




Software Technology

Eindhoven University of Technology
PDEng projects 2014



The Software Technology PDEng (Professional Doctorate in Engineering) degree programme is an accredited and challenging two-year doctorate-level engineering degree programme. During this programme trainees focus on strengthening their technical and non-technical competencies related to the effective and efficient design and development of software for resource constrained software intensive systems in an industrial setting. During the programme our PDEng trainees focus on systems architecting and designing software for software intensive systems in multiple application domains for the High Tech Industry.

The programme is provided by the Department of Mathematics and Computer Science of Eindhoven University of Technology in the context of the 3TU.School for Technological Design, Stan Ackermans Institute.

For more information, visit the website:

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Prof.dr. J.J. Lukkien

Dealing with large volumes

In 2014 Data as an important resource – a topic that was already modestly present in 2012 and 2013 in our graduation projects - has pushed through to become a dominant theme. Data can be a source of information that needs to be extracted, or it can be an increasingly important part of the control of big machines. New ways of handling, presenting or analyzing data have to be found when the sheer volume can no longer be handled by the available solutions. This provides for an interesting range of graduation topics.

Seventeen trainees have started in 2014 on a graduation project. Handling big, heterogeneous data volumes was addressed in the 'OSCAR' and 'Big Data Management Platform' projects. Methods for collecting these kinds of data for testing applications were discussed in 'Pluggable Test Data Logging and Readout'; the extraction of an underlying process from log data is studied in the 'Customer Profiles' project; the project on 'Modeling and Visualization of Trace Data' has produced a tool that supports the usage of trace data of varying formats, as well as its representation in various styles. This is also the project that won this year's Software Technology Award.

Also this year there were several projects on supporting the design process itself: 'CoDeX' and 'Coherent Tool Support for Design Space Exploration'. There were three projects from the automotive domain: 'Object Detection and Tracking for the Automotive Domain' deals with a smart method for data reduction; 'Next Generation ADAS' and 'Mechanisms for Criticality-Level Changes' deal with some of the real-time aspects of providing driver assistance.

This year's projects, as always, show that the world of Software Technology is a dynamic one and that our trainees are well prepared to face these changing challenges. To all our candidates: I wish you all the best and a successful and satisfying career.

Johan Lukkien
Scientific Director





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Challenges

Hundreds of calibration clients interact with TestLog components in order to get the needed data for every phase of them. The transition from the current way of working to a proposed one cannot happen in one big bang. Therefore, the main challenge is to develop a solution that is compatible with the existing implementation.

Results

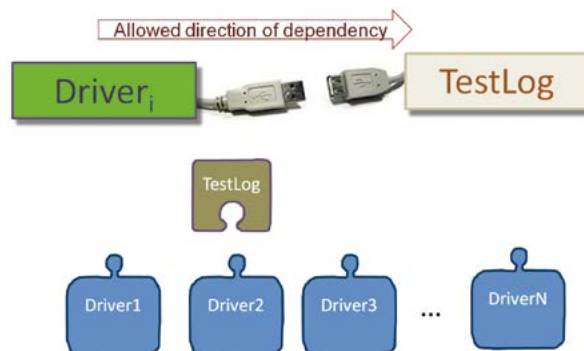
The new TestLog component offers an independent access to specific data, and thus stable, interface. Furthermore, it ensures the compatibility with the current implementation; that is, the clients are able to read TLG files that are produced either by the existing or the proposed design. The applicability of this new design was guaranteed by the creation of a prototype within the ASML system software.

Benefits

The benefit of the new design is that now it is possible to add/remove/combine/split data providers or their data without modifying the TestLog component (no change, no recompilation) and its many clients.

Christos Apostolou PDEng

Pluggable Test Data Logging and Readout Facility



“Thanks to the contribution of Christos, ASML has a new test log design that is capable of plugging in new components and component data without modification of test log itself. This design is an enabler to a modular release strategy.”

ir. P.P.A.A. Peeters
ASML

ASML lithography systems require nanometer accuracy at high speeds. Before high volume production can start, the system must go through a setup that brings it to an optimal state. This setup is performed by numerous calibration tests and a large subgroup of them involves resist based setup; that is, exposing a pattern onto a test wafer. Different steps of the latter tests use log files (TLG files) as a way of their communication. The component that is authorized to read and write to TLG files is called TestLog and the aforementioned calibration clients interact with its interfaces. In the current design these interfaces are not stable because they depend on the different data, which is provided by specific components to TestLogs. The increasing need for introducing more and more specific functionality makes this data mutable and as a result the component becomes less modular. For that reason ASML has started an investigation on its improvement.

The goal of this project is to create a new design for TestLog component, which is not dependent on different configurations (provided data and clients that ask this data) of the machine. Thus, a pluggable architecture that fulfills the new flexibility demands without forcing migration to all software components involved is needed. As a consequence there is a strong restriction that the new TestLog must be compatible with the current software clients of the TestLog component.

In the new design the data providers register themselves in the system and the interaction with TestLog is possible without exposing all the data. Furthermore, the components that own the data are delegated the responsibility of providing access to the data that the clients really need. Finally a migration strategy was created in order to achieve a smooth and risk free transition to the proposed design. The aforementioned choices are developed by following an object oriented approach and thus offering the benefits of a more maintainable and readable implementation.

Challenges

The challenge in this project was to achieve a *modifiable*, *modular*, and functionally *appropriate* architecture. The architecture has to be modifiable with the possible future extensions. The architecture has to be modular to keep the existing tools loosely coupled. The requirement for tool integration has to be functionally appropriate within the architecture. Therefore, intensive research and technology investigations were needed to find good design solutions.

Results

As a result, an automated DSE was demonstrated with help of a new Exploration Experiment tool that was designed and developed in this project. The architecture of the Exploration Experiment tool is *modifiable* with help of the Model-View-Controller and Data-Flow Architectural Patterns. Also, it is *modular* with help of the clear interface definitions between components implemented in Event-Driven architecture. The architecture is *functionally appropriate* with help of the Data-Flow Architectural Pattern.

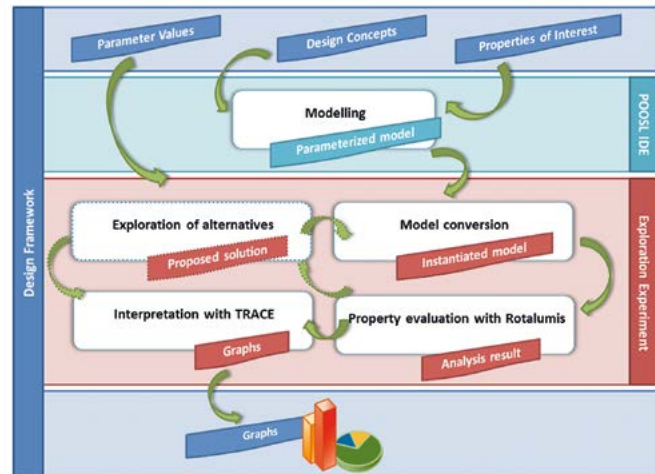
Benefits

The CoDeX project proposes a convenient way of conducting design-space explorations by performing model conversion, simulation and visualization in an integrated development environment, supporting both manual and automated search techniques. The Exploration Experiment tool is easily customizable by the ability to add other tools to its architecture.



