

BLAUWE ZAAL



PDENG PROJECTS 2018

Software Technology

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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. We are on the edge of creating and optimizing models based on data.

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 models on one hand. On the other hand you will also learn how model-driven techniques are explored to model variability or to connect existing modeling languages with Domain Specific Languages (DSLs). The development of DSLs is a challenge; one of the projects shows how a flexible type system can be created for an existing DSL. A number of projects are related to online learning and how to use data analytics to optimize the learning process. The acquisition and processing of data should be done in an efficient and flexible manner, a number of projects are related to the development of architectures to support the processing of data in the areas of automotive, Intelligent Transport System (ITS) and agriculture.

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. This booklet provides a source of inspiration and shows the challenges to advanced software development. I hope you enjoy reading the summaries of the projects. 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

A portrait of a woman with shoulder-length brown hair, smiling. She is wearing a dark blue collared shirt. The background is a blurred indoor setting.

"Along the time Anita has been working on it, IVSA redesign importance has been recognized and desired for our next generation of machines where her work will serve as first step and guide towards a fully redesigned component."

Dr. Santiago Cifuentes Costa
Software Design Engineer, ASML

CHALLENGES

Redesigning a complex system is quite challenging due to the domain complexity which requires knowledge from various disciplines. Additional challenge was to grasp the knowledge of DCA pattern as well as the data (AWSOME) and control (ASD) tools, especially to a point where one can feel comfortable developing a module that would be industrialized.

RESULTS

As a result of this project, the control behavior model for the main IVSA scenario was delivered. The deliverable was designed following the reference architecture and the well-known SOLID principles eliminating the accumulated complexity of the existing implementation. It was integrated with the Data and Algorithms aspect and it was formally verified. The model was validated by recreating real IVSA behave scenarios which proved the correctness of the implementation.

BENEFITS

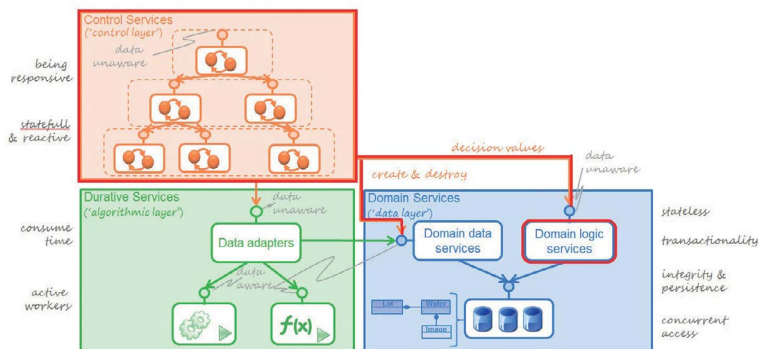
With this project, the importance of redesigning the IVSA component has become evident and recognized by the metrology department. It is going to be integrated in the new generation of TWINSCAN machines serving as a guide towards building a modular, with high quality software that can be distributed between diverse teams. It will serve as a base ground for the new redesigned component.

ANITA ASPROVSKA PDEng

Scalable, Model-Driven Software for Stage Alignment of ASML TWINSCAN Machines

CONTROL AND DOMAIN LOGIC SERVICES

ASML is the main provider of lithography systems for the semiconductor industry, manufacturing complex machines that are crucial to the production of integrated circuits. The lithography systems require nanometer accuracy at high speeds. In order to achieve these requirements the metrology department in ASML is trying to move the software development process towards a model-driven approach in order to increase the quality and efficiency. Therefore, a new reference architecture is being developed which is based on the separation of Data, Control and Algorithms (DCA pattern), and the use of model-driven engineering.



Currently in the machine software there are some modules which have complex implementation causing issues to the department such as inability to add new features to the existing code. These issues are caused by excessive usage of global variables, or by just not having a good structure in the code. One example of such module is IVSA which needs to undergo a complete software redesign.

This project delivered the design and implementation of the control logic model integrated with the other two aspects (Data and Algorithms), paving the road to newly redesigned module which will replace the existing, complex implementation. Each delivery of a feature was formally verified and validated in order to make sure that the system is built correctly and that the developed system is the correct one. The deliverable from this project is intended to be incorporated in the production code after having the complete redesign.

CHALLENGES

Using different ETL frameworks for similar process has made it challenging to share resources from project to project. In addition, lack of re-usable components has resulted in repetitive and redundant implementations when adding new ETL flows. Moreover, communicating complex ETL flow is also a challenge as there is no common frame of reference.

RESULTS

Re-usable patterns and components were identified from selected ETL case studies. Moreover, building blocks were provided to design re-usable ETL flows. Using the proposed meta-data-driven design, ETL flows with re-usable components were prototyped. By using a framework with an execution engine, the solution was integrated with current environments. Furthermore, the prototype also demonstrated flexible levels of design. The results were verified by comparing them with result of current ETL flows.

BENEFITS

The results show that creating relatively generic ETL components will increase re-usability in a project and across projects. Furthermore, using a visual framework that allows different levels of abstractions to design ETL flows, helped to capture a story in the design and ease communication.



"As the project progressed she defined, from the ground up, the concepts of model driven ETL processing, incorporating requirements from both the architectural standpoint as well as engineering and design. The work Sololia has done and the insight she has provided has initiated an internal follow-up assignment."

Ir. Tim Paffen & ir. Pieter Verduin
Océ Technologies

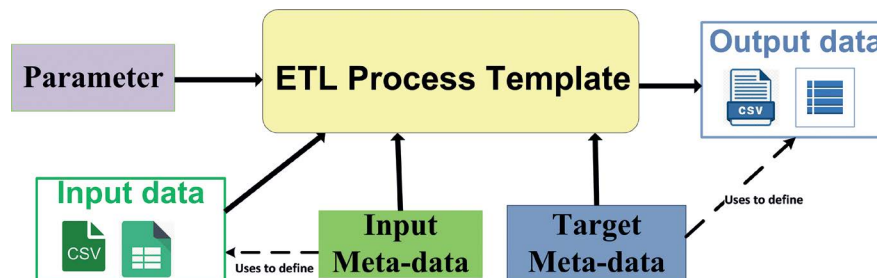
SOLOLIA G. AYELE PDEng

Applying a Meta-data-driven Modeling Approach to Extract-Transform-Load Systems

Océ is one of the leading manufacturers in printing industry. It collects data from its multiple printers in the field. The data from various printers is collected, processed and made available in a data warehouse using a system called Extract-Transform-Load (ETL) flows. A growing trend in Océ is the usage of Model-driven approaches, which are already applied in the embedded domain. Océ wanted to investigate model based development techniques in the field of ETL flows to increase productivity when adding new ETL flows.

In the current situation, different projects use different ETL frameworks. As a result, their implementation has followed separate directions resulting in different challenges. By taking two existing ETL systems as case studies, different modeling approaches were analyzed to investigate ease of communication, development and re-use between different teams. This investigation resulted in a meta-data-driven ETL design approach.

The proposed solution aims to optimize re-usability of ETL components and avoid repetitive implementation tasks when new ETL flows are added. Creating re-usable components is highly relevant because the design and development of ETL flows could take up-to 70 percent of the implementation tasks. In addition, recommendations are proposed to cases where this approach should be applied to take the full advantage of the proposed meta-data-driven design.





"Cármina gave form to a generic error detection component. Analysis on different machine learning techniques were done and, in the process, she built several error detection prototypes to evaluate these options. The differences between the unsupervised versus the supervised prototypes (with an accuracy of 99.97%) were striking. We are happy how the end result turned out. The knowledge she gathered and the insight she provided is highly valued and will become part of Océ projects such as ours."

Jos Jans, Tim Paffen
Océ Technologies

CHALLENGES

Since data is generated from different machines and services, some dataset errors are semantically specific to their source. This was an initial challenging aspect of the project. Once into the solution development it was difficult to abstract from the statistics of machine learning methods and manage the uncertainty nature of their results. Finally, it was challenging to suggest a strategy for overcoming the knowledge of rule based labels in a machine learning system.

RESULTS

The main result of the project is a series of prototypes which use different datasets to detect errors. The prototypes follow a flexible design that can be applied in more projects in Océ. The results reveal striking approximation (over 99%) to the performance of current rule based detection systems.

BENEFITS

The results of the project show that having a machine learning error detection system avoids the need for explicit rule declaration, decreases the maintenance needs in comparison to rule based systems, and makes efficient use of historical data. Additionally, it is possible to achieve near to rule based error detection performance, in the case of available labels.

