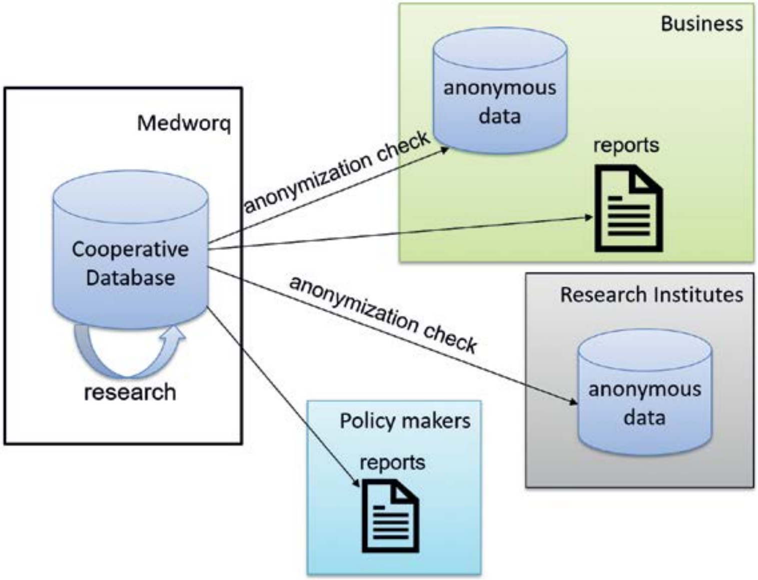
Benefits

Findings from a medical research at a national level, such as risk factors, results of treatment, and healthcare approaches, allow improving patient care and preventive healthcare. This is beneficial for both individual patients and the society. Medical research at a national level allows pharmaceutical companies to measure effectiveness of medication and medical treatment.

Vera Chembay PDEng

Analytics infrastructure for aggregated data

Medical data is often distributed across different medical organizations, stored in different systems in a variety of formats. Medworq has developed a solution, called "Population Database," which aggregates medical data at a regional level from all data sources, such as healthcare centers, pharmacies, and hospitals, and allows conducting medical research. However, medical data related to a patient can be located in different regions. In this case, conducting research at a regional level provides a limited overview. In order to create more complete input for medical research, data should be aggregated at a national level.



The goal of the project was to create a system that is able to aggregate medical data at a national level from existing "Population Databases." The solution is called "Cooperative Database." Currently, there is no solution for the aggregated data at a national level in the Netherlands. Therefore, the system is innovational and will bring added value to the different stakeholders such as pharmaceutical companies, research institutes, and the Dutch society.

The main non-functional requirement of the project is security. This requirement is addressed in two directions: security of communication during the data collection process from the "Population Database" to our system and preserving data privacy of individuals. Data privacy regulations require the data aggregated at a national level to be anonymous, i.e. it should not be possible to re-identify an individual from the released dataset. The design and implementation of the solution handle both of these concerns.

Challenges

The main challenge was to create a generic framework for generating code artifacts based on domain specific languages. The framework was demanded to be extensible and easy to use. The COM-to-C++ interface wrapper code generation based on IDL file was considered as initial use-case of the framework in the scope of the project. Moreover, the deployment of the framework on the company built environment was necessary.

Results

The project was aimed at fulfilling two design opportunities such as extensibility and ease-of-use. Therefore, the framework was designed to be extensible. We have used the factory method, builder, and template method design patterns to allow future extension for supporting different grammar, model transformer, and code generator. Also, the end-user has evaluated the framework and they have indicated that the tool is easy to learn by just following the instructions. A fifteen-minute presentation was enough to understand the goal, general technical approach, and generated artifacts of the framework.

Benefits

The framework has proved that model-based code generation is faster and more reliable than manual implementation for structural code creation activity such as the wrapper code. Therefore, the client company can benefit from the framework to reduce time-consuming and error-prone tasks. Furthermore, the framework is deployed on the company built environment and integrated to the build process. Therefore, now the framework is available to use for other consumer projects inside the client company that can help to standardize the previously manually developed code artifacts.

“Sodkhuu has managed to deliver a framework that is now part of our software code base and build infrastructure and is being used to generate files that were written manually before. Whereas other efforts mostly remained at a prototype level, Sodkhuu’s framework is now operational in our build infrastructure. Currently the framework is only applied to one pilot project and only a few files are generated. However, the framework provides the flexibility to quickly extend the capabilities onto other projects. Now that the framework has proven itself to work, I have no doubt that several teams will eagerly start using it within their own projects. Eventually the amount of (manually written) code will be significantly reduced, which will lead to more stable releases, less maintenance effort and faster feature development.”

Dr.ir. E.P.H. de Groot
Project Mentor

Sodkhuu Dalaikhuu PDEng

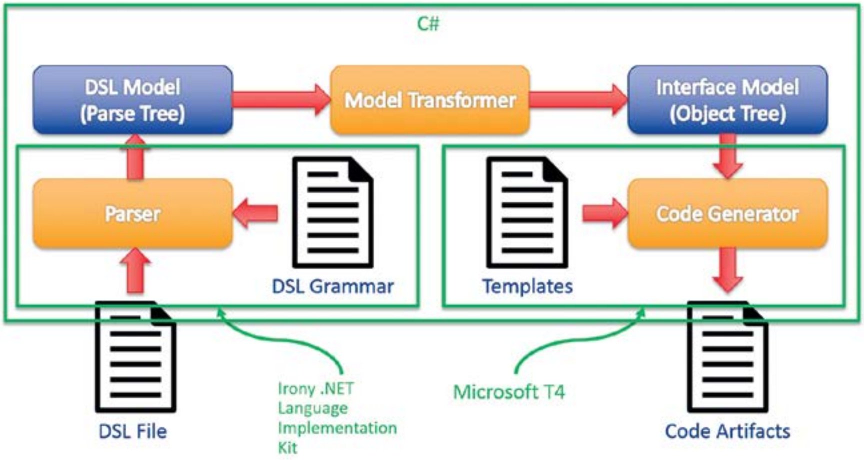
Model-Based Interface Code Generation

An extensible framework for automatic generation of wrapper code

The software of the Transmission Electron Microscope has numerous interfaces, reflecting to the complexity of the system. As microscopes evolve, interfaces are extended and sometimes changed. Apart from the code needed to provide the actual functionality of a software component, there is a significant amount of code needed for interface wrappers. The task to create such wrapper code is repetitive, laborious, and error-prone including numerous copy-paste actions from previous implementation samples and manual modifications.

