Software Technology
Eindhoven University of Technology
PDEng projects 2012
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The year 2012 has proven to be another year full of interesting design challenges for the Software Technology PDEng candidates. Eighteen more candidates have successfully completed their design project this year. The results of seventeen of these projects lie before you. When we look at the projects that have been carried out we see that many of them focus on providing tools and support for making better use of what is already available. We see examples of enhancement of support for better designs or a better design process, of user interface layers and architectures to improve usability of simulators or frameworks for designers and developers, and of solutions for uncovering or sharing various kinds of information.

Another striking feature is the great variety of domains that have been addressed in the projects. One project deals with the wealth of images that is produced by electron microscopes, another one makes sense out of the tens of millions of short messages being exchanged in the social media. One project uses a domain specific language to model the performance properties of a printer component and simulate its behavior, another takes the required performance of a collection of applications as a starting point and deduces the required amount of resources from it. There is a project that enables the usage of common services in the cloud by providing virtual network connections; another one promotes a legacy computational kernel to a computing service. Needless to say that the latter does not concern a standalone application but one that is used by many different applications. These are only a few examples, and you will discover many more in the book.

The fact that the final projects proposed by the high tech industry are diverse and complex, requires our trainees to deliver products that meet high requirements on quality attributes such as maintainability, ease of use, performance and extensibility. It also demonstrates that the industry has high expectations of our graduates and wants them to live up to that. We are proud they do. To all candidates: I wish you all the best and a successful career.

Johan Lukkien
Scientific Director
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, such as real-time embedded 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: www.3tu.nl/sai/st.
Challenges
Modeling data paths and evaluating different design possibilities to find out the best combination between software and hardware, is a long and difficult task. Data path designers need tools to support this job; they were provided with the DPATCH tool set, but this still needed to be enhanced in order to enable it to model real data path cases with different characteristics. The challenge was to introduce the needed enhancements in the Simulator application of this tool chain. Additionally, to prove that it could be used to model real data path cases.

Results
The DPATCH tool set has been enhanced, adding to the Simulator the possibility to process data with different levels of granularity, and perform impositioning. Additionally, the performance of the tool has been improved, resulting on a diminution of 70% of the total execution time during a simulation. The tool chain was used to model and simulate real data path cases, which were also validated with models created in using other modeling tools.

Benefits
The Simulator of the DPATCH tool chain has been improved, providing new features which make it usable to model real data path cases with different characteristics. The tool performance was improved, and its accuracy was validated. Thus, data path designers count now with a tool which provides support to make the data path design process more efficient.
Data path design is an important phase during the design of a new printer. A data path is the path followed by an image for its manipulation, since the moment it is received in the printer, until it is released for example in the tray of the printer. It is a combination between each of the software processing steps performed during the path, and the hardware platform where these steps are executed. The Data Path Analysis Tool CHain (DPATCH) was created with the aim to support the data path design process at Océ. Nevertheless, after its implementation it had only been used in the creation of not real data paths cases. In the context of this project, the tool chain was enhanced and introduced among data path designers with the creation of real data path cases.

**Enhancement of the DPATCH Simulator**

The DPATCH tool chain is composed by three tools: the DPML Graphical Editor, which is an application with a user graphical interface where data path models can be created and edited; the Compacter, which is an application that translates models created in the editor to a format that can be understood by the Simulator; the Simulator, which is an application used to perform simulations of a data path model, based on the description of a scenario, e.g. print 20 A4 pages. The enhancements introduced to the tool chain were implemented in the Simulator, enabling it to process data using different levels of granularity, and performing impositioning of pages.