Bayasgalan Baatar PDEng

CoDeX: Coherent Tool Support for Design-Space Exploration



“With her outstanding expertise, Bayasgalan substantially contributed to the architecture design and implementation of the Exploration Experiment tool. She also developed a much improved elegant and intuitive graphical user interface, which provided a solid basis for sophisticated demonstrators to our industrial partners. We wish Bayasgalan all the best in her future career.”

*dr.ir. B.D. Theelen
Embedded Systems
Innovation by TNO*

Embedded Systems Innovation by TNO (TNO-ESI) is a leading Dutch research group for embedded system design and engineering. Based on industry-as-lab projects, TNO-ESI drives innovation in high-tech systems technology by novel design methods and tools.

Currently, TNO-ESI actively develops and maintains three generic tools to support model-based design-space exploration for embedded systems:

1. *Design Framework* links design reasoning to concrete modeling activities and artifacts
2. *POOSL* supports editing, validation and simulation of behavioral system models
3. *TRACE* visualizes (performance) analysis and design-space exploration results

Although each of these tools serve an individual purpose during embedded system design, this project aims for demonstrating coherent use of all the three tools together. Furthermore, the project aimed to support automated design-space exploration techniques. To achieve these goals, the Exploration Experiment tool was designed and implemented by exploiting Model-View-Controller, Client-Server and Data-Flow Architectural Patterns with clear interface definitions. The new Exploration Experiment tool allows users to specify and execute manual and automatic design-space exploration experiments using POOSL simulations and TRACE visualizations, all of which being manageable through the Design Framework.



Challenges

The great challenge for this project was the exploration of the Mixed Criticality domain and the identification of the concepts that are related to the envisioned system. An additional challenge was mastering the scheduling mechanism of Linux and that of ExSched. Last but not least mapping the semantics to the design model to cover every intricate detail of the scheme.

Results

The main results of the project are threefold. A mixed criticality scheduling scheme that conforms to the norms of the automotive domain. An implementation that can be ported on most mainline versions of the Linux kernel. A normalized set of six scenarios, which test the scheme behavior irrespective of the implementation.

Benefits

The report serves as the first step towards the goals of the i-Game project and serves as one of its deliverables. Moreover it lays down the proof that the hard to achieve threesome of Systems robustness, cost reduction and certification of the automotive domain is a step closer to being conquered.

Tarun Gupta PDEng

Extending a real-time operating system with a mechanism for criticality-level changes

“I’m very happy with the results achieved by Tarun in general and the deliverable D2.4 entitled ‘Interoperable robustness measures for safety integrity levels (SILs)’ that describes the results of his work in particular.”

*dr.ir. R.J. Bril
Eindhoven University of
Technology*

Systems robustness, cost reduction and certification play an important role in the automotive domain. If there is a fault, e.g. task overshooting its allocated execution time, sufficient mechanisms should be available to safeguard the system against those. Applications of different criticalities (safety critical, mission critical and non-critical) are an integral part of modern automobiles. Typically these applications run on different and sometimes dedicated CPUs. One way of achieving cost reduction is to execute these applications on a single CPU (single core or multi core). This gives rise to issues pertaining to Mixed Criticality.

Certification Authorities (CA) tend towards pessimistic worst case behavior e.g. Worst Case Execution Time (WCET) of safety and mission critical tasks. To meet the requirements of CA and scheduling requirements of mixed criticality tasks we introduce Criticality Levels. Criticality-levels determine the WCET of a task. The criticality-levels in which a task is operational are determined by the inherent criticality of a task. A safety or mission critical task needs more assurance for CPU time than a non-critical task. Hence at a higher criticality-level a non-critical task may not be allocated any execution time (meaning either aborted or suspended). Our idea is to associate tasks (and applications in future) to Criticality Levels and provide mechanisms for criticality-level changes in a HSF.

The focus of this project was to extend a real-time operating system with a mechanism of criticality level changes. To achieve the project goal, a loadable kernel module in Linux was extended with generic functionalities of runtime monitoring, task suspend-resume and job-abort. In addition a plugin was developed to handle the criticality level changes. The semantics have been mapped to fairly generic state machine diagrams, which can be used to implement the scheme in other operating systems. A set of six scenarios was created to normalize the semantics of the scheme and used to test the system.

Challenges

A great challenge in this project was to apply different state-of-art process mining and log file visualization techniques on the ASML log files. This challenge was accompanied with gaining extensive domain knowledge in the process mining and the ASML domain. Another challenge was to deliver a portable solution. Driven by the core idea of open innovation and delivering portable solutions, TNO-ESI expected a final artifact reusable in different domains.

Results

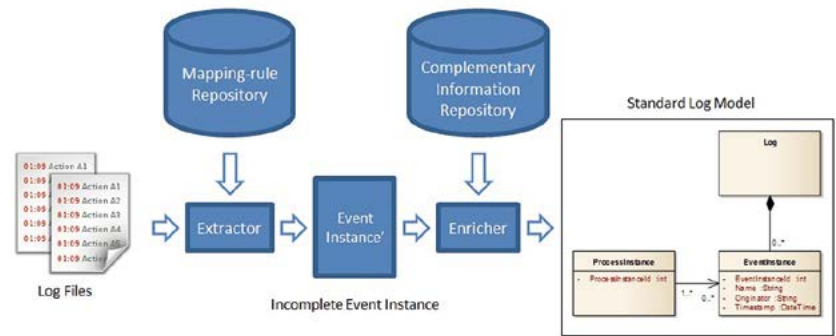
The most important project result is that extracted customer profiles in form of Petri Nets, give relevant insight into the usage of the equipment in a production environment by the different customers. In order to generate the Petri Nets, a prototype with integrated health monitoring was developed. At the same time a portable architecture that supports extracting customer profiles from different TNO-ESI clients was designed.

Benefits

By analyzing the generated Petri Nets, one can realize which of the use cases happens in the production environment and how often. Therefore, the Petri Nets can be used for test case selection and test case discovery and they directly support model based testing. Moreover, the Petri Nets give an overview of the data and control flow in the production environment, which can improve the architecture and the system design.



Miroslav Janeski PDEng



Customer Profiles: Extracting usage models from log files

“Miroslav Janeski designed and developed a prototype to obtain insight into the actual usage of systems by analyzing log files. TNO-ESI supervised the development of this prototype using ASML log files. Miroslav interacted easily with all stakeholders. Both the prototype and its output are valuable for and already in use at ASML.”

*dr. P.J.L.J. van de Laar
TNO-ESI*

Embedded Systems Innovation by TNO (TNO-ESI) performs applied research in close cooperation with its industrial and academic partners. TNO-ESI partners observe a number of trends, such as equipment becoming a node in a network, i.e., an ASML TwinScan in a Fab or a Philips MRI scanner in a hospital; and an increase of complexity needed among others to increase performance and to remove the human from the loop. These industrial trends increase the risk that a development organization loses insight in the customer profiles: the actual context and usage by the different customers of the equipment.

The customer profiles provide the insight into the production environment where the products from the TNO-ESI industrial partners are used. One of the main requirements was to design and develop an infrastructure that supports extracting customer profiles. The infrastructure design is based on certain input assumptions about the input log files. The stakeholders wanted to know whether the infrastructure behaves correctly when different input is used. Consequently, an infrastructure health monitoring was required.