In this project, we aimed to create a department global code generation framework. We have designed the framework based on the Model-Driven Architecture, which is proposed by the Object Management Group. The framework consists of parser, model transformer, and code generator. The parser extracts the input file information into abstract syntax tree. The model transformer converts the abstract syntax tree to object-oriented interface model using a transformation rule. The code generator creates code artifacts using the interface models and pre-defined templates.

The framework is more suitable to use in the C# .NET environment than other existing technologies like Eclipse xtext/xtend. It is extensible for parsing any Extended Backus-Naur Form based domain specific languages and generating object-oriented code artifacts.



> “Teachers will not be replaced by tools, but teachers will be replaced by teachers using these tools.”
>
> Ir. M.D. Klabbers
> Eindhoven University of Technology

Challenges

Making a system able to integrate data from multiple platforms is quite challenging. Platforms can differ between themselves in almost all aspects: they can have different structure of the data, different type of data, and different amount of data. All of this makes it difficult in making a system that would be general enough to accept data from multiple platforms.

Results

The nature of this system is an evolving one, based on the requirements that can change and increase with information gained from the system itself. Because of this the focus was on setting an architecture that would be able to make it possible for the system to evolve with the requirements. Main results consist of system that is extendable, easy to maintain, and integration data from multiple platforms.

Benefits

The benefits of this system for teachers are in increased control over the dynamics of their courses. The data analysis also allows them to have insight into learners, their course usage habits, and trends. The data integration allows for more accurate research and better insight into the course usage. The cross platform data integration allows for picking the best platform to use for each teacher and course.

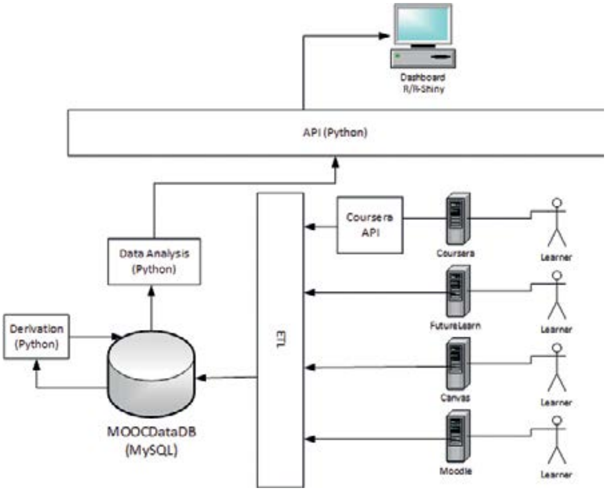
Jonce Dimov PDEng

Infrastructure of Learning Analytics Dashboard

Having dashboards for presenting the data of how learners are using an online course can be very useful for the teacher. Teachers can use this data to improve their courses and attract more learners.

Current dashboards are usually set up to work with only one source of data. This can be a drawback if teachers have courses on multiple platforms. This project describes a new architecture and implementation, set for a more general dashboard that can be easily extended. The new system is platform independent which means new platforms (sources of data) can be added easily.

A new part is introduced for data analysis which creates new derived data from the one provided by these platforms. There is also clear separation of functionality, which makes it easy to change or replace parts of the system and extend the current functionalities. This system can be useful to researchers as it contains data integrated from multiple sources. This integrated data can be useful for data analysis.



Challenges

The first challenge within this project was to get acquainted with the DCA pattern, including the Data Adapter and its functionality, as well as with ASOME and its underlying technologies. This was complicated by the fact that ASOME was still subject to some change. Moreover, it was challenging to balance the analysis and realization aspects of this project in order to deliver a modeling environment and code generator that allowed for experimentation.

Results

At the end of this project, designs for both the Data Adapter modeling environment and code generator were specified. A proof of concept for the modeling environment was implemented and integrated into the existing ASOME prototype and is ready to be industrialized. The development of a proof of concept for the code generator was initiated, but not sufficiently completed to be industrialized.

Benefits

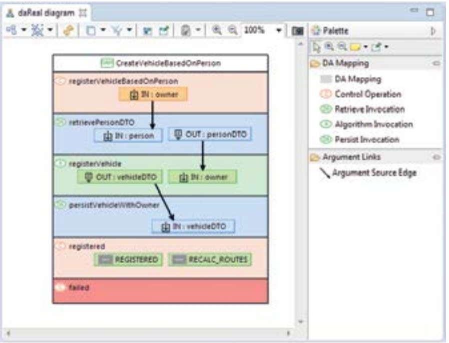
With the delivered solution, ASML is one step closer to the completion of ASOME, allowing ASML engineers to define software systems at a higher level of abstraction, automating the creation of source code and thereby improving the quality and consistency of their code base.

> “Chris works and delivers as an ASML employee. He has contributed a significant part of ASOME.”
>
> Dr.ir. Wilbert Alberts
> ASML

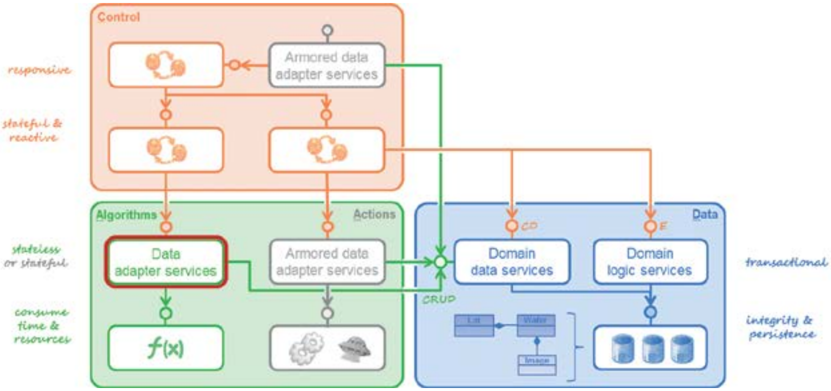
Chris Hoedemakers PDEng

Development of the DCA Data Adapter Modeling Environment

ASML is moving their software development practices towards a more model driven approach. Therefore, it is developing an environment called the ASML Software Modeling Environment (ASOME), which allows functional engineers to model software systems. That is, it allows engineers to focus on the essence of the design challenges without being distracted by the details of the execution platform. The source code is then automatically generated from these models. The underlying framework for modeling systems is the DCA architectural pattern, which organizes systems by separating their Data, Control, and Algorithmic aspects.