**Performance improved and creation of new models**

Two real data path cases were modeled, simulated and analyzed with the new version of the tool chain. The creation and simulation of these models was an important procedure for the validation of the correctness and accuracy of the results produced by a simulation. Furthermore, performing several experiments with the models in the Simulator allowed discovering important performance issues, which were improved. The result is a Simulator which execution time has been reduced in 70% of the original time. Thus, data path designers at Océ have been provided with a tool set which can be used to model data paths with different characteristics, and which offers a high level of accuracy and performance to carry out experiments with big amounts of data.
Challenges
The biggest challenge of this project was to design and implement a distributed, reliable, and fault-tolerant data stream processing system with the public API. The system should be able to scale to data streams as big as Twitter Firehose.

Results
The Forgestream system together with the public API have been successfully designed implemented. All functional and non-functional requirements were delivered and verified using unit testing, integration and acceptance testing. Both systems are currently deployed in the production environment and results could be observed via Jetlore API demo and the Qwhisper application.

Benefits
The Forgestream system and Jetlore API are the core infrastructure pieces of the Jetlore Inc. Several clients have already successfully integrated using Jetlore API providing the social identities of the users that are being processed by the Forgestream system. Clients utilize the processed data using Jetlore’s technology to provide richer content to their users.
Jetlore Inc. is a startup company that brings meaning to users’ growing content scattered across different social networks. The company has developed technology that can categorize short posts typical of social networks and identify mentioned topics, such as products, movies, and general interests. Their algorithms utilize social graph signals and are optimized for colloquial language and minimal textual context. Jetlore plans to consume Twitter Firehose message stream and handle tens of millions user message streams by the first quarter of 2013 using infrastructure built on the results of the Forgestream project. Results of stream processing should be available for retrieval by the client systems.

Forgestream
The goal for this project was to design a distributed, reliable, and fault-tolerant data stream processing system with the public API.

The resulting solution provides horizontal elastic scalability. It means that an increasing number of processing machines linearly affect system performance and it happens without down times. In addition, the system provides fault-tolerance. It gracefully fails over in case of errors in any of its components. Furthermore, it is designed in a such way that it is easy to add functionality in the future.

The Forgestream system and Jetlore API are successfully deployed to production environment and serve Jetlore’s clients. The Forgestream system at this moment is processing 200 messages per second on a cluster consisting of seven machines. The results of the processing are accessible via the Qwhisper application and Jetlore API.

“Sergey has successfully handled the mission almost single-handedly designing and building the entire system. We deployed the system to production this summer and have been happy to see the results: it’s fully distributed, scalable, and fault-tolerant.”

Eldar Sadikov
Jetlore Inc.

Sergey Andreev PDEng
Challenges
A Philips X-ray system ships with as many as four PCs for image and display processing purposes. The larger the number of PCs, the higher the cost of the product is. Philips wants to reduce the number of PCs by methodologically combining two or more of the existing PCs into one PC.

Results
Resource-usage modeling tools were built to enable the combining of two or more PCs into one PC methodologically. The tools are used to generate executable resource-usage models for the Philips applications. Using these models we can determine which PCs to combine into a new PC and subsequently what the capabilities of that new PC should be. Resource-usage models are produced from resource-usage measurements taken by the Resource-usage Measurement Tool. We provide a chart tool for a way of manually analyzing the measurements using charts. But the measurements are the input in to the Resource-usage-model Generator. The generated executable resource-usage models can then be run in groups on a new PC to get an initial estimate as to whether the original PCs can be combined into this new PC.

Benefits
The advantage of having these tools is that they reduce the costly and time-consuming task of porting the applications for each new PC by enabling us to work with models first to reduce the solution space. The tools enable us to quickly and conveniently analyze different software deployment alternatives for our applications. They help us to find out not just whether a group of applications fit on a single PC, but also how well they fit. The tools provide us with a methodological, maintainable, quantitative, and easy to use approach into staying in control of performance while combining two or more PCs into one PC.
Philips Healthcare makes the Allura Xper X-ray systems. They are used for both diagnosis and intervention. These X-ray systems contain software subsystems for image and display processing. The software subsystems require increasing amount of computing resources as their medical use broadens in scope and complexity. Currently the largest instance of these X-ray systems, the Allura Xper FD20/20, ships with at least four powerful PCs. As these X-ray systems continue to evolve, the number of PCs that ship with them may increase even further. The increase in number of PCs has cost as well as product compactness implications. More PCs means higher cost. It also means the product requires larger space for installation at hospitals. Currently the Allura Xper software subsystems run on separate PCs. The iXR business unit at Philips Healthcare which builds these X-ray systems is studying the possibilities for reducing the number of PCs by combining two or more of the existing PCs into one PC. This will then reduce cost and make the product more compact.