The solution that meets the requirements is a prototype based on the Pipes and Filter architecture. The prototype consists of several decoupled components with dedicated responsibilities such as: Data Source, Event Extractor, Event Enricher, Event Combiner, and Event Transformer. Moreover, each component was categorized into one of the portability categories: domain-independent, parameterized, and domain-specific. Based on the portability level, TNO-ESI can estimate the effort to port the same solution for different industrial partner.



Challenges

One of the main challenges was to translate the existing domain knowledge and software to a domain model. Another challenge was to shape all this knowledge in a design, which fits the existing environment and improves the software quality.

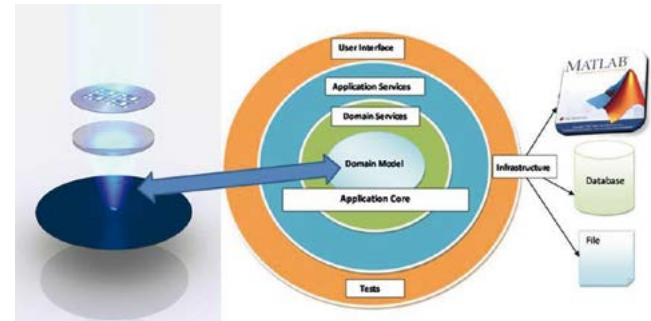
Results

A domain model for a metrology software component was implemented in a software framework. It is isolated in the core of the software implementation by using the dependency injection pattern. The implementation of the domain model using the event-driven approach creates high-cohesive components that communicate through events. It results in extensible and low-complex software, because new features are attached to the framework by listening and emitting events. The domain model was validated using data samples for the possible scenarios of the calculation.

Benefits

The domain model is embedded in the software. This bridges the gap between functional specification and software design and implementation. The domain model can be updated to add new business logic, but it does not get affected by a change in the infrastructure. The project structure allows different engineers to work together without interference to each other. Finally, the delivered proof of concept can be used as a template to re-design the metrology software components in a domain-driven and event-based way.

Vladimir Levkov PDEng



Metrology Model Driven Sequence Execution Framework

“Learning the metrology domain in a couple of months is a huge challenge. Vladimir made a big effort in order to learn it and design domain models for it in only nine months. He worked hard on this assignment that really challenged him.”

*ing. S. Szpigel PDEng
ASML*

ASML is the global leader in production of photolithography systems for the semiconductors industry. These machines provide nanometer accuracy at high production speeds. At nanometer scale, mechatronics alone are not capable to deal with distortions and drifts. That is the reason why software is involved in this task. Metrology department develops and maintains the software that measures and corrects the imperfections in the machine, in order to achieve the nanometer accuracy.

In the last years, new functionalities were added to the software in order to support the features of the new machines. The tight deadlines led to quick software implementations, which leave space for further improvements. Interlace of the responsibilities in the components created conflicts and overlapping in the daily work between the engineers that develop different software components. From the data perspective, global variables are sometimes used, hampering the maintainability and increasing the complexity of the software. In addition to data issues, a software analysis shows code duplication in several places. These issues result in difficulties to derive the business logic by inspecting the software. Furthermore, further development and maintenance became complicated processes requiring more and more resources to develop the features.

The scope of this project is the design and implementation of a domain model for a metrology specific problem, as a proof of concept. The domain knowledge necessary for building the domain model was gathered from the design documents of the current software, the inspection of the current implementation, and interviews with the domain experts. The domain-driven design approach was used to gather the domain knowledge by expressing its entities and attributes, relationships, and behavior of these entities as well as interaction of these entities with each other. The main focus of this project is on the interaction of the domain entities. The Onion architecture principle emphasizes also the importance of the domain model and puts it in the core of the implementation. Placing the domain model in the core of the software isolates it from the underlying technology.

Challenges

Due to the ubiquitous nature of luminaire deployment over a certain area (mainly a city), outdoor lighting connectivity can be used in a wide range of application contexts. POLAR architecture anticipates providing a low operational cost because of the utilization of a mesh outdoor lighting network as well as a lower price-per-Node in the absence of GPRS interface in most Nodes.

Results

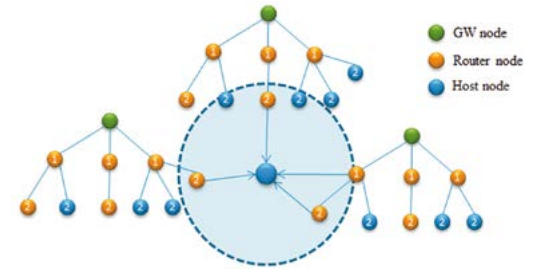
This project provides a detailed design of the bootstrapping process for POLAR architecture. It describes steps, procedures, and technology choices for a robust and thorough bootstrapping mechanism of Nodes. A demonstrator is also implemented. It follows the high level design guideline (mesh bootstrapping).

Benefits

The set of solutions proposed and implemented in this project shows that there is no single internet protocol stack that can ultimately fulfill the requirements of the intended architecture. The comparison and evaluation of mechanisms studied in this project gives a detailed understanding of the major options available for realizing the POLAR architecture. The reference implementation of DTLS relay will be used as a part of the prototype system.



Surafel Mamo PDEng



Efficient and Scalable IPv6 Communication Functions for Wireless Outdoor Lighting Networks: Mesh Bootstrapping

“Surafel managed to create an extensive overview of existing bootstrapping methods and standards, and provided us with a good overview of the design space. He provided us with a reference implementation in Java and also showed that it would work for our connectivity architecture. Our expectation is that we can take Surafel’s implementation in Q4 and integrate it as part of the prototype system.”

*dr. E. Dijk
Philips Research*

Outdoor lighting today is becoming increasingly network-connected. The rapid development in wireless communication technologies makes this progress faster and competitive. Philips Research and Philips Lighting are part of the leading forces in exploration and development of a wide spectrum of low-maintenance, high-quality outdoor/indoor lighting systems that are state of the art. City Touch is a proprietary outdoor lighting connectivity system of Philips Lighting, which is based on client-server architecture.

City Touch is an end-to-end outdoor lighting connectivity service that links a remote street light to an end operator using Internet protocol and wireless technology in a star topology. It also provides a web-based service that connects all the lighting devices in a city with a range of applications that can be used to manage and control them.

The next generation of City Touch (POLAR) is expected to employ a mesh topology with auto installation and commissioning capability, I designed a thorough bootstrapping protocol that is custom tailored to Philips’ POLAR architecture. The design brings a solution from pre-deployment configuration to the point where a new Node successfully becomes a part of a wireless network. The design is partially demonstrated with two software implementations.



Challenges

Stakeholders in the project had various and sometimes conflicting requirements to the system. Therefore the first challenge was to balance all the different stakeholder views while providing a feature-rich and generic product. Another challenge was coming from the domain of the project. For wide-format printers, emphasized in the project, image size can be extremely large reaching tens of thousands of pixels in every dimension. This requires applying special techniques for displaying of such images in order to provide reasonable system performance at the same time.

Results

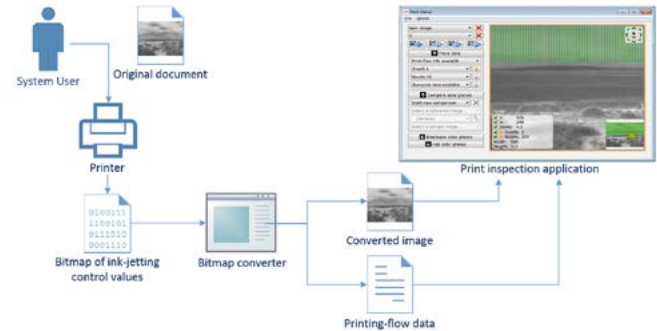
The virtual printer created provides Océ specialists with a means for printer output bitmap conversion and advanced inspection of the artifacts. The system allows displaying and manipulating full-size wide-format images. With the tool, images can be displayed on various scales, navigated, compared using various criteria, e.g., presence of pixels in all compared images. For single-color images, the result of their combined multi-color printing can be modeled. Using the printing-flow data, it is possible to indicate when a dot was jetted, by which printing element, and the number of times the dot was touched.