In this project, I explored how the DCA Data Adapter (DA) component (see figure) may be modeled in ASOME and what its generated source code may look like. A Data Adapter's responsibility is to process requests from the Control aspect for the invocation of algorithms, which typically involves the retrieval and storage of data at the Data aspect. As a result of this exploration, I delivered designs for both the Data Adapter modeling environment and code generator. These designs were implemented and integrated into the existing ASOME prototype as a proof of concept. Due to time limitations, the implementation of the code generator did not go beyond the initial stage. The DA modeling environment (see figure), however, was verified rather elaborately using tools such as JUnit and the Eclipse-based GUI testing tool RCPTT. In conclusion, the proof of concept for the DA modeling environment is complete enough to be used as input for industrialization, whereas the code generator needs additional work.



“The investigation that Panagiotis has done, the solutions that he proposed and agreed with the stakeholders, and the tool (named ALDAGen) that he created enable correct and rapid deployment of formal models in legacy code. ALDAGen is currently being used as a prototype tool, its value has been immediately identified as it correctly generates in seconds all the artifacts needed to deploy the models.”

M. Alonso MSc
ASML

Challenges

The biggest challenge of this project was to conduct an extensive domain analysis in order to first identify the specifics of the ALDA components and second to translate them into commonly agreed requirements. In addition, a considerable challenging task was to design those solutions that would allow a standard creation as well as automatic generation of those components.

Results

The main results produced in this project are:
1) translation of the analysis conducted regarding the ALDA components to functional requirements, 2) standard design solutions for dealing with common challenges related to the creation of those components, 3) identification of specifications that prevent a standard creation and therefore generation of those components, and 4) a prototype tool that generates the model-artifacts required for the ALDA components by incorporating the aforementioned design solutions.

Benefits

A major step towards a standardized and consistent creation of the ALDA components was made.
The gathered and commonly agreed functional requirements as well as the designed solutions, which allow a standardized creation of these components, fulfilled that purpose. Additionally, a significant speedup of the development time regarding the ALDA components can be achieved by using the realized tool since it is able to generate these components within a matter of seconds.

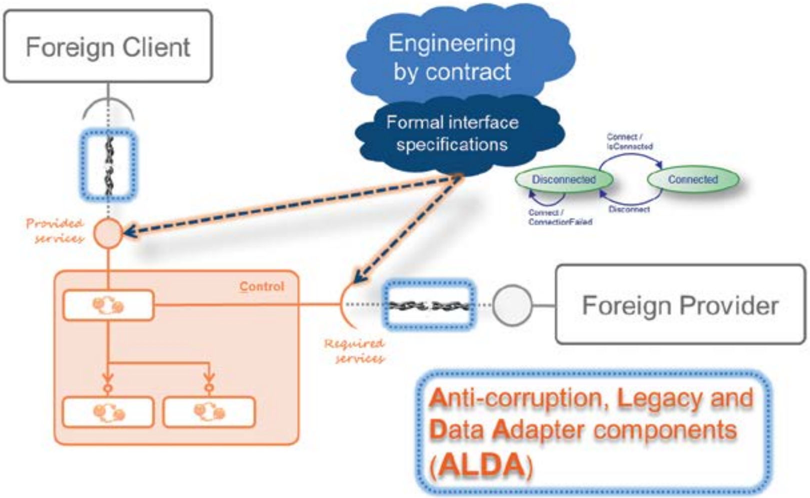
Panagiotis Kotsis PDEng

Generating Anti-corruption, Data and Legacy Adapter components

ASML engineers are moving towards “formal” development of software. Systems that are implemented by means of formal (executable) models interact with each other in a verified (mathematically proven) way. However, these formal models must interact with the existing software codebase. To guarantee that the interaction between formal models and legacy (foreign) code is correct, special mechanisms represented by Anti-corruption, Data and Legacy Adapter components (ALDA), are required. The process of creating these components is time consuming and in addition inconsistent due to the different existing implementations. Hence their standardization and automation is of a high importance to ASML.

The purposes of this project were firstly to identify the functional requirements of the ALDA components; secondly to propose design solutions that would allow a standardized creation of those components; and finally to realize their automatic generation. In addition, due to the ambition of ASML to incorporate the Model-Driven Engineering (MDE) approach into the software development process, the automation (i.e. generation) of those components needed to be realized with the use of MDE methods.

During this project, the specifics of the ALDA components were thoroughly analyzed and translated into functional requirements. Common challenges related to the creation of those components were identified. Reusable solutions that deal with these challenges were designed, documented and communicated. Anti-patterns that prevent a standardized creation of ALDA components were identified as well. Last but not least, a (prototype) tool that automatically generates the ALDA components was realized by means of Model-to-Model transformations.