While combining PCs, it is important to have tools for studying the effects it has on performance. We call this being in control of performance. One approach for being in control of performance is through building resource-usage models for your applications and using these models to easily explore the design space for optimal software deployments. A resource-usage model provides a single view on the resource-usage behavior of an application over all its use cases.

To be able to build resource-usage models you have to have a tool for measuring resource-usage at the required level of hardware abstraction. Therefore the first step is to build a tool which enables us to measure and record the resource-usage behavior of our applications. We built a resource-usage measurement tool for this purpose. Once we have resource-usage measurements for our applications, we can build resource-usage models. We built a resource-usage model generator for generating executable resource-usage models for our applications. By using the resource-usage measurement tool and the resource-usage model generator, we can generate as many executable models as we need and experiment with various deployments by running these models in groups. These tools together help us achieve our goal of being in control of performance while combining PCs.
Challenges
The goal of this project was to investigate concepts, ideas, and technologies that can deal with very large datasets in the field of data modeling and analysis for nano-scale imaging applications. The traditional techniques for storing and processing information become inefficient when Big Data are considered and novel solutions need to be found. To deal with these challenges smarter data models had to be identified and frameworks had to be re-designed in order to be suitable for distributed computing.

Results
The results of this study present a novel concept for a multidimensional, multimodal data structure that can host information from various sources and with diverse characteristics. Moreover, families of algorithms that are used in electron tomography were ported to the MapReduce/Hadoop framework and deployed in very powerful computer clusters giving insights on the use of the technology.

Benefits
The presented data model concept can serve as the starting point for the creation of the desired cross-instrument standard that will enable new opportunities. Additionally, the insights gained by the Hadoop investigation can be utilized in order to develop cluster/cloud image processing applications that will be Big Data aware.
FEI Company produces electron and ion-beam microscopes along with tools for nano-scale applications. FEI’s scientific instruments’ acquisition capabilities advance continuously, generating larger amounts of data from multiple sensors. At the same time there is the demand that all these data should be stored and processed – every electron counts.

Solutions need to be found in order for FEI’s clients (such as researchers in such diverse fields as industrial and academic materials research, life sciences, semiconductors, data storage and natural resources) to be able to utilize all the available knowledge. This project tries to answer the “Big Data” challenges on data modeling and data analysis, with a focus on electron tomography applications.

Hypercube: A novel multimodal, multidimensional data structure
Combining information from different instruments or different sensors on the same sample can provide insights otherwise unobtainable. However the absence of a common data structure that can host information from different sources and with diverse characteristics makes this task very hard to realize. To answer this problem we documented a novel concept for a data hypercube that can store and combine measurements based on their spatial and temporal co-ordinates. The described idea can become the basis of a cross-instrument standard that will allow the realization of complex use cases.

Hadoop: The popular distributed computing framework utilized for scientific image processing
Hadoop is a highly-adopted, scalable, highly-deployable distributed computing framework. Hadoop is very popular in Web analytics and the abstractions that it brings to cluster/cloud computing can be very beneficial in other domains, like the scientific image processing applications of FEI. In order to prove that Hadoop can be used by this kind of applications several demonstrators were developed to exhibit how the relevant file formats and the relevant algorithms can be ported to the Hadoop platform and the MapReduce programming model. Furthermore the compatibility of Hadoop with other data management frameworks that are being investigated by FEI was ensured. Extensive profiling in very powerful computer clusters\(^1\) showed that with the help of Hadoop, scientific image processing algorithms can deal with massive data sets in reasonable time.