Benefits

The virtual printer created facilitates the process of print quality inspection. With the use of digital images instead of paper prints it is easier to view an image on various scales from an overview of the entire image to a level where individual pixels can be easily distinguished. With the extraction of the printing-flow information for an image, we make it easier to define in which pass of a print-head over the paper and by which ink-jetting element of the print-head a dot was jetted. Together with other means, provided in the tool, this lightens the process of validation and verification of the image processing software in the printer.

Vadim Marchenko PDEng

Virtual printer: An environment for digital print modeling and inspection



“Vadim has constructed a tool to reconstruct and display the bitmaps printed by large format printers.

Because these bitmaps usually are very large and such a tool should still have an adequate performance, this task is far from trivial.

He has tackled this challenge in a systematic and organized way, resulting in a versatile tool, with a well thought design, being appreciated by its users.”

dr. L.J.A.M. Somers
Océ-Technologies

Océ-Technologies B.V., a member of the Canon Group, specializes in providing solutions for enterprise printing, large format printing, and production printing. Software is an important part of a modern printer. One of the tasks for printer software is to transform input print data into a printer output bitmap of firing commands for inkjet-nozzles. To validate a new print data transformation algorithm or to verify its implementation in a printer, it is necessary to produce and inspect test paper prints. This process has certain drawbacks and limitations. First of all, it is difficult to distinguish individual ink dots on paper and to define their characteristics such as coordinates, the number of the ink jetting element printed a dot, and the pass of a print-head over the paper within which a dot was printed. Following that, the process of image comparison also becomes not trivial. Additionally, if an artifact is found, it is difficult to define its domain as there are many factors of influence for a print, including ink spreading, paper alignment, forming of the print output bitmap.

The goal of the project is to develop a virtual printer for the Research and Development Department of Océ. The virtual printer should replace test paper prints with digital images and facilitate their inspection. Essentially, this is achieved by converting a printer output bitmap into an image together with providing a tooling for the image display and inspection. Targeting wide-format printers in the project, an additional challenge is introduced as the size of an image can reach tens of thousands of pixels in every dimension. Such images are hard or even impossible to display without applying special techniques. As the conversion of a printer output bitmap is a printer-specific process, the bitmap conversion tool is designed allowing its easy extension for various printer models. Additionally, the tool is able to extract the printing-flow information related to the printer output bitmap.

The image view and inspection tool design is based on a layered architectural style. This style enables component responsibility separation on different levels of abstraction. For future maintenance, several levels of abstraction make it easier to understand the system and to find a place where a modification is needed. The virtual printer created provides Océ specialists with a means for advanced printer output bitmap conversion and detailed inspection of the artifacts on a print. With the image inspection tool, images can be displayed on various scales, navigated, and compared using various criteria. Using the printing-flow data extracted by the conversion tool, it is also possible to indicate within which pass of the print-head over the paper and by which nozzle a pixel was printed.

Challenges

Learning a lot and learning fast were the very first and critical challenges of this project. The scope of learning was Machine-Controlling Module of YieldStar architecture as well as Reactive Extensions and TDF from Microsoft. The second challenge was to adapt to ASML's way of working. The key design challenge of this project was applying two qualities of maintainability and consistency while preserving the functionality of the system.

Results

Two mockup applications were developed in order to examine the capabilities of Rx and TDF in handling dataflow scenarios within YieldStar. As a result of the feasibility study a guideline was compiled to help ASML engineers utilizing those technologies in their future (re)designs. This resulted in helping the team to quickly apply Reactive extensions for image acquisitions where timing and performance is very important. That means the results went one step further than the initial requirements (prototyping) and were delivered as a part of the product.

Benefits

Using the generic .NET libraries instead of ASML specific libraries and structure block obviously reduces the maintenance work load on the company side. Moreover, technologies like Rx bring up the opportunities to separate the in-code data-flow and control-flow, which makes it easier to read/understand the code and thus makes the design changes easier to manage. In the case of YieldStar applying Rx and TDF seems to be very effective as they are addressing the fundamental nature of the system as dataflow machine.

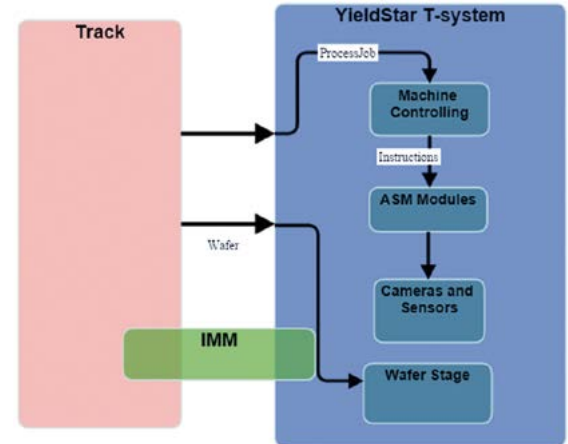
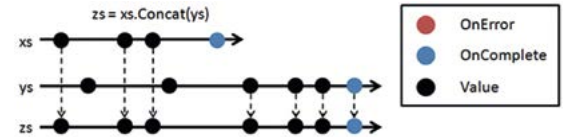


Mohsen Mehrafrouz PDEng

Data-Driven Machine Control

“Mohsen quickly gathered knowledge and learned about the YieldStar software design and implementation as well as the new .Net technologies of Dataflow and Reactive extensions. After prototyping steps Mohsen also made design improvements to the YieldStar machine control software to fully use the possibilities of data driven software.”

R. Peeters
ASML



YieldStar is a relatively young and evolving product of ASML. It measures an exposed wafer and provides accurate feedbacks for the exposer phase. Traditionally machine control software focusses on the control flow; this is also the situation within ASML and YieldStar. With the increased complexity of the machine control software more and more data is needed to accurately control a tool like YieldStar. In other software application areas, like web applications, these similar problems are addressed by more data-centered solutions applying design patterns like producer-consumer or pipes and filters. This approach has resulted in standard implementations for these patterns. Within .Net now two of these implementations are available: Dataflow and Reactive extensions. The project is about prototyping these new .Net implementations within the context of machine control software and embedded systems for the YieldStar.

A feasibility study was defined as a result of the requirement elicitation phase. The goal of this study was to explore the mentioned technology following a data-driven approach. A number of measures were defined to quantify the capabilities of each technology and eventually be able to qualify them to be applied to YieldStar code base. The initial non-functional requirements of the project were broken into more concrete and measurable pieces. For example, separation of control-flow and data-flow, less explicit use of multi-threading and replacing ASML specific code with generic C# code were amongst the measures by which the maintainability of the results is evaluated.

On the other side a comprehensive understanding of the behavior and structure of Machine Controlling module was required in order to make design opportunities and challenges more visible. Having the best practices in Rx and TDF as well as the dataflow scenarios within YieldStar make it possible to initiate the final phase of the project that introduces design improvement and implements the prototypes.