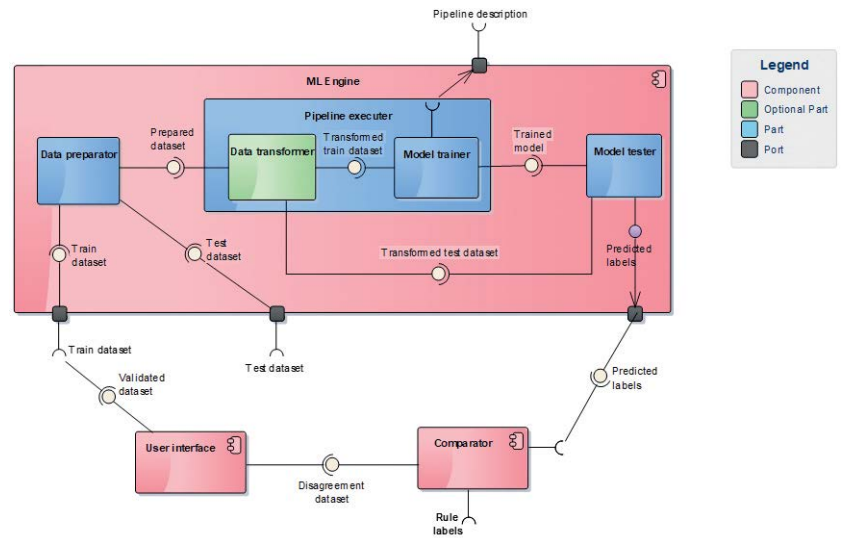
CÁRMINA AZEVEDO PDEng

On the Application of Machine Learning Techniques to Dataset Error Detection

Océ is one of the leading manufacturers in the printing industry in the world. In Océ different projects deal with the data is produced by machines and services. Thus, the quality of the data is at the core of their domain. Since dataset errors are known to occur, it is important to detect fast and tackle the errors to prevent lowering the quality of the data.

In the current situation, rule based and manual methods are used to detect errors. The problem with rules is that they are too specific to be applied within different projects. The problem with manual work is that it is time costly. The goal of this project is to develop a common and flexible strategy that will improve (automate where possible) error detection.

The main delivery of this project is a series of prototypes that use data from two projects in Océ to train an error detection system. A supervised machine learning methodology is used to develop the prototypes. The results show error detection performance approximate to current error systems.



CHALLENGES

The most important challenges are the application of MATLAB Coder and architectural redesign in an existing code-base with limited documentation. Additional challenges were to identify the changes needed to MATLAB algorithm to enable code generation, to optimize the generated code for performance, and to analyze the existing code-base for redesign.

RESULTS

The generated C-code of the algorithm was functionally equivalent to the MATLAB algorithm. The performance equivalence is not much deviating compared to the existing C-code for the algorithm. The C-code generation from MATLAB code can be embedded in both time critical and non-critical software. The generated code may require additional optimization techniques to address the needs of time critical software. ASML can apply code generation as replacement of manual implementation for various applications. The proposed architectural redesign introduces a two percent additional delay which is acceptable for the candidate algorithm.

BENEFITS

The resulting proof of concept shows that code generation can be applied for time critical algorithms. Thus, the code generation helps ASML to maintain only one single source of truth, i.e., the MATLAB algorithm. Additionally, we can apply the architectural redesign in the existing production code gradually without any additional risks. The project proves that ASML can innovate the way they make changes in the existing code.



“Laavanyaa showed that we can apply code generation for time critical MATLAB algorithms in measurement systems software. Moreover she proved that the architectural preconditions can be gradually introduced in legacy code. This allows ASML to innovate in the development workflow for new and existing machines with nearly no additional project risks. Laavanyaa will continue to work at ASML since her dedication and architectural skills were highly appreciated.”

Ir. Wouter van Heijningen
ASML

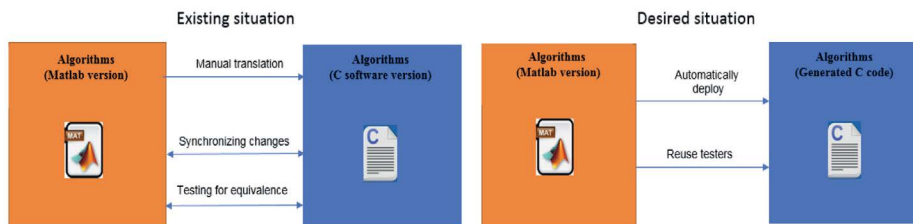
LAAVANYAA BALASUBRAMANIAN PDEng

Improving Maintainability of Time Critical Software by Applying MATLAB Coder and Architectural Redesign

ASML supplies semiconductor manufacturers with advanced lithographic machines. The short time to market is crucial for ASML's business that also helps them in maintaining their position as market leaders. Additionally, ASML also strives to ensure the products' quality. So, there are several pilot projects focused on code generation to replace manual effort and to create products on time.

Within several ASML engineering departments, the functional teams develop MATLAB algorithms and the software teams translate the MATLAB algorithm into production software (handcrafted C-code). The ASML engineers spend time and effort to translate, maintain, synchronize and validate these two versions of the algorithms. The code generation will help ASML to maintain only the MATLAB algorithm and generate production code (generated C-code) from the MATLAB algorithm without compromising the performance such as execution time. This will help ASML to decrease the overall time spent in development, decrease synchronization effort, decrease maintainability effort, and avoid translation errors.

The solution focused on evaluating the code generation for algorithms in production software and proposing an architecture that is a precondition for the application of code generation. The project evaluated code generation using MATLAB Coder for an algorithm from an ASML domain. The proposed architectural redesign separated the external dependencies of the algorithm, i.e., the algorithm invocation and the algorithm parameters. This architectural redesign helps to increase maintainability, readability and cohesion.





"Qing did a great job in verifying that non-intrusive interceptors can be applied in ASML context. He has quickly learned the ASML way of software development, which is quite an achievement as it has a high learning curve. As more stakeholders were interested in his results, he included their requirements where possible."

Will Denissen
ASML

CHALLENGES

The challenge in this project was to consider and evaluate all the contributing factors to the applicability of interceptors. The factors are, for example, all client/server interactions, support on different operating system and performance. The research on VxWorks takes significant amount of time as it is needed to understand the internal workings of kernel modules.

RESULTS

The result proved the applicability of non-intrusive interceptors within the ASML context. A modified code generator was also delivered. This serves as a reference for the formal engineering of the code generator.

BENEFITS

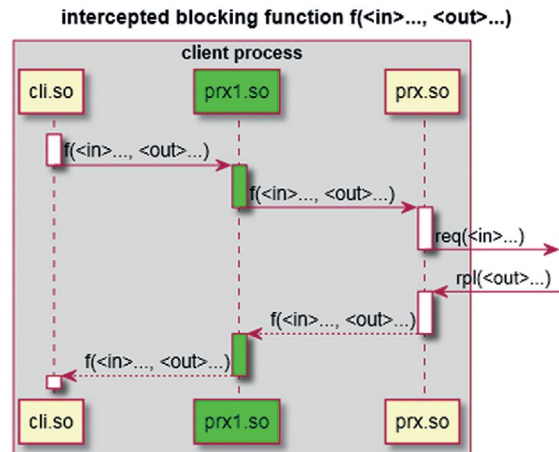
With the help of non-intrusive interceptors, the production software components can be enhanced or altered without touching the production code itself. This ensures the quality of production software. Development tools such as tracing and simulating can be installed as interceptors and will not be shipped to customers. This greatly facilitates the evolution and testing of ASML software.

QING CAI PDEng

Non-Intrusive Interceptors: A Dynamic Feature Extension Mechanism

Plugins, which are software packages adding additional features to host software, are seen in many software, for example, Chrome. Such mechanism is also desired at ASML. First, it is not wanted to change production code for development tools. Doing so has a lot of complications, such as maintenance, testing, integration, which all takes a lot of man-hours. Second, there are a variety of features to add, for example, diagnostic tracing, protocol violation checking and hardware observing. Third, enabling and disabling certain features should be easy. All the reasoning brings this project to the table.

In the project, a thorough investigation on the interceptor mechanism was conducted based on the ASML context. The internal communication mechanism is the center of the investigation. Language support, OS support and all client/server interactions are taken into account. The design part makes decisions on the modified code generator and workflow. With the proof and a design, the implementation and further integration with a production software component consolidated the concept. In the near future, the proposed design will be fully integrated into the ASML toolsets.



CHALLENGES

The main challenge was to conduct the domain analysis of the day-old chick production chain since it involved different roles, processes, and data sources that work as information silos. Besides, finding a good showcase for the system demonstration was also a challenge.

RESULTS

The main project result is the design of the system for aggregating, storing, and providing file-based semi-structure and unstructured data. One system prototype was also implemented based on the design with the products from the Microsoft Azure cloud platform, and there is no customization in the implementation. The system was verified by a data-driven application regarding day-old chick quality.

BENEFITS

The system enables more comprehensive data-driven applications based on multiple datasets from different data sources. Furthermore, the cloud-based solution makes it easier to facilitate large-scale automated analyses and combine other resources to realize data-driven applications. Hence, with the system, people can think out of the box, think big, and think with the help from other existing resources.



"Wei-Sheng has raised eyebrows with his approach. Not only within the layer business unit, but also within our IT department. Largely due to his effort, the concept of cloud based and data-driven solutions has been put on the map for Hendrix Genetics. His work will be the start of wide-spread adoption of this strategy in our company."