Challenges

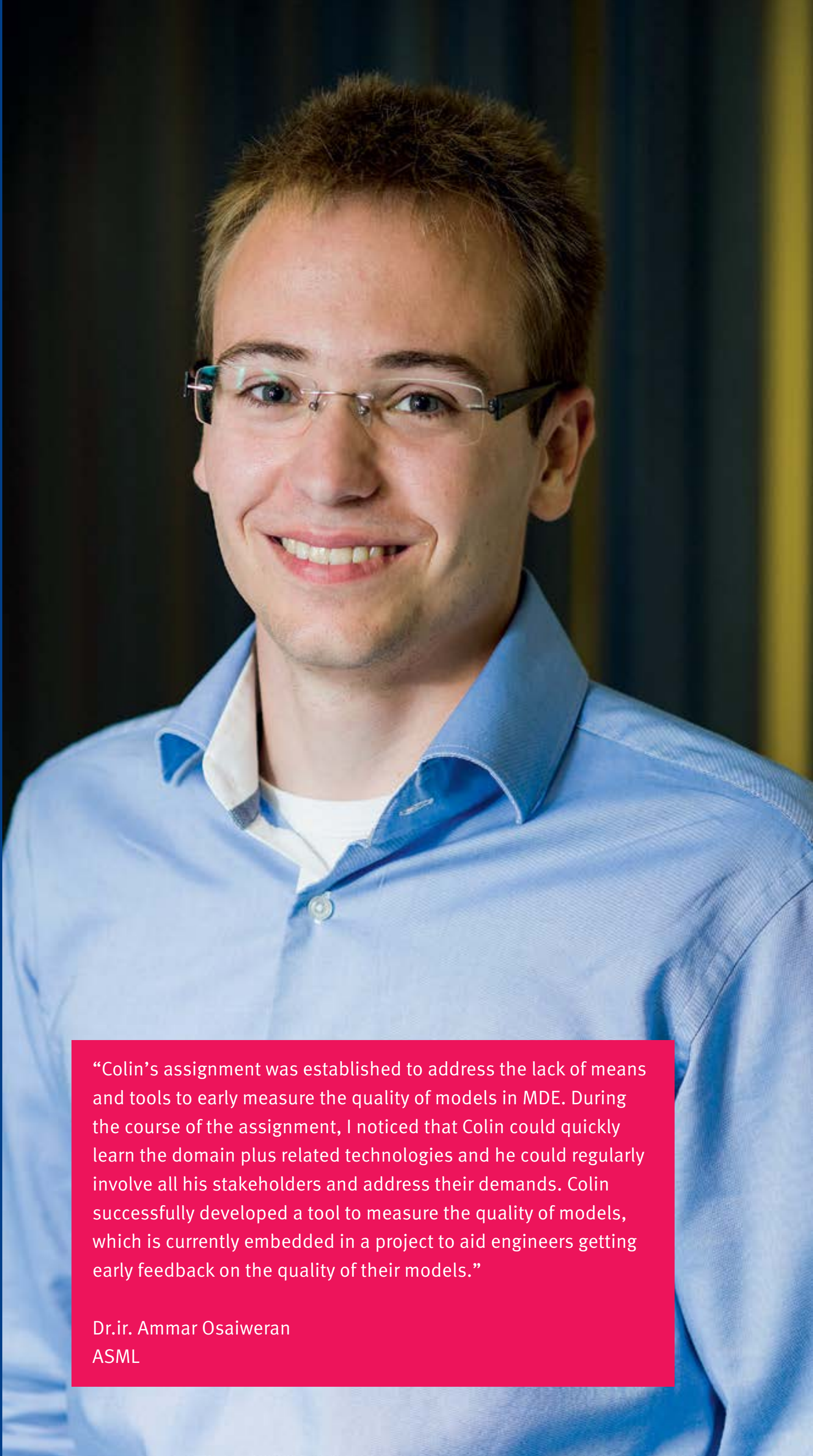
The development of quality metrics for models is a not a widely explored area within MDE. At this moment, there are no mature metrics or frameworks available to assess the quality of control models within ASML. Therefore, the biggest challenge of this project was to design and implement an extensible tool that is generic enough to measure various types of control models and still practical and usable within mature industrial settings. Furthermore, the developed tool uses a number of different technologies, metrics, and quality evaluators which needed to be integrated into a single stand-alone application.

Results

This project achieved three main results. Firstly, a framework and methodology for the definition and implementation of metrics for control models were designed. Secondly, a set of complexity metrics was empirically validated. Thirdly, a tool was developed that is able to compute the metrics, evaluate, and visualize their outcomes. The tool is extensible with new metrics and can be used in different development environments. The tool is deployed in a real industrial project assessing the quality of models of a real product of ASML.

Benefits

With the designed methodology and developed tooling, ASML can early define, validate, and compute metrics to assess the quality of their control models. Following the established methodology in this assignment, the steps performed for the definition and empirical validation of the constructed metrics can be reused to guide the development of forthcoming metrics. This project provided an important step towards the quality assessment of the production models by the engineers, architects, team leaders, and quality assurance, among others.

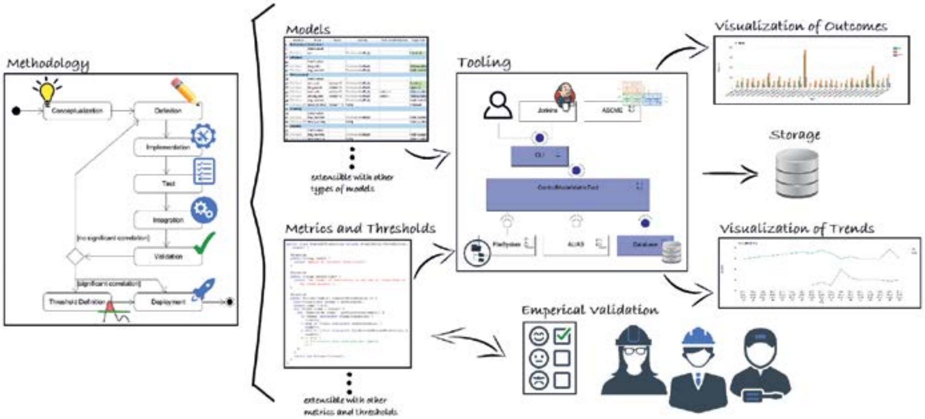


"Colin's assignment was established to address the lack of means and tools to early measure the quality of models in MDE. During the course of the assignment, I noticed that Colin could quickly learn the domain plus related technologies and he could regularly involve all his stakeholders and address their demands. Colin successfully developed a tool to measure the quality of models, which is currently embedded in a project to aid engineers getting early feedback on the quality of their models."

Dr.ir. Ammar Osaiweran
ASML

Colin Lambrechts PDEng

Metrics for Control Models in a Model-Driven Engineering Environment



Delivering high-quality software is important for any high-tech company, like ASML. Assessing the quality of software through metrics on code-level is a well-known and well-studied area. Applying these principles to a Model-Driven Engineering context is not trivial. The ideas behind common complexity metrics, such as Cyclomatic Complexity, are still applicable to models; however, their computations are not, since the computations are expressed using code constructs and not model constructs.

During this project, a framework and methodology for the definition and implementation of metrics for control models was designed. Control models are responsible for the reactive control aspects of the software and are specified using state machines. A set of complexity metrics, based on the Cyclomatic Complexity and Halstead metrics, was defined and implemented according the designed framework and methodology. Additionally, these metrics were empirically validated by means of a survey including more than twenty engineers within ASML.

Based on the designed framework, a tool was developed to compute the metrics, evaluate and visualize the outcomes, as well as visualize the trends. The tool is designed to be extensible with new metrics and state machine specifications. In addition, the tool is designed to be usable within different development environments. At this moment the tool is deployed within the development environment of ASML and is used by a project to measure the quality of the developed control models.

“The advantage of applying temporal logic for the observers has been shown. The application of a Bayesian network for the diagnosis shows promising new possibilities. The created prototypes are a good basis for the development of next generation health monitors for the upcoming automated driving systems.”