Challenges

The first challenge in this project was to understand the real-time requirements of iVSP and to choose an appropriate OS for its development and execution. Not less challenging was the implementation of the real-time application, because it was sometimes needed to intervene in the kernel functionality. The final challenge was choosing an efficient method to evaluate the developed application.

Results

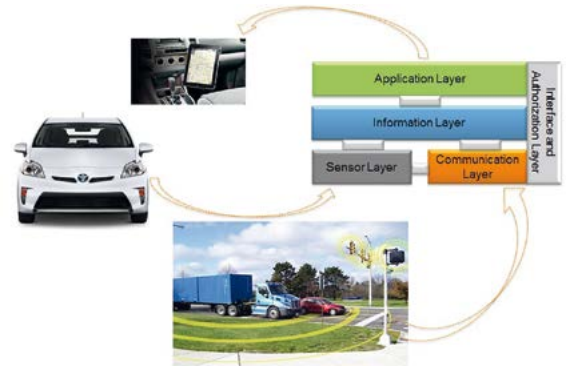
The main result of this project is the real-time prototype of iVSP, the predictability of which was improved compared to the previous version. This project had also several research deliverables including the evaluation results of the OS and of the developed application; a method of evaluation of the real-time behavior; an approach showing how iVSP can be used to serve the needs of different ADAS applications.

Benefits

As it was intended, the real-time version of iVSP expanded the possibilities of iVSP, allowing the support of more demanding ADAS applications. Thanks to its firm real-time behavior, iVSP now can be used in ADAS applications that are considered safety critical. Being implemented on a Linux-based system, it also reduces the costs of development of such ADAS applications.

Mari Mnatsakanyan PDEng

Next generation Advanced Driver Assistance Systems: Real-time platform for ADAS development



“Mari contributed to the development of iVSP by examining the steps to be taken to make iVSP (more) predictable. Her results, in the form of studies and experiments, provide insights in how iVSP can be applied and what we can expect from iVSP. Her results help TNO to strengthen the basis of iVSP and continue with developing and deploying next generation cooperative ADAS systems, as well as further improving iVSP itself.”

***dr.ir. T. Bijlsma
TNO***

TNO has developed a layered architecture called *intelligent Vehicle Safety Platform* (iVSP) as a scalable and flexible way for the execution of *Advanced Driver Assistance Systems* (ADAS). Running on a Linux platform, iVSP was able to support ADAS applications not requiring strongly predictable behavior. The goal of this project was to realize predictable behavior for the lower layers of iVSP, to enable support for ADAS applications that involve vehicle actuation and reactions in bounded time. Examples of such applications are *Cooperative Adaptive Cruise Control* (CACC) and *Automated Emergency Braking* (AEB).

First of all, the underlying operating system (OS) had to be altered to provide low latencies and predictable processing times. Second, the layers in iVSP that are responsible for sensory acquisition and vehicle actuation had to be implemented using the services of the new OS. Finally, the improvement in predictability of iVSP had to be validated by measurements.

The applied solution was the installation of a real-time extension of Linux called Xenomai and the development of the real-time version of the iVSP layers on this system. The predictability and responsiveness of iVSP was validated by simulations and experiments. Taking the jitter and its standard deviation as measures of predictability, improvements have been shown. In separate cases, the improvement of standard deviation was up to 100 times and jitter up to 200 times. These validations have been performed for idle and stressed systems.

Challenges

The goal of the project was to extend the WFS with WEX Simulation, in order to increase the test coverage of the software in the development environment. The main challenge was to connect two simulators, which are part of two subsystems, having different ways of working and testing objectives, via a minimal interface.

Another challenge was to create an intuitive extension to the Domain Specific Language describing the hardware concepts of the wafer handling subsystem.

Results

The results of the project were a design and an implementation of four prototypes leading to the connection of the two simulators. To support this connection the WFS has been extended with the hardware concepts of the other subsystem. This included extensions to the DSL, the code generator, and the tests.

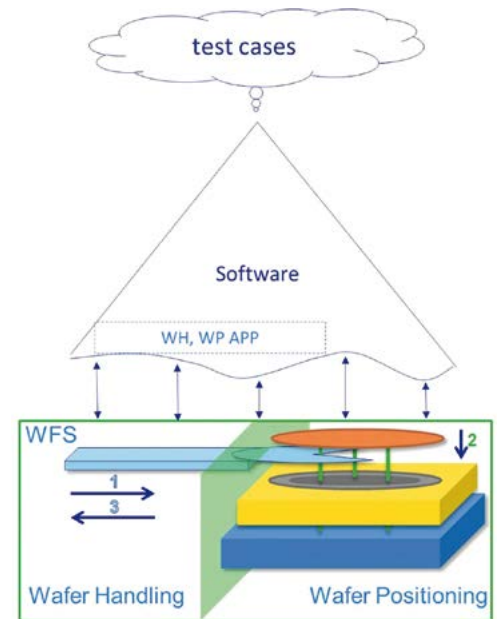
Benefits

The benefits of the WEX Simulation is that the WEX can now be tested in software, without needing the hardware, the WEX can be tested with harmful behavior without damaging anything, the WEX Simulation enables calibration, performance and diagnostics tools to be tested, and the WEX Simulation allows testing of timing behavior of the complete wafer flow. This complete package of benefits saves valuable testing time on a testing machine.



Jonathan Nelisse PDEng

Wafer Exchange Simulation



“The resulting product designed and developed by Jonathan allows the testing of interfaces between Wafer Handler and Wafer Positioning module early in the software development lifecycle, which was previously difficult and expensive due to lack of simulation.”

*ir. E.M. Xavier Lobo PDEng
ASML*

ASML invents and develops complex technology for high-tech lithography, metrology and software solutions for the semiconductor industry. The technology consists of complex hardware that is controlled by software. Testing of the software is crucial to ensure that ASML’s key drivers, namely, throughput, imaging, and overlay, are according to specification. It also ensures machine-availability, i.e., reliability, diagnostics of errors, service, and recovery. Testing this software ranges from using the real hardware to simulators. Testing on real hardware is a challenge because of scarcity of hardware available for testing and testing bad-weather scenarios. Therefore, there is a need to improve the functionality of simulators.

One such simulator is the Wafer Flow Simulator (WFS), which simulates the flow of a wafer in the Wafer Handling (WH) subsystem. The WH receives the wafer from the outside world and loads it to the Wafer Positioning (WP) subsystem, which positions the wafer for measuring and exposing. The Wafer Exchange (WEX) specifies the protocol for transferring the wafer between the WH and WP. Currently, the testing of the WEX software is executed after integration of these subsystems on the real hardware. This project provides an extension to the WFS to enable testing of the integrated software of the two subsystems in a software-only environment, which is widely available and relatively cheap.

The solution direction is to extend the WFS to describe and simulate the WP hardware required to execute the WEX. The result is that the WEX software can be tested before deploying the software to the real hardware, hence saving valuable machine time and increasing test coverage.



Challenges

Combining all the different design constraints and providing the optimal solution on the upgrade of the distribution's infrastructure, which complies with the needs and the responsibilities of the four Océ internal departments that had direct interest to the project. The technical design decisions for the infrastructure of the distribution were important aspects of the project. Moreover, the development of the prototype required a wide range of different technologies.