\(^1\) The profiling was performed on Big Grid’s Hadoop service, which is managed by SARA and financially supported by the Dutch national science foundation, NWO.
**Challenges**
The project can be characterized by three challenges. The first challenge was getting familiar with the state-of-the-art algorithms that are involved in 3D reconstruction. The second challenge was reusing and extending the highly-optimized parallel implementation of the algorithms. The third challenge was to interact with the agile open-source community in order to deliver the extensions with quality and speed.

**Results**
An open-source real-time 3D reconstruction application was extended in order to create photo-realistic reconstructed models from scan large indoor areas. Another extension was to reconstruct the textures using the RGB images obtained for the Kinect (RGBD) sensor. The prototype reconstruction pipeline is available as open-source code.

**Benefits**
The immediate benefits are three-fold: the system becomes a potential industry standard, it is maintained and extended by many developers around the world with no additional cost to the VCA group, and it can reduce the application development time by reusing numerous state-of-the-art algorithms.
In many industries like engineering, building construction, and manufacturing, objects are created from digital models on a daily basis. However, the reverse problem, inferring a digital description from an existing physical object or environment, has received much less attention. We refer to this problem as reverse-engineering or 3D reconstruction.

The scope of this project involves 3D reconstruction of photo-realistic 3D models from large indoor areas. A great amount of research has been done in this field, and one of the latest and most promising applications is KinFu. KinFu was introduced as part of the open-source project, called the Point Cloud Library (PCL). Among its many advantages we can find the interactive frame rate, the fine-detailed reconstruction level, and the high availability of the hardware and software.

During this project, two main extensions were developed to enable using KinFu to reconstruct 3D photo-realistic models of large indoor areas. The first extension is the creation of a circular buffer to optimize the memory resources in the Graphics processing unit (GPU). The second extension is a screenshot generator. These screenshots are used in a post-processing stage, where the color texture is generated for the reconstructed model.

This project was carried out at the VCA Group as a part of the Sandia Robotics Code Sprint for the open-source project called the Point Cloud Library (PCL). The system has been integrated into PCL and is fully available as open-source.
Challenges
A huge amount of diagnostic data is available for the iXR systems in Philips Healthcare. This data is specific for certain components that are part of the systems. The main challenge of this project was to design a mechanism that can combine the available data to create diagnostic models of the systems and provide support for different system configurations at the same time.

Results
This project serves as a proof of concept for a solution that can be applied in the context of Philips Healthcare iXR systems. The main result is a prototype of the new optimized version of the Design for Diagnostics design method that supports compositionality and different system configurations. A user interface was implemented that provides means for identifying a failure in a system by recommending an optimal sequence of tests to be performed.

Benefits
This project helped the D4D team members to deepen their understanding of the requirements, design, and algorithms of a Diagnostic Reasoner, and especially a modeling tool for capturing the contents for the diagnostic data. It helped in recognizing the opportunities provided by the current diagnostic designs of the systems and also the limitations. These insights into the fundaments of a Diagnostic Reasoner help the D4D team to be sharp and well prepared in the supplier selection process, which is of significant importance for the diagnostics in Philips Healthcare.
Philips Healthcare is market leader in Interventional X-ray (iXR) equipment. Hospitals are more and more managed as regular businesses; therefore, fast and reliable service of this equipment is crucial. The main indicator for measuring serviceability is Elapsed Time To Repair (ETTR), i.e., the time from the customer's call indicating a problem until the moment that the problem is resolved. The business objective of this project is to reduce the ETTR and therefore lower the service costs and improve the service quality, by focusing on diagnosability of the systems.

The Design for Diagnostics (D4D) team in Philips Healthcare is developing and deploying a method that takes serviceability structurally into account during the design phase of a system and provides a way of diagnosing a failure in the system. However, this method has several severe constraints that limit its practical side and scalability.