Dr.ir. Tjerk Bijlsma
Ir. Frank Benders PDEng

Challenges

Road safety is past, present, and future evolving challenge for multiple collectives. Vehicle manufacturers, regulatory institutions, governments, and research institutions among others, concentrate on efficient and safer mobility. Therefore, the main challenge of the project is to combine multiple disciplines, such as system control, formal methods, and statistics, into a flexible and adaptive future proof solution for safety critical systems.

Results

The result of this project is a framework that generates Advanced Health Monitors for software and cyber-physical components. The framework automatically generates signal and parameter observers for low level abstraction analysis from safety specification formulas. The framework facilitates analysers, Bayesian Networks, for aggregation and categorization of signals, parameters and observers’ results for higher level of abstraction analysis.

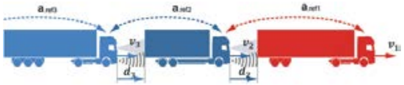
Benefits

The project generates system health monitors that can be applied to commercial off the shelf components. This allows TNO to specify and monitor explicit safety requirements on commercial and experimental products during operation. Additionally, the generated monitors evaluate nominal and faulty behaviour. The specification of the monitors, aligned with TNO’s functional and technical safety requirements, uses Metric Temporal Logic, which is a formal method with verified algorithms.

Ivan Mikovski Iotov PDEng

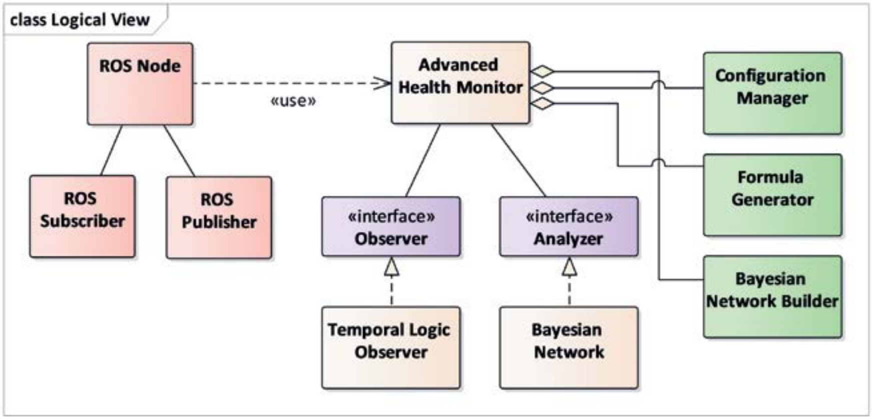
Advanced Health Monitor for Automated Driving Functions

Truck platooning aims to increase road capacity and reduce vehicle emissions by decreasing the distance between trucks. TNO in collaboration with DAF, NXP, and Ricardo, aim to demonstrate truck platooning on the European public roads with the EcoTwin project. In this project, trucks drive at 0.5s apart, achieved by using Cooperative Adaptive Cruise Control (CACC) to autonomously operate the trucks. This system requires special safety measures.



The goal of this project is to develop an advanced system health monitoring prototype. The prototype’s functional objectives can be summarized as detect faults, analyse these faults, and suggest corrective measures. Additionally, the prototype has to adapt to different systems, such as EcoTwin trucks and TNO’s Hardware In the Loop simulators.

The Advanced Health Monitor for Automated Driving Functions is the prototype and a solution that achieves important results securing truck platooning and the underlying automated driving functions. It provides a system monitor and a framework to specify safety requirements which are used for detecting and analysing faults at different levels of abstraction. At a low level of abstraction, it detects faults by comparing parameter values against boundaries. At higher level of abstraction, it uses time based observations and statistical analysis for component status and situation reasoning.



Challenges

There were quite some learning challenges throughout this project: the domain knowledge had to be gained, the modeling paradigm had to be understood, the design principles had to be clarified, and the actual implementation had to be studied. This was the only way to go in order to successfully extend the existing software prototype.

Results

The prototype of a simulator and renderer were extended to support the modeling of more complex examples of print products: documents with tabs, booklets with irregularly shaped outline, and booklets containing holes. These software extensions proved the feasibility of modeling of a wider range of print products. In addition to that, a tool for automatic regression testing was developed that significantly reduced time and effort needed for testing.

Benefits

The value of software extensions does not only lie in the successful completion of the requirements, but also in gaining the insight into prototype's boundaries that can steer the future development steps of the software prototype. The regression testing tool enhanced the developers' experience and increased the correctness of acceptance testing as manual simulation and visual inspections were error-prone processes.

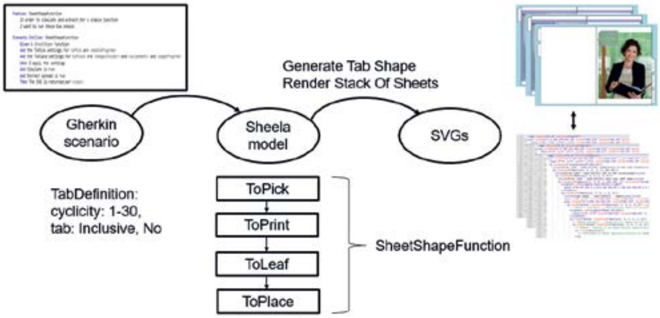
"The Shape project was part of the larger Sheela project that is unlike most others in our company. Sheela is a TD (Technology Development) project. We explore new value propositions and establish their feasibility. There are many unknowns. Not everything we try is worthwhile or doable. Yet Mia found her way around and delivered a number of show cases with free form sheets – even with holes in them. This was very useful in convincing our stakeholders that this really is feasible. Mission accomplished. Thanks Mia, Sheela is in a much better shape now."