Results

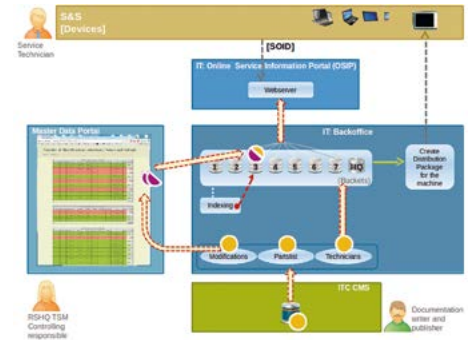
A design that fulfills Océ's plans for the improvement of the service working methods, accompanied by an extended analysis and evaluation of the design choices and alternative options. Furthermore, a prototype that demonstrates the context-dependent distribution of the technical manuals in real life use cases and gives a clear view of the responsibilities and the future work to each of the interested parties.

Benefits

The project triggered and solved complex business and technical choices lining up the plans of the four departments on the future vision of the infrastructure. The proposed design of the infrastructure upgrades and expands the current customer support methods of the company, while it adds features that are missing from the current approach. The future steps for the implementation of the new infrastructure are specified and include the upscale and engineering of the project's prototype.

Konstantinos Plataniotis PDEng

An Infrastructure for Context-Dependent Distribution of Technical Manuals



“In the end, the satisfaction of all the stakeholders who had their own agenda, is one of the big things that Konstantinos achieved, we have a prototype that demonstrates what the direction of everyone should be for the distribution of the technical manuals.”

*ir. T.F.P. Paffen PDEng
Océ-Technologies*

The infrastructure for context-dependent distribution of digital technical manuals to the service technicians demands the appropriate functionality in order to manage the releases of the technical manuals, to apply filtering preferences, and to distribute them to the technicians. The Master Data portal, through which the approval of released manuals will happen, is designed and integrated with the infrastructure. The process that the infrastructure supports is responsible for integrating with the current technical service manuals publishing mechanism. It also takes care of creating variations for each manual and of broadening the access channels to the technicians.

The improvements of the service working methods that this project is investigating in order to deliver the customers high print system uptime are:

- To broaden accessibility to the service information. The technical manuals should be accessible by a technician through a variety of devices and should be always up to date.
- The customized compilation of the technical manuals. The technical manuals consist of generic content and region-specific content. Each regional headquarters should be able to approve through the Master Data portal which elements will be released for the technicians of that region, while the generic content will be accessible to all the technicians.

These features are missing from the current infrastructure.

This project presents the design of a solution to the above issues. The solution consists of

- The analysis of the problem and a proposed software design for the distribution that fits to the stakeholders' responsibilities, while it is coping with the limitations and the restrictions of the Technical Manual release format.
- The results of the research of the accessibility expansion that would allow the service information to be viewable under multiple generic devices.

The results contain evaluated options on possible choices and were chosen based on criteria of ease of use and feasibility of the solution. The project was the first feasibility analysis towards the extension of the manuals distribution; a new infrastructure is proposed with proven feasibility through a prototype that was implemented based on the proposed architecture.

Challenges

The entire project could be divided into two parts: TRACE Development and Exploration Experiment (EE) Development. The challenge of the TRACE development was to refactor the current code to make it more extendable. The challenge of the EE development was to provide a generic and extendable architecture for the new tool to define and execute experiments.

Results

An extended version of TRACE was released with two new features: multiple Gantt Charts comparison and design-space visualization. Additionally, a TRACE standalone application was built to support the same features as TRACE Eclipse plugin version. Moreover, a new EE tool was developed as an integrated environment to support design-space exploration. The EE tool provided a graphical user interface to define experiments and conducted experiments under a stable environment.

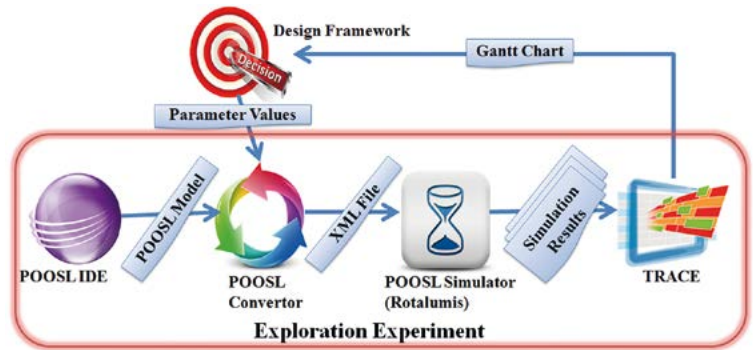
Benefits

The extended TRACE tool with its new features provides an easy way for the tool users to diagnose design-space exploration results. Furthermore, the EE tool enables a combination of design decision management and simulation-based design-space exploration. It also supports a convenient way of conducting explorations by performing model conversion, simulation and visualization automatically.



Fangyi Shi PDEng

Coherent Tool Support for Design-Space Exploration



“Thanks to Fangyi, a much improved version of our tool for visualizing performance results is released. Fangyi also contributed significantly to a new tool for defining and executing design-space exploration experiments by loosely coupling our existing tools, which provided a solid basis for sophisticated demonstrators to our industrial partners. We are very pleased that Fangyi stays with us as an expert on our software tools.”

*dr.ir. B.D. Theelen
Embedded Systems
Innovation by TNO*

Embedded Systems Innovation by TNO (TNO-ESI) is a leading Dutch research group for high-tech embedded systems design and engineering. It strives to improve embedded systems engineering by doing industry-as-laboratory research projects. Contributions from these projects have resulted in three generic tools: Design Framework, POOSL and TRACE. These tools are actively being professionalized to improve industrial applicability.

One goal of this project was to extend TRACE with two features: multiple Gantt Charts comparison and design-space visualization. Another goal was to demonstrate cooperation between the three tools as an integrated environment for design-space exploration. The integrated environment, called Exploration Experiment (EE), required a user interface to define experiments by specifying a sequence of a model and executors. It also aimed for a stable environment to execute well-defined experiments.

The solution of extending TRACE in a structured way was to apply the Model-View-Controller architecture pattern. The key solution of developing EE for integrating the ESI tools was to develop a web application for defining experiments and a server for executing experiments. Additionally, a generic and extendable architecture for EE was addressed.



Challenges

The main challenge of this project was designing a generic and, at the same time, an extensible and configurable framework for visualizing multiple trace data types. The challenge in the design process emanated from the lack of crisp understanding of the domain concepts associated with generic and configurable visualization tools. Furthermore, some of the technologies used within ASML were not fully mature, resulting in difficulties in making good design decisions.

Results

Three main results were achieved in this project. First, generic and extensible trace data and visualization data formats were defined. Second, generic and extensible transformation modules that transform data between different data types were defined. Third, an extensible visualization tool based on the first two results and Eclipse IDE was realized.

Benefits

ASML utility application developers can now easily develop a visualization tool for any type of trace data. A sample application developed in this project shows that the majority (more than 80%) of the code required to make a new visualization tool can be imported from the results of this project. This will dramatically reduce the development time and cost of making new visualization tools.