Ir. Bram Visser
Hendrix Genetics

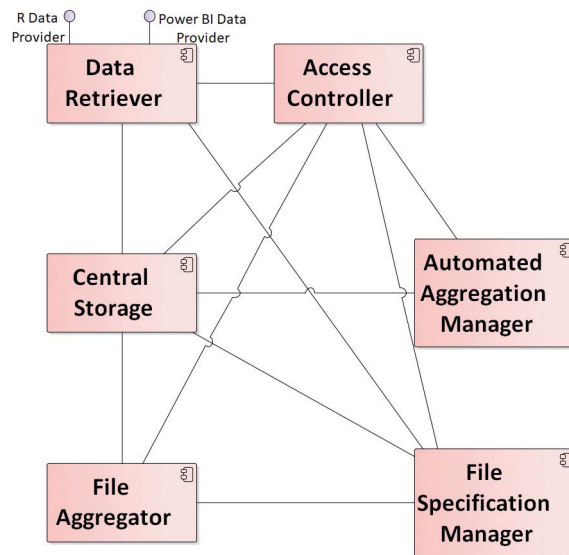
WEI-SHENG CHEN PDEng

Architecture for Supporting Data-Driven Processes on Layer Hen Production Data

Hendrix Genetics, an international multi-species animal breeding company, is one of the world's leading breeders and distributors of white and brown layers. The company collects a great variety of data during the layer day-old chick production chain. The collected data could be analyzed to generate insights for production improvement. However, the data is generated by multiple machines and systems, and some types of data were collected by people with computer files or paper forms. This situation made it difficult or impossible to conduct the data analyses based on multiple datasets. Therefore, the goal of this project was to design the architecture to aggregate these heterogeneous data to enable data-driven applications to create new insights and improve the quality of the day-old chick production chain.

A system was designed to aggregate, store, and provide the file-based semi-structured and unstructured data collected during the production chain. The design considered the requirements about cloud-based implementation with standard products and minimum customization. A system prototype was also implemented based on the design with several Microsoft Azure products.

Besides, a data-driven application regarding day-old chick quality was designed and implemented with multiple datasets aggregated from different data sources to the system prototype. The application has verified the system and demonstrated that the system could support the data-driven processes by enabling data-driven applications.





“Education is seen as a fundamentally optimistic human endeavor characterized by aspirations for progress and betterment. Education is perceived as a place where [young people] can develop according to their unique needs and potential. [Schofield 1999] These sentences are applicable to this project and the PDEng training as well. ”

Ir. M.D. Klabbers
Eindhoven University of Technology

CHALLENGES

One challenge of the project was to explore how teachers and learners can be helped out with the help of technologies. From the technical point of view, the challenges involved intensive investigations within Sakai LMS to find out the most optimum design solutions without violating the existing Sakai itself.

RESULTS

The main results of the project are twofold. An automatic email notification tool was designed and developed along with an email rule engine to send out notifications/reminders to the learners to maintain their learning progress. An initial prototype of an intelligent teaching assistant was designed and developed in a form of a chatbot to prove the concept that the chatbot can support teachers to reduce their work load by answering an administrative/operational type of questions initially, then content-related/domain specific questions gradually.

BENEFITS

Currently, the Email Notification tool is available to use in the company's web site. It is beneficial for teachers by automating their manual tasks while improving learning progress of learners with personalized approach for each learner. The overhead of the intelligent teaching assistant is virtually non-existent, even in the first steps while the chatbot still needs to learn about the course topic and the organization, while the benefits are for both students and teaching staff: it increases the response rate for the students, while decreasing the efforts needed from the teaching staff.

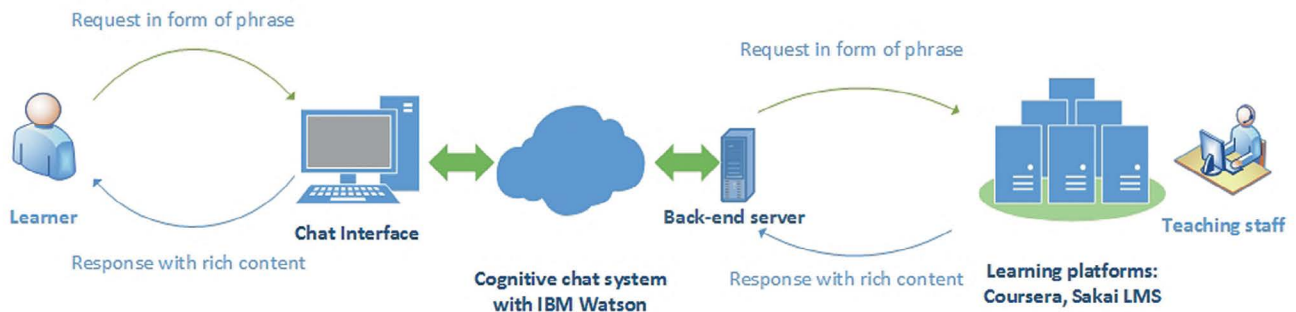
MUNKHTUYA DASHNYAM PDEng

Robocoach: A Scalable Solution to Support Teachers and Students Using Email and Chatbot

An important goal of educational organizations is to pursue strategies that engage students in their learning activities. Student engagement involves not only teacher's effort to engage students, but also their own activities. To improve a student's engagement, a close connection between student and teacher is crucial. However, the more the number of students increases, the less personal attention the students receive. The situation becomes worse in an online setting because the level of isolation of students from their peers and teachers is greater than in an on-campus setting.

EIT Digital, and specifically EIT Digital Academy, is a leading European organization aiming at digital innovation and entrepreneurial education and driving Europa's digital transformation. As an educational organization, switching the interaction with the learners to improve their engagement is an important but not a trivial task for EIT Digital. EIT Digital seeks a scalable solution to guide and motivate the learners either in an online or blended setting.

Therefore, an automated solution with the help of technology is needed to scale up teaching assistance in a place where physical face-to-face connection is missing. In the context of this project, automated solutions we are providing are Email Notifier and Chatbot. Both of them aim to maintain student's progress.



CHALLENGES


Modern data technologies have been providing a number of advantages for farmers. The farmers become capable of monitoring differences between the planned and the actual business performance and therefore, can take necessary actions based on their farming experience and data analysis. In order to survive in today's fast changing and competitive environment, they would like to use all kind of sensors, machines, and advanced data analysis such as machine learning algorithms. However, the farmers spend a lot of time and effort on collecting and organizing the data.

RESULTS

The aim of this project is to prove the feasibility of an architecture design for a data integration platform that can be used for the storage and management of Precision Farming data. Based on the domain study and the selected data from the case-study farm, data models that suit the needs of the case-study farm including mandatory operational data by law, farm management, and sensor data were developed. These data models can lead to a common understanding of the data with semantic metadata descriptions. The presentation of the data is shown in a dashboard. It validates the current data structure of the database and allows users to interact with the data in the database. The data, together with its visualization, has a potential for data users to identify causalities of better results.

BENEFITS

The design of the data integration platform emphasizes the re-usability and realization attributes of the solution. It follows a distributed architecture divided into building components that make it extensible. An implementation of the platform, a prototype was developed as part of this project. In order to prove the data models, a database was designed and implemented. The data were analyzed with an interactive interface that provided a search and filter mechanism for finding a data. In conclusion, the results obtained demonstrate the benefits of using integrated and combined data, providing an ability to perform intuitive analyses for making data-driven decisions with better insights of the current available data.

A portrait of Prof. dr. Jakob de Vlieg, a woman with long dark hair, smiling. The background is dark with out-of-focus warm lights.

"The DIPPA system (Data integration platform for Precision Agriculture) developed in this PDEng project is an essential step forward to manage and analyze the heterogeneous precision farming data sets and to translate data in value for the farmer in this era of sensing and big data. This first version of DIPPA allows the integration of in house, open source and commercial software tools to provide a strong basis for the development of predictive algorithms for precision farming and new scientific crop growth models. This is an essential step to increase our insights in e.g. the relationship between seed and soil. Moreover, the software engineering architecture of DIPPA will make it possible to make cross-connections with other (inter)national platforms and data lakes based on applying meta-database management principles to design powerful dashboards based on among others "farmers in the lead"."

Prof.dr. Jakob de Vlieg
Applied Data Science Group
Department of Mathematics and Computer Science, TU/e

Data Integration Platform for Precision Agriculture

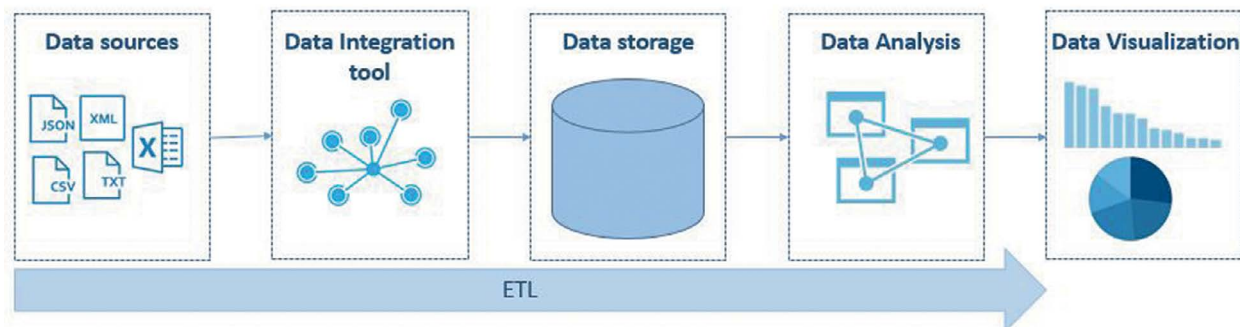
Between now and 2050, the U.N. predicts the world population will grow to 9.8 billion. As a result of that population growth and changes in diet associated with rising incomes drive greater demand for food and other agricultural products. The question we need to answer is – how can farmers increase crop production sustainably to meet significant increases in demand?