The goal of this project was to create a prototype of one possible solution for overcoming those problems. The designed solution provides a mechanism for composing the diagnostic models, which broadens the scope for performing diagnostics from a group of components to the system level. Also, by making a clear distinction between the physical structure of the system and the logical propagation of failures through the system, support for different system configurations is provided. The final product of this project is the Diagnostic Reasoner, which is a graphical user interface that guides the field service engineer stepwise to the root cause of the problem in the system.

This project was a study aimed for the D4D team to learn what possibilities exist for improving the method of diagnosing failures in the medical systems. It was the first attempt of extending and optimizing the D4D design method which serves as a proof of concept for a solution that can be applied in the context of Philips Healthcare iXR systems.

“*In her nine months project, Ivana delivered an impressive amount of work, which has deepened our insights in the challenges of creating a solution for Diagnostic Reasoning.*”

*dr.ir. M. Boosten PDEng*  
*Philips Healthcare*
Challenges
The first challenge in this project was to combine the available realistic data with domain knowledge and artificial data generation techniques to arrive at as-realistic-as-possible data cheaply and quickly. The second challenge was to simulate different sensor types and their coverage. The third challenge was related to the repeatability of stimulating a system with data. Repeatability is crucial for many use cases relevant to ESI: Not only for experiments where the difference in system behavior and performance should only be caused by changes in the system, but also for demonstrations where the system should behave exactly as rehearsed during the dry runs.

Results
A Simulation Framework prototype was developed that addresses the main challenges of the project. The prototype developed uses plugin architecture. This design choice ensures that the Framework is independent of the sensor simulation created.

Benefits
The Simulation Framework conceived in this project would be useful for testing of new technologies, training of monitoring personnel, etc. In addition to this, the output generated would be used by the Metis project.
Efficient monitoring and management of maritime activities is a critical task for all coastal states. It is necessary for collision avoidance, enforcement of fishing policies, pollution control, deterring criminal activities such as smuggling and terrorism and guidance in cases of bad weather. The challenge today is how to effectively monitor and manage coastal areas with a minimum of resources in terms of skilled work force and active enforcement.

To address these issues, a group of research partners and industrial partners initiated two projects named “Poseidon” funded by BSIK and “Metis” funded by COMMIT. The main goals of these project is to develop System of Systems concept to combine multiple sources of information, analyze them, provide risk factors, and deliver the results to operators controlling the maritime areas.

Within the context of these main projects, a project named “Simulation Environment for Maritime Safety and Security Systems” carried out in Embedded Systems Institute aims to design and implement a Simulation Framework that is capable of producing realistic simulations of a collection of sensors observing different possible maritime events such as collisions and criminal activities.

In this project, we implemented a Simulation Framework that simulates different sensor types and their coverage and generates two important outputs. The first output is System Tracks. System Tracks are the results of the fusion process where the results of the different sensors observing sequences of events are combined together and can be expressed in the NIEM XML format. The second output is the information related to the maritime domain gathered from different websites.
Challenges
The SPACE architecture involves complex functionalities. The major challenge faced during this project was to acquire knowledge about working of all the relevant components of the system as this was scattered among teams in different geographical locations. Integrating a new application in the existing SPACE architecture which manages the UI functionalities was itself a challenge since it included designing various communication libraries for data transfer between various components in the system. In addition, implementing a proof-of-concept for the new design involved a considerable effort in design, development and testing.

Results
This projected resulted in the design and prototype of a new uiApp architecture. It was built on the existing system. This implementation serves as a proof of concept for improving the efficiency of the SPACE architecture using a separate application to handle the user interface related activities. In addition the design was evaluated regarding its ability to improve the efficiency of the existing system.