J. Geels
Océ – A Canon Company

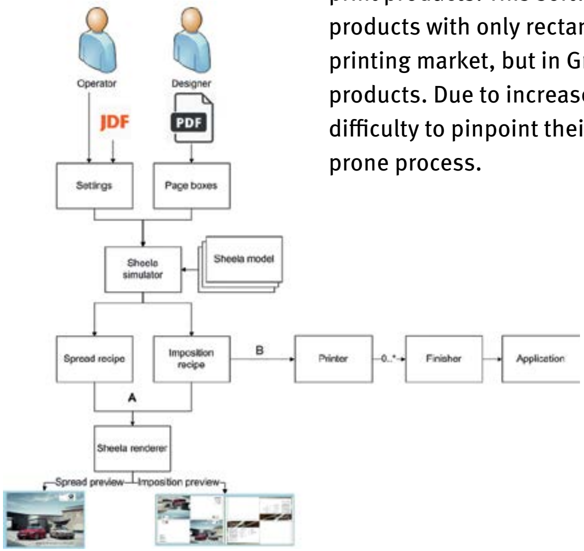
Mia Petković PDEng

Shape: extending the range of print products that can be modeled

Océ is the world's leader in the printing industry. In Océ's current focus of development is the field of Graphic Arts. Graphic Arts cover a broad range of visual artistic expressions. Océ's versatile devices are capable of producing a large variety of print products, such as billboards, car wraps, smartphone covers, and packages. This variety generates a challenge when developing software to prepare and manage print jobs.



A software prototype built around a modeling paradigm was created to simulate different production chains and print products. This software prototype had several limitations. The simulation of print products with only rectangular shape of sheets was possible. This was sufficient for the printing market, but in Graphic Arts, it only covered simulation of a small range of print products. Due to increased number of SVG files generated by the software, as well as the difficulty to pinpoint their differences, regression testing was a time-consuming and error-prone process.



The main objective of this project was extending the range of print products that can be modeled. Three exemplary products were chosen as guides towards that goal. Those were document with tabs, booklet with irregularly shaped outline, and a booklet with holes. An integrated solution was designed and developed to add support for modeling of these three cases and to check for the regression of SVG files that are the outcome of the prototype. The automatic regression tool provided not only the comparison functionality, but also the unified view of their structural and rendered differences.

“The work done by Konstantinos Raptis on developing the meta-model and the graphical front-end for Tisflo 2.0 whose result shows that MDSE is truly bringing value to development and deployment of real-world engineering tools.”

Ir. Rob Faessen
Stamicarbon

Challenges

Working on a project that combines more than one domain is challenging. In this project, an understanding of the terminology used by process engineers and a basic understanding of how a urea plant is designed is required. From the technical point of view the challenges involved the understanding of the technology stack and the constraints of the kernel.

Results

The result is a visual-based application for editing and solving flowsheets. The application is compatible with the text files that are being used with the old tools. In addition, the application provides diagrams and forms where the process engineers can view and edit the flowsheet designs. Finally, the process engineers can merge reusable predefined sections by connecting them on the flowsheet canvas.

Benefits

The application enabled the process engineers for first time to edit and solve flowsheet using one tool. The application eliminated errors related to the rigid layout of the text files. Furthermore, the application enabled the process engineers to use predefined reusable sections that can be merged in a visual editor. All the above simplify the editing and reduce the time required for a flowsheet design.

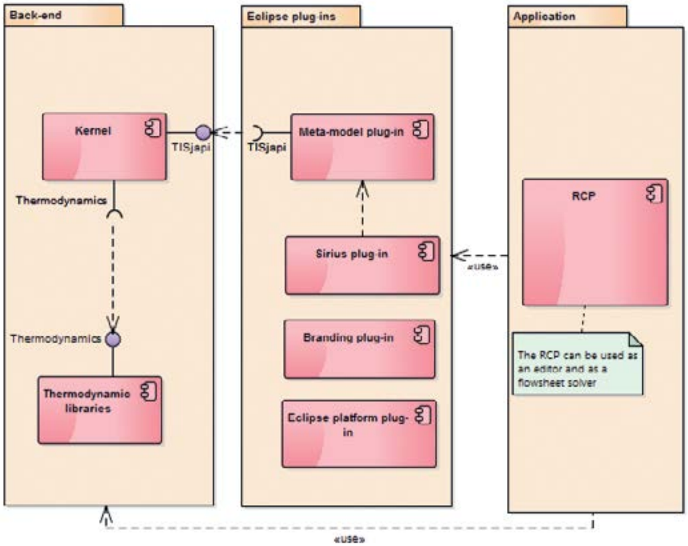
Konstantinos Raptis PDEng

Visual environment for editing and solving flowsheets

Urea is an organic compound that is used widely as a fertilizer to increase the crop size and the yield. Urea is produced from ammonia and carbon dioxide in urea plants. Stamicarbon's main activity is designing and licensing urea plants.
An important activity of the process engineers at Stamicarbon consists of the design of the flowsheet and the calculation of the solution of the heat and material balances for the urea plant.

Improving the productivity of the process engineers and shortening the learning curve of the new process engineers is of great importance to Stamicarbon. Stamicarbon's vision is to the change the flowsheet design from text-based to graphics-based. This project aimed to implement a graphics-based solution that would increase the comprehension of the structure and the state of the flowsheet design. This project also aimed to enable the process engineers to visually merge plant sections that could be reused in flowsheet designs. Finally, a part of this project involved the integration of the graphics-based editor and the flowsheet solver into one tool.

The three major design criteria are usability, navigability, and extensibility. The main tools used for the implementation of this project are the Eclipse Modeling Framework (EMF) and the Eclipse Sirius. The domain model is designed with EMF. The visual representations are created with Eclipse Sirius. The architecture of the system is plug-in based. The final prototype is deployed as an RCP outside the Eclipse IDE.



Challenges

Creating simulators for formal components was a new challenge for ASML. Due to this fact, there was limited knowledge and expertise regarding this topic. Moreover, there is also limited scientific material available on Model-Based Simulation. The situation is also similar regarding the commercial software available in this domain. Therefore, the concepts of Model-Driven Simulation had to be explored and an architecture together with a pragmatic solution had to be realized.

Results

The engineered solution enables, to a large extent, the automation of testing process by generating artifacts. These artifacts can be then easily deployed in the software environment, thereby simplifying the testing process and reducing lead-time. As a comparison, an experienced engineer might need around two hours to write the test artifacts by hand, while the generation of the same artifacts from the engineered solution takes a matter of seconds.

Benefits

The validation of the engineered solution provides very promising results, which indicate a significant reduction (from hours to seconds) of the test writing and deployment time. This solution will enable ASML's developers to achieve more by using less effort, as a large part of the difficult and time-consuming work is now entirely automated.

"Nontas has done a fantastic job in exploring and deploying protocol complete simulators to validate formally specified software components. The results further open the doors towards increased efficiency in the development cycle helping us to create reliable verified and validated software, faster."