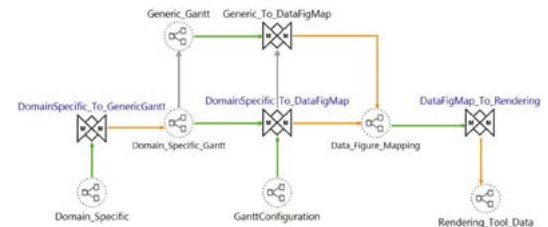
Abelneh Yirsaw Teka PDEng

Modeling and Visualization of Trace Data

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C	7	4	53.0	70.0	0	2	Orange
C	8	4	73.0	95.0	0	2	Red
C	9	3	20.0	110.0	0	2	Green
C	10	13	100.0	140.0	0	2	Red



“Abelneh has delivered a usable tool in which he showed the added value of Model Driven Engineering. In this he has demonstrated two properties that will be very fruitful in his further career:

- 1) the ability to create real working tools and programs and*
- 2) the perseverance to learn and master new skills and technologies.”*

dr.ir. W. Alberts PDEng

ASML produces complex lithography machines that need careful calibration to maximize the quality and quantity of their wafer throughput. The primary input for this calibration process is trace data generated by the machines’ components. To visualize these trace data, ASML engineers regularly utilize Gantt chart based visualization tools.

Different components of lithography machines use different data formats to log their behavior. Accordingly different departments in ASML are using different trace data visualization tools. Developing and maintaining multiple visualizer tools is costly, time consuming and reduces interoperability.

This project is aimed at defining a generic and an extensible trace data model. Based on the generic trace data model, development of an extensible visualization tool was also a key requirement. The generic trace data format and the visualization tool are developed using Model Driven Engineering (MDE) methodology. To capture generic trace data attributes and visualization figures, Gantt_Data and Gantt_Figure language are defined. Furthermore, transformation modules that transform data from one format to another are specified. The extensibility of the Gantt visualization tool is verified by porting the tool into two different domains. The effort required to port the tool to a new domain was found to be very minimal (12 man-hours). This is a considerable gain compared to an average of four to six months that would have taken if the tool was developed from scratch.

Challenges

The main challenges were the heterogeneity of the hospital systems and the lack of concrete interfacing and reporting requirements. Instead, it was required that the proposed solution be extensible to support future use case requirements. In addition, the vast number of technologies and tools available poses a challenge to the designer who needs to make a selection.

Results

OSCAR resulted in a data warehouse solution that links and hosts the collected hospital and telehealth data. The solution has the form of a virtual machine and is ready for deployment at hospitals. Hospital data are collected with the use of a modular service-oriented data collection component by exposing web services described in WSDL. The data is linked, loaded, and stored within the OSCAR data warehouse, where it is available for reporting.

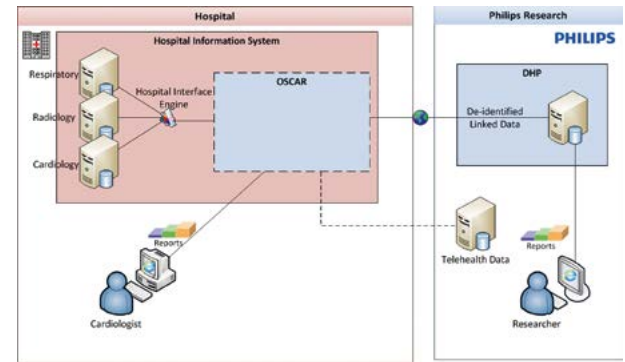
Benefits

OSCAR provides Philips Research with a working prototype of an analytical system able to integrate data from hospitals and Telehealth services. The prototype is ready to be deployed at hospitals to provide reporting to the clinicians and become a source for linked hospital and telehealth data for Philips. In addition, the extensibility characteristics of the solution enable an iterative process of refining the data inputs and provided reports according to future stakeholder demands.



Panagiotis Thomaidis PDEng

On-Site Customer Analytics and Reporting (OSCAR)



“Thinking out of the box, Panagiotis proposed a design that welcomed changes [...] His solution was ingeniously crafted, easily configurable, and seamlessly integrating into the Hospital IT infrastructures.”

C. Xanthopoulakis PDEng
Philips Research

The H2H business unit of Philips Research takes pride in delivering innovation that matters to people’s lives, with a particular focus on Telehealth services and applications. Towards improving their inventions, they are constantly looking for the facts and figures that allow them to evaluate the efficiency and efficacy of their remote patient health monitoring applications. In order to close the loop between patient hospitalizations and home tele-monitoring and investigate the Return on Investment for Telehealth services, the patient clinical and telehealth data need to be combined.

Stringent privacy and data protection laws expressly forbid the export of personal patient clinical data outside the hospital premises. This entailed that clinical and telehealth data analysis and linkage must take place on-site, notwithstanding the variability and complexity of Hospital IT Infrastructures.

The solution focused on delivering a concrete system that is easily extensible and poses as few constraints as possible to future extensions. The system follows a modular, service-oriented design for the data collection, while using off-the-self data warehousing tools for storing the data and exposing the reports thus supporting the stakeholder requirements in the best way. The whole solution is deployed as a virtual machine, aimed to be deployed within the hospital virtual machine infrastructures rendering it portable to any such organization.



Challenges

The SSTAF project had both technical and non-technical challenges. As an important technical challenge, SSTAF had to accommodate different applications. Complex applications were involved and it was needed to understand how they worked. The strategy was chosen to reuse the available applications as much as possible instead of developing the new ones. As an example of non-technical challenges, SSTAF faced some organizational problems that had an impact on the project. However, the project was continued with the same initiative and goal.

Results

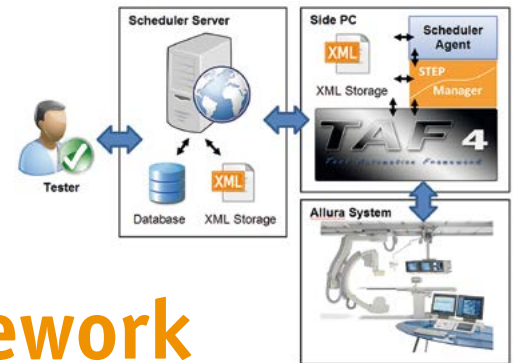
The Scheduler System for Test Automation Framework has gone through all the phases of the development cycle. The requirements were defined with the user in the starting phase of the project. Then, several common off the shelf tools and related Philips tools were explored in the investigation phase. After the selections, several architecture and design decisions were made in the design phase. Then, the implementation of the system was made, followed by verification and validation.

Benefits

The design decisions taken in the development of Scheduler System provide several advantages. By using several tools available in Philips, the system can be used and integrated easily with Philips environment. By having a website, the system is easily accessible by a user. By having the activity block template, the tester can reuse the sequence of activities. Finally, by having Smart Agent, the scheduler system is more reliable and it can operate without server connection.

Djohan Wahyudi PDEng

Scheduling System for Test Automation Framework



“The entire project entails the scheduling and reporting of installation tasks, and the installation and configuration of test environments. Djohan created the scheduling and reporting part of the project. He investigated the use of Common off the Shelf (COTS) tools to do the job, as well as existing tools that are used within Philips. He developed the missing pieces and integrated these with the existing tools. With his contribution, we are now able to compile a set of tasks that are required to install and configure a test environment and to run a series of tests at a given time.”

*ing. A. Visser
Philips Healthcare*

An Interventional X-ray (iXR) system provides real time X-ray imaging with high image clarity and low X-ray dose. After several years of development, the iXR System has become complex. In order to verify the correct operation of the system, the system integration and test group performs extensive testing on a variety of test environments. The preparation of these test environments is a time-consuming and labor-intensive activity. The system integration and test group wants to automate this activity. This project is created and defined to solve this problem.