Benefits
The Single Engine UI application proves to be an improvement over the existing used system by separating the UI functionalities from the rest of the system. The redundant functionalities done by each application is carried out only once by the UI application thereby decreasing the start-up time. The new implementation also implements mechanisms for managing the window creation and display of the flash files on the screen. As the functionality of flash engine instance initialization is handled by the centralized application, it decreases the memory usage.
The user interface used by Philips TVs is quite simple and user friendly. The architecture of the system is based on HTML and flash technologies. This is based on SplitApplication architecture (SPACE). In this architecture applications are isolated in dedicated separate processes which are centrally managed.

Certain bottlenecks are identified in the architecture which has an impact on the resource usage and performance of the UI. These include the system start-up time and memory consumption.

To overcome the bottlenecks found in the currently used system, a thorough investigation has been done on an alternative architecture of the system by introduction of a separate application that manages the UI centrally.

**Single Engine UI Application**

The result of this project is the design and prototype of a new uiApp architecture. It is built on the existing system. This implementation serves as a proof of concept for improving the efficiency of the SPACE architecture using a separate application to handle the user interface related activities. In addition the design was evaluated regarding its ability to improve the efficiency of the existing system.

The prototype for the centralized UI application has a great potential in SPACE context. It serves the purpose of improving the efficiency of SPACE architecture. This prototype will also be a starting point for all further developments on SPACE architecture for the user interface related activities.
Challenges
The first challenge was to get deep understanding about the ASML machine and more important, the alignment process. The biggest challenge, however, was to find a solution that met the requirements without knowing a solution is possible.

Results
A prototype which is working in a subset of the full domain and that is able to generate time optimal, robust and accurate alignment sequences has been designed and developed. Moreover, the prototype can evaluate alignment sequences created by an engineer in order to provide useful details about the sequence like execution time, accuracy and robustness.

Benefits
The prototype implementation shows the feasibility of an alignment sequence generator. The tests performed show that the system complexity can easily be increased as the application offers an extendable architecture.
ASML is a company that designs, develops and produces photolithography machines, called wafer scanners, used in the process of manufacturing chips and integrated circuits. In order to achieve this it requires nanometer accuracy at high speeds. For the nanometer accuracy to be reached, the system must have a highly accurate calibration system. The calibration is achieved both through hardware and software means.

Currently, the software calibration is performed through a sequence of measurements which is created manually by an engineer. This has three drawbacks. The first is that the judging if the scheme is robust can only be done by the engineer, based on his/hers knowledge and experience. The judgment is error prone. This leads to failing calibrations on systems with particular inaccuracies. The second is that the engineer’s knowledge and experience does not always guarantee that the sequence created is also the fastest sequence that reaches the targeted accuracy. This means that the sequences created by the engineer are not always optimal when the execution time is considered. Finally, it becomes much harder for an engineer to create good sequences as the complexity of the system increases.

The main focus of the project was to create a prototype that will help remove the current drawbacks. The system designed was split into two components: an evaluator component which assesses the sequences and gives details about the execution time, the level of accuracy and the robustness the sequence provides and a generator component that creates optimal sequences given the mechanical tolerance specifications of the system.
Challenges
The first challenge of this project was to learn the modeling domain and POOSL as a language used for that purpose. The biggest challenge, however, was the design and implementation of the type system, which required defining type check rules for POOSL which were not defined before.

Results
A text editor for creating a POOSL model has been developed. It offers validation checks, scope providers and a type system that performs type checks during compile time.

Benefits
The UIL for POOSL gives the users possibility to create a model in a simple and user-friendly manner. It provides error messages and warnings during compile time. These messages are helping the users to create a correct model ready for simulation. The design of the UIL is extensible for additional functionality and it allows easy change of components.
System-level design methods are frameworks for structuring the early phases of the design process in order to reduce the design time. They focus on developing executable models that allow analyzing correctness and performance properties before actually realizing the system with hardware and software components.

System-level design methods support performance modeling i.e. development of an executable model of a system for the purpose of performance analysis. The design methods provide heuristics for applying certain modeling languages and performance analysis techniques. Efficient application of the heuristics, modeling languages and analysis techniques is often supported by user-friendly tools that enable the execution of the constructed models.