Ir. E.M. Xavier Lobo PDEng

Epameinondas Rontogiannis PDEng

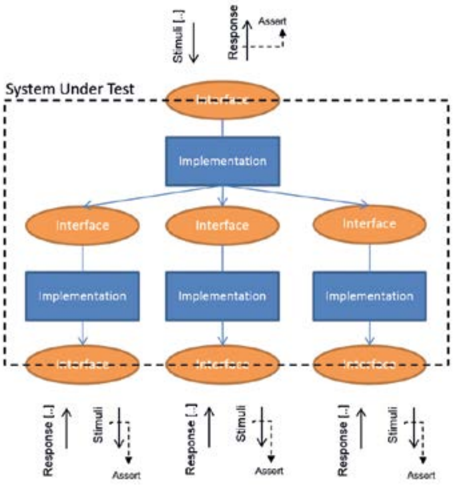
Protocol-Compliant Simulators

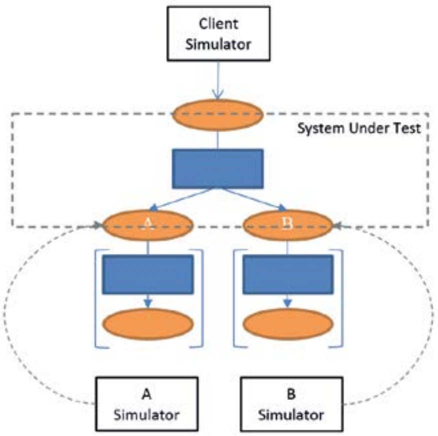
Generating protocol-compliant simulators for and from DCA's control interfaces

ASML Netherlands (ASML) is one of the world's leading manufacturers of chip-making equipment. The machines produced by ASML focus on a very specific (yet absolutely crucial) step of a chip's production: lithography. During this step, specific structures are created on a silicon wafer.

The software used to control and coordinate every piece of the machine is far from simple. Due to its complexity and cruciality, ASML is increasingly adopting Model-Driven Engineering. In this approach, developers use software tools to create models of the system's behavior. Afterwards, the models are verified for correctness against specific properties and source code can be generated, which is executed on a machine.

This approach has two advantages. First, many pitfalls can be detected at design time, before generating the code. This reduces the number of rework cycles of the software. Second, due to the verification, developers spend more time analyzing the requirements and their completeness, thereby producing better designs. However, verification can only check specific properties of software components. In order to the requirements are met, developers need to further test the model. Validation via testing requires effort and increases lead-time in the software development process. This project did an investigation on the possibilities of testing model-driven systems and the use of protocol-simulators was proposed as a solution direction.





“Fariba has built a prototype implementation to showcase the integration of different data sources. This prototype has been used by actual end-users for verification and we are very happy how the end result turned out. Her work and the insights she has provided will become part of our Data Architecture Roadmap. We are very happy she has accepted a job position at Océ and that she will actually start in one of our teams.”

Tim Paffen, Jeroen Janssen
Océ Technologies

Challenges

Since data is generated from different machines and services, formats are different and they have incompatibility with each other. This was also a challenging aspect of the project. Additionally, choosing the right technology for implementation was a challenging process, since preferences and needs of the data consumers were different. Another challenge was to providing a high-performance data access layer.

Results

The main result of the project is a prototype DAL for providing access to a combination of several data sources. The prototype became available to selected users in order to support them with their data access activities. The results are verified based on a survey showing that the use of a DAL is beneficial.

Benefits

The results of the project show that having a DAL strengthens the data analysis activities by incorporating the data from multiple sources. It helps to create a comprehensive view from the data of the customers and the products.

Fariba Safari PDEng

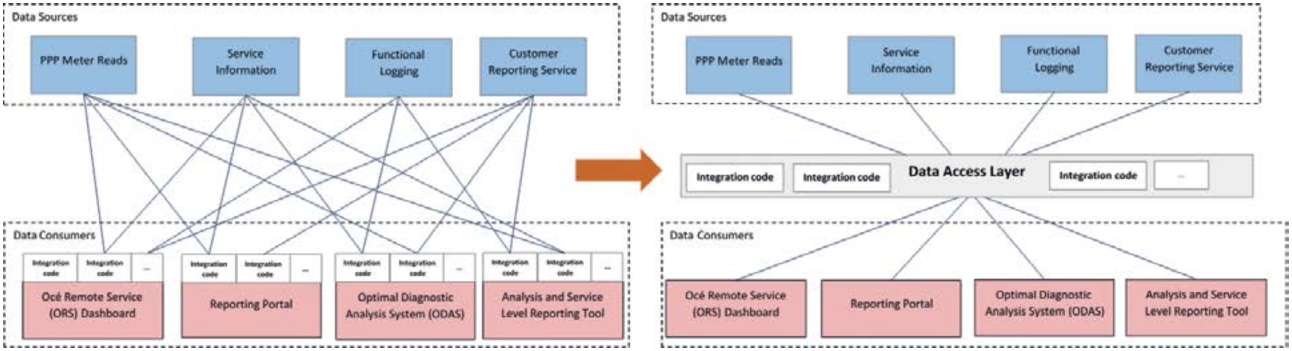
The Design and Engineering of a Unified Data Access Layer

Bridging Data Consumers and diverse Data Sources

Océ, as one of the leading manufacturers in printing industry, deals with various machines and services that produce data. In addition, it deals with various business systems that aim to gather insight from the data for the purpose of analysis and reporting. To improve the data access process for accessing and combining the data sources, Océ decided to take advantage of the data integration technologies.

In the current situation, each business system needs to take care of the data access and handle the incompatibilities of the data. This makes the process of data access complicated when data from multiple sources are needed. By bringing data together, users gain comprehensive insights for analysis. Hence, the goal of this project is to develop a Data Access Layer (DAL) for combining diverse data sources.

The main delivery of this project is a prototype that provides the data access and integration. The Foreign Data Wrappers technology is the choice for implementation based on the results of the evaluations and the requirement analysis. The system design is modeled to cover the challenging aspects of the design, such as mapping the schema of the data sources to the foreign tables.



Challenges

At the beginning, one part of this project depends on the ASML's company project. After several discussions with the stakeholders, we finally removed this part from this project. During this project, a lot of time was spent on learning ASML specific technologies, such as interface definition, process creation, and dealing with the legacy code.

Results

A software framework has been designed and developed for improving extensibility and flexibility of Reticle Heating Correction. Furthermore, a Reticle Heating Correction data model was designed based on the Data, Control and Algorithm separation pattern that is used in ASML.