Over the past years, farmers have been adopting new technologies. Precision Agriculture (PA) is a farming management concept that aims to help farmers to make more profit and reduce environmental risks and operating costs. This requires effectively managing input resources like fertilizer, water, and seed quality and minimizing the impact of unpredictable variables such as weather and pests.

An integration of different data in Precision Agriculture leads to a better understanding of the processes and interactions between site characteristics, management practice in order to improve decisions in a farm. The main contribution of this project is to explore the opportunities and challenges for utilizing data in Precision Agriculture through realizing and designing a Data Integration Platform for Precision Agriculture – DIPPA.

The overall study covers:

1. Data Modeling, which analyzes data structures of the domain
2. Data Integration, which investigates the process of bringing diverse data to a centralized system
3. Data Storage, which deals with the actual storage management
4. Data Processing, which describes the processing steps of the system
5. Data Visualization, which shows visualization of the processed results





"Carlos worked on a tool to provide a more extensive feedback loop; a dashboard to provide the insights in the online courses at Coursera for EIT Digital. He also experienced what it is to learn quickly, especially in his quest to finish this project in half a year, how to cope with external assessments, user evaluations, how to manage a development team of inexperienced software engineers and become a leader, and how to achieve the project goals on time."

Ir. M.D. Klabbers
Eindhoven University of Technology

CHALLENGES

The biggest challenges for this project were: the limited time required to achieve a functional solution, the responsibilities derived of the collaboration with the SEP students, and the design process in order to achieve an architecture capable of providing storage and analytics to a variety of MOOC-related data sources.

RESULTS

The outcome of this project consisted of a working platform named "Lab4MOOCs". It provides EIT Digital with a Learning Analytics dashboard where they can monitor the status of any subset of their online courses. The resulting system was verified and validated by end users, and has triggered the company into further studying a solution that integrates with the efforts of their educators for providing good quality courses.

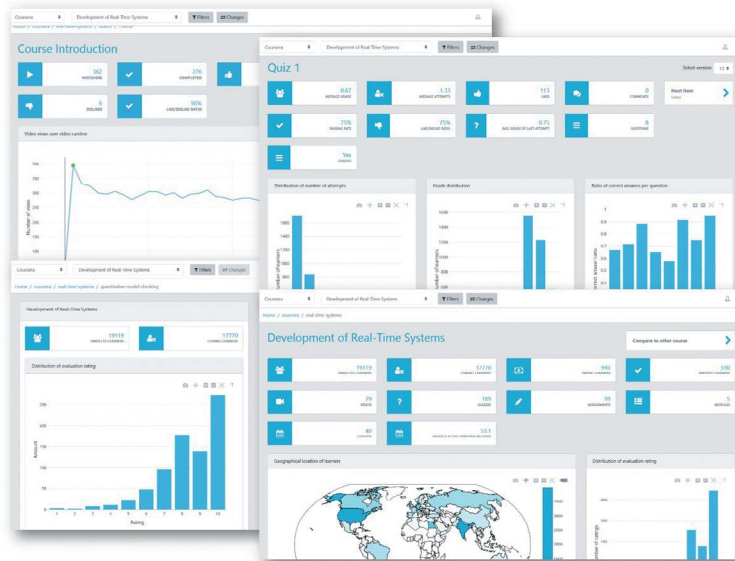
BENEFITS

The resulting system benefits EIT Digital since it presents a tool for their education experts to understand the dynamics of their courses. The Learning Analytics allow them to have more insight in the quality of their materials, and to identify problematic sections.

CARLOS GIRALDO GARCIA PDEng

Designing and Implementing a Learning Analytics Platform for Online Courses

Delivering high quality lectures and learning materials is important for any teacher, and perhaps even more important for educational organizations, like EIT Digital. With their focus on starting a revolution in the world of education with the use of the latest technologies, EIT Digital provides a plethora of online courses on a variety of MOOC (Massive Open Online Course) platforms, like Coursera. Generally, MOOC platforms provide multiple maintenance tools, including access to the data generated in the interaction of the students and the MOOCs. In order to ensure student satisfaction and course quality, EIT Digital pursued the design of a Learning Analytics platform that employed MOOC-related data and provided teachers with the necessary insight to recognize which elements need improvement.



We aimed to create a system that could be extended in the future in terms of the number of supported MOOC platforms. Considering that different MOOC platforms would provide data in many different ways, the final design allows each one to be treated differently. In order to prove the concept, only the analytics for the Coursera platform were implemented.

During this project, I had the opportunity to collaborate with a group of students in the role of the customer of their Software Engineering Project (SEP). Their participation contributed to a large degree to the success of this project.

CHALLENGES

The greatest challenge for this project was the exploration of the eventing domain and the identification of the concepts that are related to the envisioned system. An additional challenge was mastering the Hue System architecture and developing design alternatives that are compatible with the Hue system's architecture standard. Finally, making sure that the requirements are satisfied by different stakeholders.

RESULTS

This project demonstrates a clear overview of different eventing design alternatives; compare them based on significant factors, including latency, recoverability, reliability, memory optimization and ease of implementation. Moreover, one of the main deliverables is the proof of concept (PoC) of eventing for the resource attribute changes. Another outcome is the design and implementation of fine-grained subscription and dynamic group subscription support in eventing for the application user in the Local Area Network (LAN) environment. In addition, the final outcome of this project is giving suggestions in order to improve the Hue system architecture for optimizing the eventing resource usage.

BENEFITS

Eventing is hugely beneficial compared to polling in sending the delta messages instead of the whole state to the client, lowering the latency with reducing load on the server, and scaling. Moreover, the removal of polling enables more flexibility and efficiency in their application development. Besides that, adding fine-grained and dynamic group subscription gives a lot of flexibility to the user to interact with the Hue system.



"A fast-moving business and changing priorities can be challenging and turn a project upside down. Pouya mastered this challenge - his topic 'Eventing in the Hue System' suddenly gained high business priority. He played an important role preparing and de-risking the development of this architectural improvement of the Hue System and the first steps are already released. Development continues and Pouya also helped us to shed light on some of the important challenges to come."

Daniel Goergen PhD
Lead System Architect
Signify

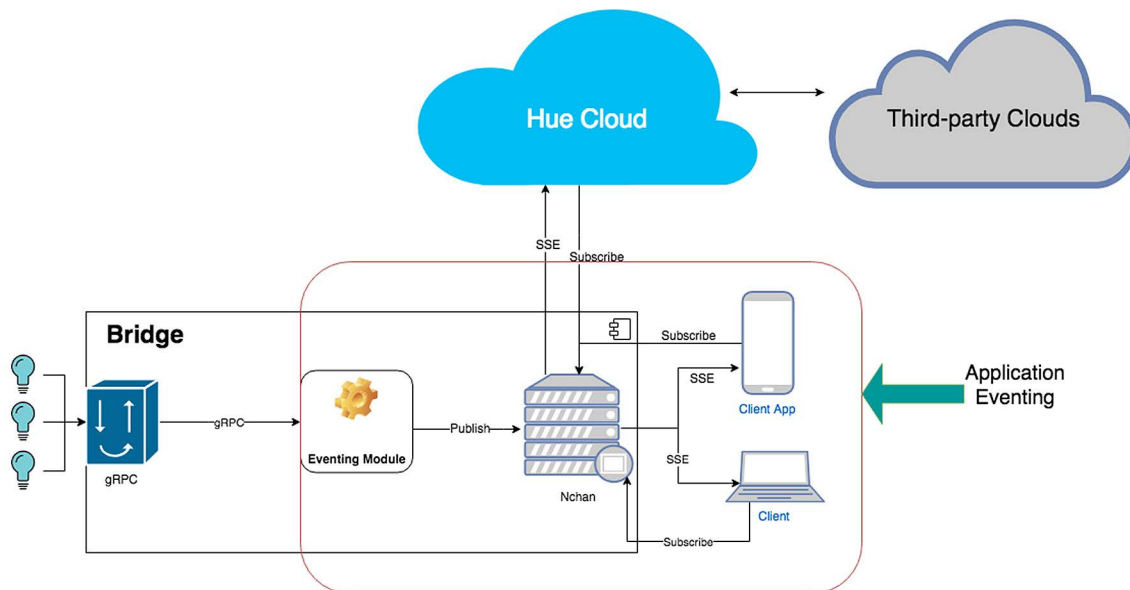
POUYA SAMADI KHAH PDEng

Eventing in the Hue System

Signify, previously known as Philips Lighting, is the leading provider of lighting solutions and applications for both professional and consumer markets, pioneering in how lighting is used to enhance the human experience in the places where people live and work. In 2012, Signify launched the Philips Hue system, which is a connected home lighting system of linked bulbs that can be controlled by a smartphone or tablet via a ZigBee bridge.