Problem statement
The Software/Hardware Engineering (SHE) method is an example of a system-level design method. SHE assists a designer in constructing executable models based on a modeling language known as Parallel Object-Oriented Specification Language or POOSL and by two different tools: SHESim and Rotalumis. If certain requirements have to be verified for a certain system, a user must first create a POOSL model using SHESim and then simulate it using SHESim interactive or Rotalumis high-speed simulation. The tools are quite powerful but there are several shortcomings which affect the user experience and the usability aspect. The scope of the project is to provide all the existing functionalities from the tools but with an improved user experience.

User Interface Layer (UIL) for POOSL
Based on the problem statement, an UIL was developed which gives the user the possibility to create a POOSL model. While creating the model, messages based on errors or warnings are displayed. These messages help the user to correctly create the model before running the simulation. The messages appear whether a validation, scoping or type error occurred. Moreover, the model can further be transformed to the expected XML format needed for performing Rotalumis++ simulation.
Challenges
The first challenge of the project was to get familiar with the clinical domain of cardiovascular diseases and their treatment. The second main challenge was to improve the usability of the registration step in the VesselNavigator application. This required understanding the way surgeons work and how they can interact with the software.

Results
The main result of the current project is the increased usability of the registration step in the VesselNavigator application. This was achieved by implementing new ways of interacting with a 3D volume in an intuitive manner and enhancing the user interface to help guide physicians through the registration process.

Benefits
In any clinical application developed in Philips Healthcare patient care is the ultimate goal. Making the registration step as easy to use as possible can potentially reduce the surgery time.
Vascular diseases are one of the leading causes of death in the developed world. Treating a vascular disease can be done in two different ways: using open surgery or using a less invasive endovascular approach. In an endovascular procedure the affected area is reached from inside of the vessel using catheters.

VesselNavigator is a clinical application designed to offer surgeons assistance while performing endovascular procedures such as the endovascular repair of the abdominal aortic aneurysm (EVAR). The main goal of the application is to help physicians navigate their instruments through the blood vessels using a small quantity of contrast agent. This can be achieved by overlaying a pre acquired 3D vessel structure of the patient on top of the live X-ray stream. The vessel structure can be extracted from a CT angiography or a contrast enhanced CT-scan done before the surgery. This 3D overlay allows the surgeon to see the contours of the blood vessels without constantly injecting contrast agent. This means that correctly aligning the 3D volume with the X-ray images (called registration) is vital in using this application.

The goal of the project was to improve the usability of the manual 2D-3D registration step in the VesselNavigator application, with the aim of improving registration accuracy and reducing registration time. In the registration step the pre-acquired 3D volume, often a CT-scan is manually registered to the position of the patient on the operating table. This is done by matching the position of the volume with two X-ray images acquired from different angles. Improvements were added to help physicians translate and rotate 3D volumes in a more intuitive manner. Additionally, the user interface was enhanced to streamline the registration process and guide the physician through the steps needed for successful registration.

“Tudor can be proud that his work is not only being used and evaluated in multiple hospitals, but also that from the feedback we get, it is clear that Tudor has gotten it right!”

Thijs Elenbaas
Philips Healthcare
Challenges
Improving the reconstruction library is quite a challenging task, especially for an outsider. The medical imaging processing domain is not easy to grasp. The reconstruction library code base is complex, written for high-performance. The reconstruction library has many stakeholders, some with considerable investments in the library as-is, and others asking for rapid edit-test cycles and easy-to-use GUI tools. Last but not least, there is a strict requirement for the improved reconstruction library to meet the original library’s high image quality and performance standards.