Benefits

This software framework helps improving reticle heating correction extensibility by providing a mechanism for adding new models. Additionally, its online switch method for reticle heating correction models could help the engineers to save a considerable amount of time. In addition to these benefits, the software framework did not introduce negative overlay impact to the legacy system, which has been proved by the backward compatibility test.

"Jie faced many challenges during the project. She had to learn ASML's interface definition language and code generators, dealt with the large legacy code base and concurrent development. Successful project completion would have been impossible without her ability to learn and strong commitment. Thanks to Jie's hard work we have a proposal for the evolution of the sub-system software architecture along with the highly valuable performance measurements."

S.M. Shumiacher
ASML

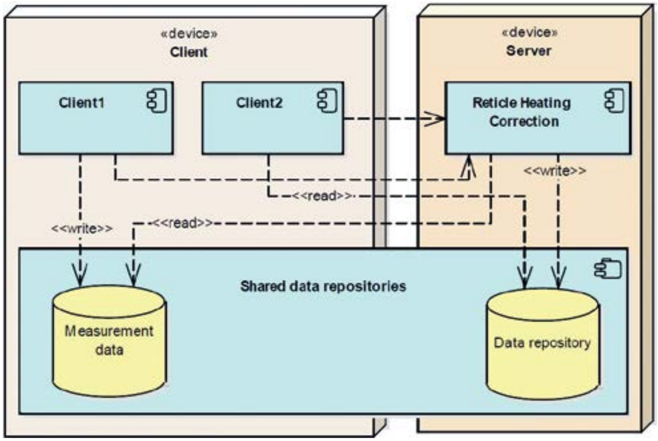
Jie Wang PDEng

Scalable Reticle Heating Correction Design

ASML is the world's top supplier of photolithography systems, which are broadly used by the semiconductor industries. In the systems, the hardware needs to be moved with nanometer accuracy. This accuracy is achieved by the help of measurement and correction mechanisms. In the past years, several measurement and correction mechanisms have been developed to improve the photolithography system accuracy. One of the important mechanisms is the reticle heating correction.

Because of the increasing complexity, reticle heating correction is suffering from several issues. For example, software is hard to extend for adding new models. Switching between different models costs a lot of time, since the engineers need to shut down the machine, change the software, deploy the software on the machine and start the machine again.

This project focused on solving the problems that are mentioned above. A software framework was introduced for reticle heating correction. Additionally, several design patterns were used in the software framework, for example, the Facade pattern, the Abstract factory pattern and the Bridge pattern. For improving the data handling, a reticle heating correction data model was developed. However, since the model depends on other components' data models, which have not been delivered yet, one subcomponent was designed to replace this data model.



“Yinghui has successfully achieved the goal to provide a proof-of-concept and based on that we already know that this was a valuable step in the right direction. Her hard work in learning new domain and technologies as well as in balancing own work and student supervision has concluded in convincing and complete results. We are happy to adopt these results and continue maturing and developing them further.”

Ir. Hristina Moneva PDEng
Océ Technologies

Challenges

One challenge of this project is to enable the framework to be compatible with the controller development team’s current way of working; and the other challenge is to promote the framework to the team so that the framework can be utilized in practice and subsequently facilitate the development and maintenance of the controller.

Results

The framework manages to establish an overview of the controller’s architecture by modeling the controller’s structure (Controller Structure Modeling) and interface definitions (Interface Modeling). With the framework, the overview can be created and updated automatically whenever necessary. Besides the framework itself, deliverables of the project also contain a collection of documents consisting of requirement specifications in addition to architecture and design details. These documents can contribute to the framework’s further development.

Benefits

The framework, by formulating the overview, allows the controller development team to interpret the architecture comprehensively, discover the controller’s deficiencies promptly, investigate influences of changes efficiently, and document design decisions regularly.

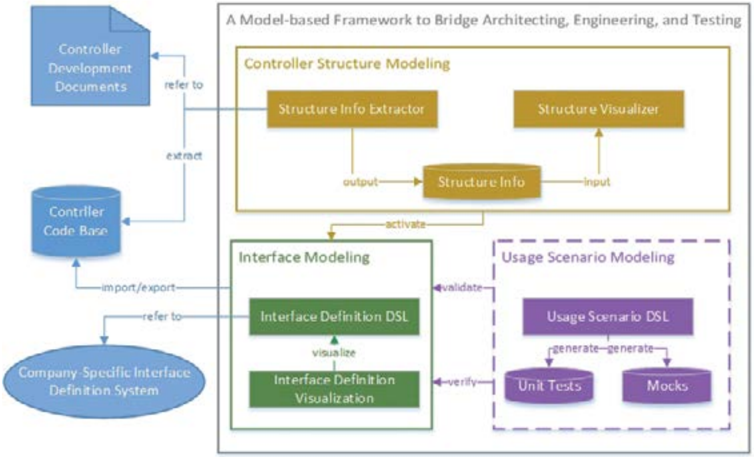
Yinghui Wu PDEng

A Model-based Framework to Bridge Architecting, Engineering, and Testing

Océ Technologies focuses on digital imaging, industrial printing, and collaborative business services. Since 2009, Canon and Océ have joined forces to create highly-advanced printing products. As a result, customers can choose from one of the industry's broadest range of products backed by best-in-class service and support organizations across the world.

The Print System Controller (hereinafter referred to as "the controller"), as one of the printing products' software systems, contributes to lower training and running costs, higher productivity, fewer mistakes, and bigger profits. However, the controller is complex due to its development history and techniques. The current characteristics of the controller have the possibility of causing costly errors and delays in the controller's evolution. One solution to prevent such risks is to formulate an overview of the controller's architecture so that the controller development team is able to analyze the architecture of the controller (Architecture Analysis) and the impacts of changes (Impact Analysis) efficiently and effectively. Moreover, the solution serves as the basis for further specification, analysis, and construction of various development artefacts.

The architecture modeling framework, which realizes the solution, was accomplished within nine months with general techniques (Java, Unified Modeling Language, and Systems Modeling Language) in addition to a new concept (C4 Model) and state-of-the-art technologies (Interface Definition, Domain Special Language, and Meta-programming).



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The programme is provided by the Department of Mathematics and Computer Science of Eindhoven University of Technology in the context of the 4TU.School for Technological Design, Stan Ackermans Institute.

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