The brain of the Hue system is an embedded device called Hue Bridge. This device controls and monitors Hue lamps, sensors, and switches; it acts as a local home lighting controller. The bridge communicates both with IP and ZigBee networks and facilitates the message translation from one to another. In this system, apps and services poll to get information. Polling in the Hue system generates lots of load, consumes a lot of bandwidth, and forces the client to compare and detect the changes if there is a change.

To address these challenges, the eventing approach is suggested. Eventing changes the way consumers interact with the APIs. Any change from one state to another is an event. For instance, when the light goes ON, it results in a state event. Therefore, with eventing, it is possible to only send the state changes by lowering the latency and load.





"Dmytro was faced with the daunting task to create, from scratch, a prototype user interface and business logic that showcases the use of modern technologies in a microscopy context, and to create a system that moves us up in the knowledge pyramid from data to information to knowledge. No mockups allowed! Dmytro has worked his way through and around the problems he encountered in a commendable way. After completion of his work with Thermo Fisher Scientific, we now have a fully functional prototype which we can use to explore the (im-)possibilities of AI and natural language interfaces."

Dr. Remco Schoenmakers
Thermo Fisher Scientific

CHALLENGES

The challenges of the project were to find use cases that would highlight modern AI capabilities in a microscopy context and trigger ideas for new use cases. The Intelligent Microscope resulting from this project is a software system that uses different frameworks and libraries that were combined together in an extendible design within the 10 months available for the project.

RESULTS

The results of the project shows how microscope control can be simplified using a conversational interface, how image analysis can be improved using object segmentation, and how information about microscope image context can be interpreted using a microscope knowledge database. The Intelligent Microscope serves as a virtual microscopy assistant that can understand user voice-commands and simplifies user-microscope interaction.

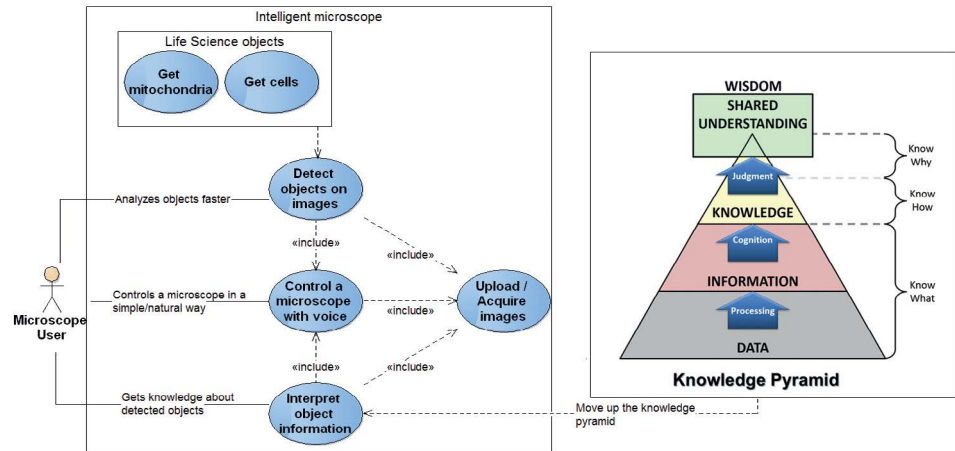
BENEFITS

The Intelligent Microscope project answered the questions, how AI can be integrated in microscope software and how an electron microscope can move up the knowledge pyramid by providing understanding of image context to microscope users. The deliverables of the project highlight capabilities of AI in combination with electron microscope software. The Intelligent Microscope could serve as a starting point for future AI integration into electron microscopy software.

DMYTRO KONDRASHOV PDEng

Intelligent Microscope

The Advanced Technologies department at Thermo Fisher Scientific conducts, amongst others, research on how Artificial Intelligence (AI) technologies can be used and integrated into electron microscope software. AI gives software users the ability of a novel interaction with applications. The goal of the project was to create a prototype of an Intelligent Microscope (IM). The main motivation for the project was to explore and show possible ways of User-IM interaction. The IM is an AI-web system that can understand predefined user voice-commands, control an electron microscope, detect objects on microscope images, and highlight specific objects requested by a user.



The IM is capable of detecting and highlighting specific types of objects, such as cells and mitochondria. Also, it is able to interpret information about detected objects and show which of the objects are big, small, or relatively close to each other. These use cases provide examples of how the IM can be used. Even though these use cases are unique they do not limit the IM to mitochondrion and cell detection only, because one of the main implemented IM requirements is extensibility with other use cases.

Convolution neural networks were used for object detection. The Amazon Lex service was used to create the IM conversational interface. The IM architecture consists of five tiers to segregate different functions of the software system. Therefore, the IM can be extended easily as well as deployed in a distributed way.

CHALLENGES


Acquiring the necessary knowledge from all the projects and establishing/maintaining communication channels with stakeholders was the greater challenge during this project, as the teams of the different projects were distributed. The different approaches followed in each project introduced another level of complexity to the analysis as well.

RESULTS

The result of this project was the proposal of a validation software toolchain to be used in the platform solution. Knowledge was shared across projects which facilitated the shaping of the recording architecture of one of the projects. That architecture was used and extended to include the hardware-in-the-loop validation.

BENEFITS

The first steps towards the HIL realization were implemented on the proposed testing tool. When the implementation of it is complete, Valeo will have one tool that validates the functionality of the latest front camera. The tool will be applicable on at least two current projects and on future ones.

A portrait of Vladimir Hájek, a man with dark hair, a beard, and glasses, wearing a maroon polo shirt over a blue and white plaid shirt. He is smiling and looking towards the camera. The background is a blurred indoor setting with warm lighting.

"After thorough analysis, Periklis defined the most important features that should be part of the future platform solution and based on his proposal one of the currently developed tools was chosen as the core of the future platform solution. His contribution to the tool became integral part of the platform solution."

Vladimir Hájek
Software Team Leader, Valeo

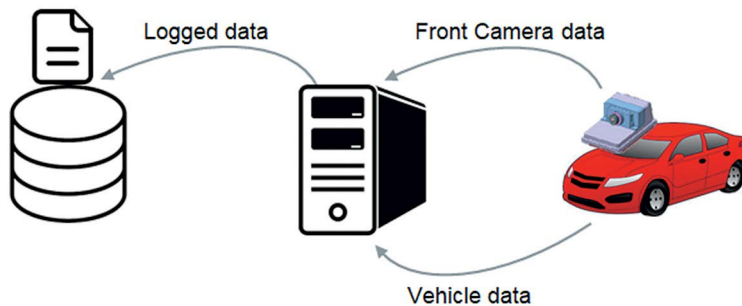
PERIKLIS KYRTSIS PDEng

Development of Front Camera software toolchain (Recorder, Player, and HIL)

Over the recent years, all major automotive companies have been trying to increase road safety and comfort levels and reduce the fuel consumption and greenhouse gas emissions. Automated and fully autonomous driving is perceived as the more promising and prominent solution towards that direction.

As a leading automotive supplier, Valeo offers a large range of smart sensors and Advanced Driver Assistance Systems (ADAS) features that improve vehicle safety and comfort. Front cameras have come into play in the past few years and are the key sensors for ADAS / Active Safety systems and Automated Driving (AD). Valeo develops and produces front cameras for several different customers and this led to several different testing tools.

In this project, the different software toolchains used to validate the functionality and performance of front cameras were revisited and reviewed, in order to come up with an architecture proposal for a validation software toolchain that will be applicable on current and future projects. A tool that was under development and its architecture was under definition was selected for that matter. The hardware-in-the-loop (HIL) architecture was designed and partially implemented to enhance the functionality of the tool.





"The type system Guido developed supports a unique combination of features that greatly improve the usability of our tool, and I along with the colleagues here at Siemens would like to thank Guido for the effort he put into this project."

Cesar Santos
Siemens PLM Software

CHALLENGES

Finding the right balance of features and creating the architecture of the type system to meet the requirements were the main challenges in this project. Type systems are delicate in the sense that the addition or removal of a feature tends to have a high impact on the other features. Extendability of the type system required an additional layer of abstraction for types and a type-rule neutral architecture.

RESULTS

The results of this project are three-fold. Firstly, a survey of programming preferences among various engineers working at Siemens PLM Software. Secondly, an architecture for an extensible, configurable, and high-performance type system. Finally, the implementation of the architecture together with a set of type-system features that enable flexible and correct programming.