The project goal is to automate the System Integration and Test in Allura Xper System. The project aims to provide a scheduler system that will run the preconditioning activities (installation, configuration, customization, calibration) and test activities automatically.

Common off the shelf schedulers and the related Philips tools are explored in the start of the project. The scheduler system consists of a custom scheduler tool and several related Philips tools. The architecture, design, and implementation of this project are made based on the tools used. The scheduler system has a scheduler website as the user interface. Therefore, it provides easy user access. The scheduler system integrates with TAF, an existing Test Automation tool, for the execution of preconditioning and test activities. The scheduler system provides interfaces to TAF execution. After the execution, the results are collected automatically. The complete system has been tested and verified.

Challenges

Computer vision is not an easy domain to grasp. The first challenge of this project was to get familiar with various feature extraction methods, artificial intelligence and machine learning techniques that enable object detection and tracking. The second challenge was to design and implement different vision processing pipelines for major automotive use cases from scratch. The third challenge was to gain insights about the details of feature extraction methods that provide the most generic solution for all use cases.

Results

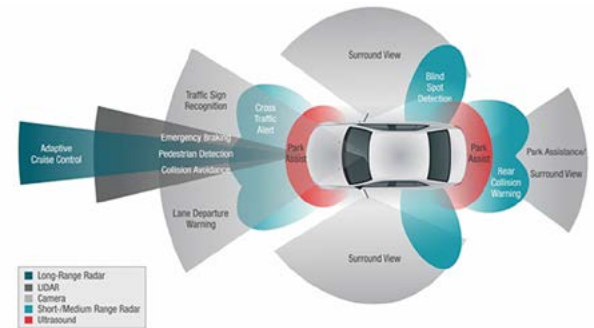
A vision processing pipeline was designed and implemented covering all major automotive use cases, namely vehicles, pedestrians, traffic signs, and lanes. The current system was designed based on the Pipes and Filters architectural pattern. The system is modular, extensible and reusable. In addition, the functionalities of the automotive use cases can be extended by adding new filters with minimum effort. The system allows recombining different filters and enables visualization of the object detection and tracking results.

Benefits

This project has created an understanding about how feature extraction methods work in practice to detect and track vehicles, pedestrians, traffic signs, and lanes. These methods were compared to each other with respect to their suitability and effectiveness in an automotive context. The comparison was carried out against challenging automotive images by using state-of-the-art datasets and evaluation methods. Lastly, data reduction and CPU load of the pipeline steps were analyzed for a possible smart camera chip solution.



Suleyman Yildirim PDEng



Object Detection and Tracking for Automotive Domain

“With an excellent attitude of perseverance, determinism, hard work, and focus on practical results, executed with a friendly personal style, Suleyman has delivered the insights that we wanted to achieve. Therefore from my side I extend my warm thanks to Suleyman.”

*dr. G. Daalderop
NXP Semiconductors*

Advanced Driver Assistance Systems (ADAS) are systems to help the driver in the driving process. ADAS are one of the fastest-growing application areas in vehicles today. Three different functions of ADAS can be distinguished: *Sense*, *Think*, and *Act*. *Sense* monitors the environment around the automobile with various sensors. *Think* evaluates the information gathered by sensors. *Act* performs the desired action. A variety of smart sensors has become available, including radar, lidar, ultra sound, and video cameras that monitor the environment around the vehicle. These sensors assist the drivers by providing information and support ADAS functionalities such as object detection and tracking.

Camera-based systems have immensely progressed in recent years and will be an indispensable part of ADAS. The trend in cameras is the increase in camera resolution towards High Definition (HD). This trend increases the capabilities of the camera in terms of the quality of the captured images. However, HD cameras produces large data streams (e.g.: 3 GB/sec), which is not easy to handle for the in-vehicle network. Therefore, innovative methods need to be investigated for smart compression which reduces the data rate coming from the HD cameras.

For that reason, NXP started an investigation into the principles, capabilities and future requirements of smart camera systems, being able to detect and track objects with a large degree of accuracy and confidence. In this project, insights about the feature extraction methods for object detection and tracking for automotive domain were gained. Various methods are compared with respect to their suitability for the major use cases, namely, *vehicles*, *pedestrians*, *traffic signs*, and *lanes*, especially for data reduction.



Challenges

Advanced electron microscopes and image processing applications generate large amount of data in various structures and file formats (data types). Moreover, metadata produced by these applications is constantly changing. The main challenges of this project were providing a solution to access metadata of the image files with diverse/ unknown structures, to deal with changing nature of metadata, and to select a database that can accommodate metadata from different data structures. Finally, the solution had to be extensible to new image data bases.

Results

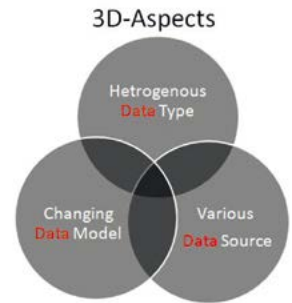
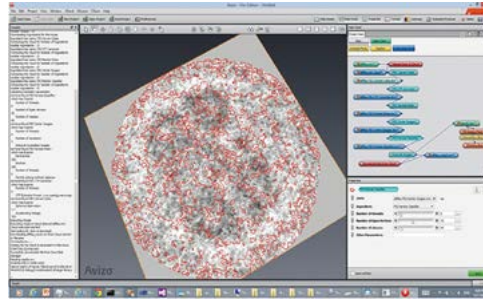
The proposed framework is open to user-defined data types. In this framework, metadata from different file structures is stored in mongoDB, a database with flexible schema and ability to search based on complex conditions. Another contribution of this framework is in providing a well-defined extension point to establish connection to external data sources.

Benefits

The deliverables of this project serve as an additional component for PALLAS, an image processing and data management platform in FEI, to make it able to absorb different data types and connect to external data sources in a consistent and clear manner.

Parisa Zahedi PDEng

A Big Data Management Platform for Rapidly Changing Environments



“Parisa had a lot of ground to cover. When we started the project with her, we had no clear idea or vision on what we exactly wanted, let alone on how to do that.[...] I trusted her to make the right ones [decisions], and this thesis proves she did. Writing the thesis proved the greatest challenge; it is difficult to find the right phrasing to explain complex ideas and trains of thought, but once done right is very satisfying.”

dr. R. Schoenmakers
FEI

FEI is a premier provider of electron and ion-beam microscopes as well as microscope/ image processing applications that are able to acquire, analyze, and modify the images with resolutions down to the sub-Angstrom (one-tenth of a nanometer) level. Storing, processing and managing of a large amount of data generated by these applications are aspects of the well-known data management and processing problem referred to as Big Data. In addition to that, FEI deals with two other problems: Changing environments, meaning that the file types and image processing algorithms are constantly changing, and high performance computational issues due to very large size of each dataset.

Looking for a solution which addresses all three aspects in an integrated fashion, FEI developed an integrated prototype framework to manage, process and visualize microscopy data. The main goal of this project is to cover a number of shortcomings of this prototype with respect to big data management. Precisely speaking, this project is aimed to investigate, design, and prototype a solution to tackle three main issues: heterogeneous data types, changing data models, and various data sources.

Heterogeneous data types refer to diversity in the type of content (e.g. image files). The aspect of changing data models addresses the changes in the metadata of file types. New versions of image processing/microscope applications generate new metadata or change existing ones. Various data sources cover easily connecting to external databases.

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