BENEFITS

Gradual typing enables engineers to mix flexible and correct code. First-class functions and multi-methods enable them to abstract over functions and easily extend programs by adding new functions for specific problems. The configurability of the type system allows for having different levels of strictness. This enables programming effectively in different settings. The extensible architecture makes adding types easy and enables reuse of existing rules in combination with added types.

GUIDO LOUPIAS PDEng

A Type System for Technical Computing Languages

Siemens PLM Software offers a programming language for the purpose of analysis as part of a generative engineering solution. Programming languages need to enable a productive programming experience. The ability for a compiler to reason more effectively about the code is a key enabler for such productivity gains. Currently, the compiler lacks this ability.

Therefore, the goal of this project was to design and implement a type system for the language. A type system enables a compiler to reason more effectively about the code by tagging language constructs with additional information. The design space of type systems is large. Flexibility, correctness, and performance are key overall requirements for the type system of this language. Furthermore, given that future additions to the type system are to be expected, extendability is another important requirement. Finally, the chosen set of features needs to match the expectations of the end-user.

The solution delivers a tightly integrated type checker that meets the performance requirements. The type checker centers on multiple passes and is designed around an extendable set of types. The type system features gradual typing, first-class functions, and multi-methods. Furthermore, it enables the language to be used in different programming contexts by supporting multiple configurations.

```
In [1]: type myint = int
        myint x = 2
        typeof x
        int
```

```
In [2]: type myfun = funcref int(float)
        typeof myfun
        type[(float) -> int]
```

```
In [3]: int foo(float x) = x as int
        myfun bar() = foo
        myfun baz = bar()
        baz(2)
        2
```

```
In [4]: int quux() = foo(2)
```

```
In [5]: int foo(int x) = (x*2)
        print quux()
        print baz(3)
        4
        3
```

```
In [6]: typeof foo
        overload[(x: float) -> int, (x: int) -> int]
```

```
In [7]: typeof baz
        (float) -> int
```

```
In [8]: typeof int
        type[int]
```

CHALLENGES

Getting familiar with concepts such as the Data Control and Algorithms (DCA) architectural pattern, model-driven engineering approaches and tooling being employed by ASML such as ASOME it was the main challenge of this project. Also, understanding the physics and mathematics domain knowledge that underlies the new design of the functionality that the ASML machine performs it was a demanding task.

RESULTS

The results of this project are:

1. The implementation of the most challenging and significant algorithm for the vertical alignment functionality.
2. The definition of the domain data model relating to the new algorithms that were created.
3. Set up the base for the execution of the measurement function by creating the garage and the algorithm that this function requires to perform.

BENEFITS

The new redesign fits the DCA architecture, therefore it solves the prevalence of spaghetti code and creates software that is less complex and testable. IVSA redesign improves manufacturing throughput time of the machine because uses a single lane of measurement instead of three lanes that the old vertical alignment was using. Finally, major customers of ASML are satisfied hence they receive an improved functionality for the creation of their chips.



"Ilanislav delivered valuable results for the vertical alignment functionality. His new design will be the baseline for the implementation of IVSA in future TWINSCAN platforms."

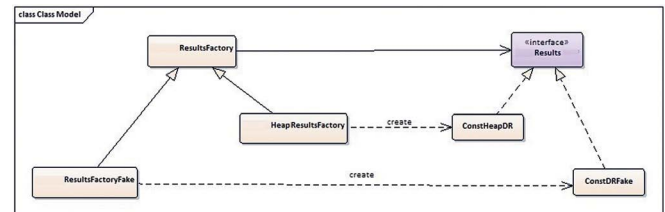
Dr. Milan Stanic
ASML

IANISLAV MINTCHEV PDEng

Design and Development of Model-Driven Software for Vertical Stage Alignment of the ASML TWINSCAN Machine


WITH FOCUS ON ALGORITHMS AND DOMAIN DATA SERVICES

The quality of the software that runs inside an ASML machine is very significant for the company. This project, is aiming on the software improvement of one of the several functionalities that ASML machine is executing for the manufacturing of the chips. Is following the Data Control and Algorithms (DCA) architectural pattern for creating a software that is reusable, maintainable and testable.



The goal of this projects is to recreate the Improved Vertical Stage Alignment (IVSA) functionality in such a way that will have a better design and implementation. At this moment the code of IVSA is complex, and the are no tests available for it. Is difficult to understand and extend the code since it can cause errors to other parts of the system. The IVSA redesign fits the DCA architecture. Therefore, solves the prevalence of spaghetti code and will create software that will be less complex.

In this project we implemented the plan measurement garage and the data valid function. We set up the base for the IVSA measurement since that the two functions the we mention before offer the required inputs to the measurement function. Furthermore, we worked on the Data aspect of DCA and designed a data model that will offer the necessary data to the algorithms that IVSA consists. Finally, this project delivers a quite significant algorithm for the IVSA functionality. A lot of customers that ASML has, such as Intel, Samsung, Toshiba, and TSMC, will be benefited since this algorithm is improving one of the measurements conducted inside the machine.

A portrait of Dmitrii Nikeshkin, a man with a shaved head and a slight smile, wearing a grey button-down shirt. The background is a blurred indoor setting.

"Dmitrii Nikeshkin has successfully proven his capability of extracting information from relevant stakeholders and sufficiently understanding each of the domains and integrating them into a number of sensible prototypes which he has shown in an integrated fashion to the Océ embedded software departments. Dmitrii is a great co-worker. He is naturally curious, capable of obtaining insights fast, and demonstrates an ironclad ability to solve tedious engineering problems that keep many people from progressing swiftly."

Eugen Schindler PDEng
Systems Modeling Interoperability Architect
Océ Technologies

CHALLENGES

One of the main challenges in this project is exploration different domains. Another one is the analysis of the closed source tool and distinguishing what functionality is important for the end users. However, the biggest challenge in this project is to develop the IDE that can help to change the way of modelling in the whole company.

RESULTS

ESME UML-RT support module allows creating embedded models using UML-RT concepts. This module was designed with intention of usage by any domain specialist. ESME proves that information from the same model can be represented in a different way depending on the end user expertise and domain, by providing two different editors for the StateMachine concept. Automation of the RSARTE model import reduces the engineering effort.

BENEFITS

ESME allows interfacing domain models from non-software disciplines with the software behavior models that are described in UML-RT. It means that the main goal of this project is achieved. Moreover, the provided results can initiate global changes in the Océ software development process. ESME could remove the boundaries between domains at the level of models and unify the development process for all engineers.

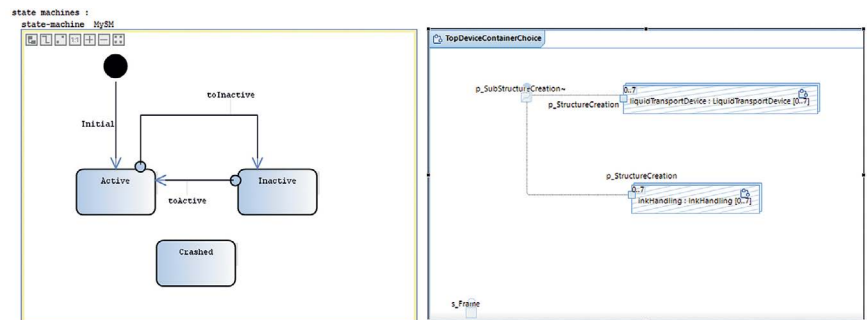
DMITRII NIKESHKIN PDEng

Domain-Extensible Model-Driven Embedded Software Development IDE

Océ is an international leader in digital document management and printing for professionals. The printing systems of Océ are developed in a highly interactive, multi-disciplinary context. Core of Océ high-end productivity print systems is the print engine, which is responsible for accurately printing images at high speed on mediums of different types. As the complexity of the print engines increases, the inherent complexity of their behavior realized by embedded software grows.

Currently, Océ uses Rational Software Architect (RSARTE) to model the software behavior and generate code for the run-time target environment. One of RSARTE's drawbacks is limitation to embedded software development. Embedded software designers work with designers from other disciplines. The interfaces to the other disciplines are increasingly formalized by using domain-specific languages (DSLs) and Integrated Development Environments (IDEs) for editing the models in these DSLs. For this purpose, Océ uses the MetaProgrammingSystem (MPS) language workbench. In order to provide interfacing at the level of models, the UML-based embedded software models must interface with these domain-specific extensions. One of the ways to solve this problem is to build ESME that can be a future alternative to RSARTE.

ESME is designed to interface the embedded software domain with any other domain at the level of models by supporting UML-RT concepts and providing RSARTE model import facilities. In addition, the code generated by ESME is suitable for the run-time target environment.



CHALLENGES

The main challenge was the lack of documentation on the calibration algorithms making it difficult to understand them. The challenge faced during redesign was to make it testable and modifiable for further automation. While I was extending the AutoStar component to support the calibration algorithms, changes in the underlying AutoStar component made the extension challenging. The fourth and final challenge was the lack of smoke tests to validate the refactored code.

RESULTS

The AutoStar component has been successfully extended to support the calibration algorithms. The correctness of the code was proven by running module tests that mimic the client behaviour. The first calibration algorithm was redesigned and due to time limitations, partially implemented. A Test-Driven Development (TDD) approach during implementation made the calibration algorithms testable. The design principles and design patterns used, reduce the cyclomatic complexity to less than five, an indicator of the modifiability of the design and code.

BENEFITS

The redesigned calibration algorithms are testable and modifiable. This makes maintaining, improving and extending the calibration algorithms easier and faster. The TDD approach resulted in generation of automated tests. These tests free a skilled software engineers time for better use, who would otherwise test the code manually for every release. Further, they ease the pressure on the limited availability of microscopes for validation. Automated tests also reduce the cost of finding and fixing defects since more issues can be caught before release.



“First, Nityanand demonstrated the feasibility to migrate all the calibration algorithms one by one while keeping the old user interface. Subsequently, he explored the design options for extending the current C++ framework with the new requirements for the calibration algorithms. The chosen option is proven by partially implementing an existing algorithm. The newly developed approach and interactive task is now being used to refactor the calibration algorithms and create a factory test program. The used TDD approach and the extendible architecture ensure less test effort and options for future task automation.”

Ir. P.L. Janson PDEng
Project Mentor

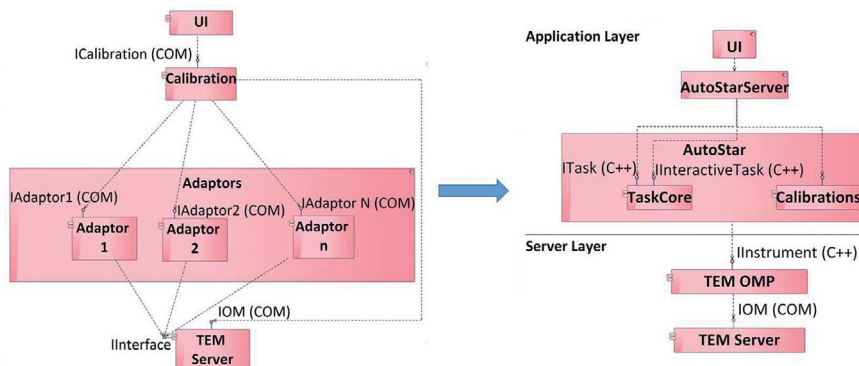
NITYANAND PANPALIA PDEng

Redesigning Calibration Algorithms for Transmission Electron Microscopes

Thermo Fisher Scientific is involved in the research, development, and production of high-end transmission electron microscopes that can generate high resolution, high quality images. To achieve such high quality, the microscopes need to be calibrated. The current calibration algorithms, developed in Delphi, are part of a legacy software stack with little or no tests making them difficult to maintain. The manual testing required for every release and the manual interactions needed to calibrate, wastes the time of a skilled engineer. The project involved redesigning the calibration algorithms to integrate into a C++ component called AutoStar, making them testable for adding new features, and modifiable for further automation.

I used an incremental and iterative approach to execute the project in two phases. During the first phase, I successfully developed a prototype to prove the feasibility of the project and address the challenge of minimal calibration algorithm documentation. In the second phase, I extended the AutoStar component to support the calibration algorithms and then initiated the redesign of one calibration algorithm using the AutoStar extension.

The calibration algorithm redesign shows that the algorithms can be successfully integrated in the AutoStar C++ component. A Test-Driven Development (TDD) approach during implementation made the calibration algorithms testable. Coverage metrics of over 90% show that I employed TDD successfully. The use of Single Responsibility and Dependency Inversion design principles as well as the template method design pattern, led to a good separation of concerns and reduced strong coupling. This allowed the redesign to be modifiable for further automation.





"Saurab has managed to deliver Cooperative Intelligent Transport Systems architecture for North Brabant. This architecture was significant for C-Mobile project, a large scale C-ITS demonstration Europe Union project. His enthusiastic and passionate approach towards learning the C-ITS domain is appreciable. His efforts resulted into successful delivery of system level architect and implementation for North Brabant. These results would be considered for the later C-ITS implementation at various other deployment sites involved in C-Mobile."

Priyanka Karkhanis
TU/e

CHALLENGES

The main challenge in this project was to understand the vast domain of C-ITS in a very short time, together with the large number of terminologies and details related to the subject. Since, the development of the architecture had begun before the start of this project, tasks were provided from the first month of the project. This led to a limited time for domain analysis.

RESULTS

The result was a harmonized C-ITS System Architecture designed with the definition of standard communication standards and protocols. Together with this, the CycleFlow application, which is a smartphone application that provides GLOSA advice to the VRUs, was developed and demonstrated. Additionally, the testing service was used to verify and validate non-functional requirements, such as security, usability, scalability and availability.

BENEFITS

The harmonized C-ITS System Architecture will help in avoiding fragmentation of the various C-ITS deployments around Europe. It can help current C-ITS implementations to communicate and share data with each other, as well as act as a blueprint for new C-ITS deployments in other cities around the world. This in turn will benefit road users and make transportation safer and managed.

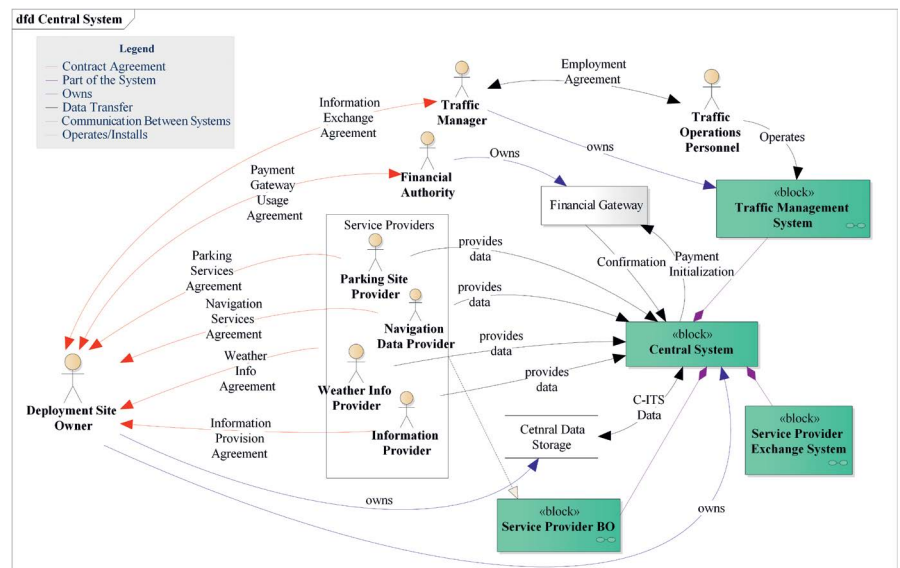
SAURAB RAJKARNIKAR PDEng

Designing C-ITS Architecture and Services for North Brabant

Cooperative-Intelligent Transport System (C-ITS) is a field that has seen tremendous progress recently. Together with cooperative systems, such as traffic management systems, traffic light controllers, roadside signals and connected vehicle on-board units, C-ITS has provided benefits by increasing energy efficiency and safety for specific transport modes. Currently, implementations of C-ITS have been deployed independently from each other with different goals, stakeholders or settings. C-MOBILE has been working to solve this problem by defining the C-ITS System Architecture that can be deployed in large scale across Europe.

The goal of this project was to contribute to the C-ITS System Architecture by designing and developing models for C-ITS Systems and Services chosen for the North Brabant region together with an implementation and test cases for the same services. To achieve this goal, the project was divided into three phases.

The first phase covered designing and developing C-ITS System Architecture based on three viewpoints, namely Physical, Context and Functional, together with the services selected for the North Brabant region, such as Road Works Warning (RWW) and Green Light Optimal Speed Advisory (GLOSA). The second phase covered the development and demonstration of GLOSA that was performed as final projects for students from the TU/e, and the third phase covered defining the test use cases required for technical validation of the defined designs.



CHALLENGES


The challenge in this project was to ensure that the EMC tool is adaptable. This was ensured by using configuration files that hide project specific details.

RESULTS

The result of the project is an easy to adapt EMC Validation Tool that was demonstrated for one of Valeo's Front Cameras. The adaptation guide details the steps to be followed in order to adapt the tool for a new Front Camera.

BENEFITS

The EMC Validation Tool saves a lot of time and money for Valeo because they do not need to develop a new tool for EMC Validation of every new Front Camera project. Furthermore, the tool helps Valeo achieve its goal of standardizing the tool chain for the Front Camera.

A portrait of a woman with dark hair and glasses, smiling slightly. She is wearing a dark blue top. The background is blurred, showing what appears to be an office or laboratory setting with some lights.

"Grace already brought a very good knowledge of software architecture, design and development with her, when she started her work on the EMC test system. Additionally, it was easy for her to gain the necessary knowledge about the automotive CAN bus technology in general and the quasi-standard CAN tools from Vector that are widely used within the automotive industry inside and outside of Germany specifically. Grace was able to accomplish her task successfully and to fulfill most of the stakeholder requirements. The result of her work has been demonstrated and verified in an EMC test setup, similar to the setup used at the EMC lab at Valeo, for an existing front camera customer project and is ready to use for future projects, just like intended."

Ir. Bernd Holste
Valeo Schalter und Sensoren GmbH

GRACE VASU PDEng

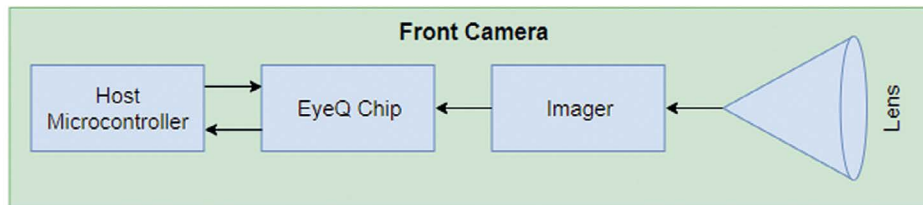
Development of a Tool for EMC Validation of Front Camera Sensors

The automotive industry is undergoing tremendous change due to autonomous driving. The Valeo Front Camera is a component that is manufactured by the Comfort and Driving Assistance group. The Front Camera is used by automotive OEMs to realize functions that are required for driving assistance and partial automation.

When light enters the camera through the lens, an image of the surroundings is formed on the imager. The image is sent to the Mobileye EyeQ chip for processing. The EyeQ chip contains sophisticated Image Processing Algorithms that help identify the objects in the image. For example, traffic signs, road lanes, other vehicles and pedestrians are identified. The EyeQ chip sends details about the objects to the host microcontroller. The host, in turn, processes this information further, and sends the results from the camera onto the CAN network.

When the Front Camera is installed in a car, there could be electromagnetic interference from other components. This interference can be detected by observing the signals emitted by the camera onto the CAN network. The aim of this project is to develop a tool to test for Electromagnetic Compatibility (EMC). The tool should be easily adaptable to all Front Cameras.

The result of this project is a tool for EMC Validation which can be adapted to work for any of Valeo's Front Cameras. It also includes a user guide, an adaptation guide and a process guide.





"Yongchao has worked on three assignments, aimed at analyzing and improving the structure of the software that controls the Transmission Electron Microscopes made by Thermo Fisher Scientific. Each assignment came with new challenges. In tackling these, Yongchao has shown commitment, inventiveness, and a willingness to learn. The results of his last assignment are used to start up a new project around the definition of a reference architecture for software."

Dennis Dams
Project Mentor

CHALLENGES

The first challenge was to work with a large code base, to learn how code and interfaces evolve over time, and how to cope with such changes. The second challenge was that the project had a relatively open scope, in which I was expected to research and identify improvement points. The third challenge was to analyze the code base, identify code patterns leading to complexity, and then use those patterns to create code transformations.

RESULTS

Three main results were achieved in this project. Firstly, a tool was designed and implemented that analyzes the import dependencies in the TEM Server code. A substantial part of the code was refactored according to the analysis results. Secondly, a third-party tool was explored to remove redundant inclusion in the C++ and COM code base. Thirdly, a tool was developed to show the reference architecture and to pinpoint the violations in the real code dependency structure.

BENEFITS

The results of this project allows Thermo Fisher Scientific to get to a better architecture, which is more maintainable, more extensible, and with less technical debt. Especially, the visualization tool, which detects violations to the reference architecture, serves as a starting point for a sequel project to further improve the dependency structure.

YONGCHAO WANG PDEng

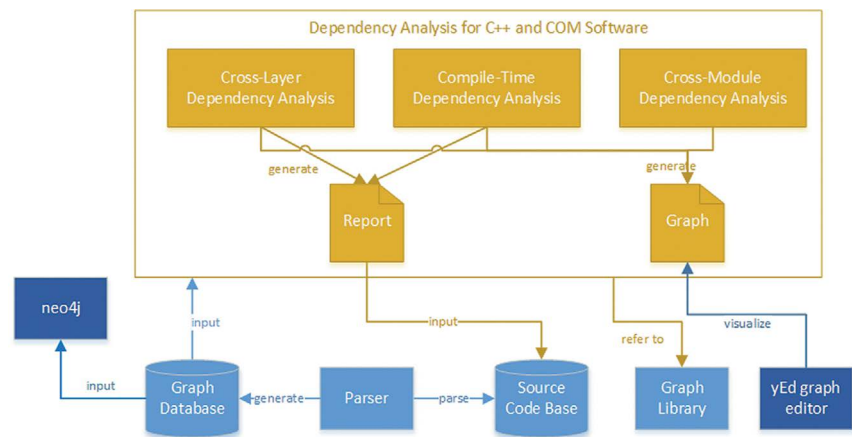
Dependency Analysis for C++ and COM Software - Applied to Thermo Fisher Scientific TEM Server

Thermo Fisher Scientific, as the world leader in serving science, designs, manufactures, and supports Transmission Electron Microscopes (TEM) that provide ultra-high resolution at sub-Ångström levels.

Thermo Fisher Scientific maintains the TEM Server software system, which offers unified APIs to control all the configurations of TEMs. Over the years, numerous extension and maintenance activities have resulted in a server with six million lines of code with a sub-optimal source

code dependency structure. There is a high demand for gaining a sound overview of the software structure and for refactoring the code base to improve its structure. Therefore, Thermo Fisher Scientific collaborates with TNO-ESI to develop tools for analyzing and restructuring large code bases.

My project identifies more improvement points, extends the tool set, and further analyzes and reduces the unintended complexity of the source code dependency structures. During the project, three improvement points were identified: to get a better insight in inconsistent library reference dependencies, to remove excessive inclusion dependencies that cause long compile times, and to detect undesired dependencies that violate the reference architecture. Finally, these analyses and refactoring lead to a product with better maintainability and extensibility.



CHALLENGES


The CEX sequence models are complicated and they differ within each machine types. The main challenge was to identify the common behavior within each sequence and enhance the WLSAT design accordingly.

RESULTS

Modeling the CEX using the enhanced WLSAT framework brings new design opportunities. A new way of designing the CEX sequence is prototyped using the enhanced WLSAT and it shows a promising result. In addition, the analysis of the model results were verified against the machine traces.

BENEFITS

Through models, it is easier to show the CEX timing analysis without deploying a single line of code on the machine. It also helps software and functional design engineers to work closely to get accurate prototypes that will be used to drive less error-prone implementations.



Berihun showed with his proof of concept that validation of a chuck exchange design can be done at design time and development cycle can be shortened.

Umut Uyumaz PDEng
ASML

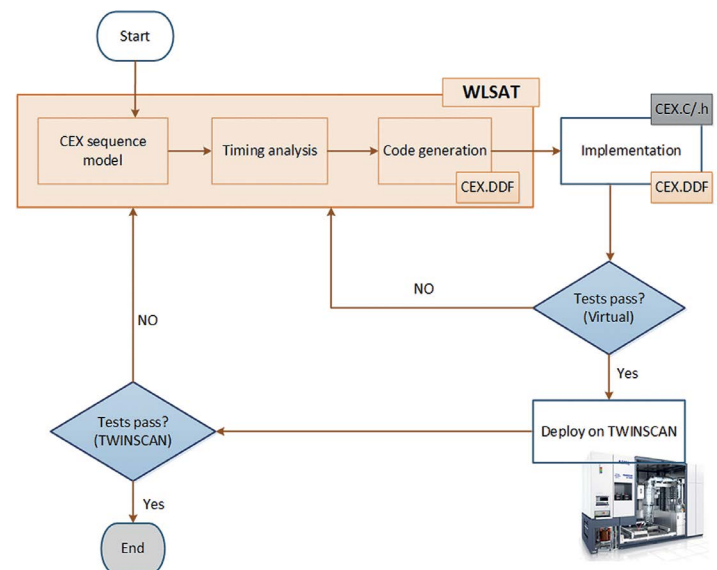
BERIHUN FEKADE YIMAM PDEng

Logistics Modeling and Analysis for Chuck Exchange using Product Line Engineering

ASML is the world's leading provider of complex lithography systems for the semiconductor industry. In these machines, plates of silicon material, so called wafers, are transported using several robots. Optimal logistics controllers are required for this transport to make system throughput as high as possible. To optimize throughput, ASML is developing a Wafer Logistics Specification and Analysis Tool (WLSAT) methodology and the technologies allowing controllers to be formally specified, automatically analyzed and even optimized. This methodology has already been applied successfully to model and analyze the input and output paths of the wafer flow logistics.

The main goal for this project was to extend an existing WLSAT methodology system so that it can model the Chuck Exchange (CEX) sequence. The specification languages were designed on the basis of the logistics flow of wafer and the domain variations with the CEX were not included. In this project, the aim is to enhance the WLSAT methodology to incorporate the new CEX domain behaviors.

As a result, the enhanced WLSAT methodology is able to model the CEX logistics domain. In addition, the WLSAT was extended with a code-generation functionality to automatically derive implementation running on the TWINSCAN machine. The enhanced WLSAT framework has an improved specification language to model the CEX domain behaviors so that the results from the model are easily analyzed.



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