Results
A configuration mechanism was designed and implemented successfully covering all of major requirements in the redesigned reconstruction module. The module is fully configurable from outside using a human readable text file, without requiring recompiling for changing different configuration settings. Additionally, the image quality results based on a proposed methodical verification approach show a near perfect match with a slight difference of less than 0.00005% following from hardware and image processing library differences. Moreover, a Configuration Test tool was developed which offers the combination of a GUI based editor to change configurations, a built-in reconstruction library to reconstruct volumes for a configuration, and mechanisms to comparing images. Finally, the redesigned reconstruction module supports multiple reconstruction passes in one reconstruction job, going beyond the 2-pass reconstruction pipeline in the current product.

Benefits
The results of the project demonstrate the ease of configuring the 3D Rotational X-ray Reconstruction module with GUI tooling support. The configuration format makes very few assumptions about the reconstruction parameters, and by design is open to new parameters. Furthermore, the improved design of the reconstruction module retains the image quality and performance of the original design, satisfying the most important constraint of the project. Last but not least, the outcome of the project serves as a proof-of-concept for making the Reconstruction module fully configurable from outside. The Philips interventional X-ray business unit has started adopting the project outcome for future products.
Philips Healthcare is one of the global leaders in professional and consumer healthcare. The main priority of the company is to improve the quality of people’s lives by focusing on the people in the care cycle: patients and care providers. Within the Interventional X-ray business unit of Philips Healthcare, the focus is on innovative systems that create, display, and process images that are used for diagnosis and treatment purposes by clinical specialists such as interventional cardiologist and neurologists.

The Interventional Workstation is a dedicated, high-performance product, which extends the functionality of X-ray cardio vascular systems with the powerful capability of 3D X-Ray interventional tools. The 3D Rotational X-ray reconstruction module in this workstation reconstructs 3D volumes out of 2D X-ray images from a rotational X-ray run. The 3D volumes are then used for inspection and visualization purposes. However, the 3D Rotational X-ray reconstruction module is hard to maintain and not easy to customize for specific clinical needs. In addition, it lacks support for the diagnosis of image quality problems. This project is to design and implement a configuration mechanism for the module. The configuration mechanism fully defines a reconstruction job using a single text file. For visualizing and editing the configuration text file easily, a configuration GUI editor is created to enable rapid evaluation of configuration changes.

"We are very pleased with Huy’s achievements. His improvements to the reconstruction library are currently being adopted in our interventional X-ray business unit code base, and will definitely help us in bringing future reconstruction improvements to the market quicker."

W. van der Sterren PDEng
Philips Healthcare

Xuan Huy Nguyen PDEng

Configurable 3D Rotational X-ray Reconstruction
Challenges
Stakeholders from different disciplines have different ways of working and different needs. Therefore, one of the main challenges was to balance the sometimes conflicting needs of the different stakeholders while providing a usable, extendible, and acceptable solution that could be integrated with existing tools. Another main challenge related to synthesizing data from various sources and inferring some details that are not explicit in that data.

Results
The existing MOBASE framework was completely redesigned. The proposed architecture was implemented and validated by successful deployment in a real system-under-development (SUD). Some of the framework tools are now part of the product development process of this SUD. Furthermore, a roadmap for the evolution of the framework was proposed.

Benefits
With this revamped MOBASE framework, the efficiency of the product development process has been improved. For example, previously repetitive, manual work has been replaced by a tool that automates data importation (notably CAD data acquisition which was identified as a bottleneck). In addition, a carefully designed data model and input data validation reduce the risk of common errors such as naming mistakes that were hitherto difficult to prevent.
Océ Technologies B.V., a member of the Canon Group since 2009, specializes in providing durable, high-end document management and printing systems. The development of these systems is a very challenging task involving the collaboration of several engineers from different disciplines such as electronics, mechanics, computer science, physics, chemistry, and workflow management. In order to improve efficiency, reduce time-to-market, and decrease production cost, a model-based approach is adopted. This involves the use of several mono-disciplinary models to investigate (e.g., explore design choices, simulate, and/or test) specific aspects of the overall system. Typically, these models result in key design parameters that need to be shared with other disciplines.

Fostering multi-disciplinary collaboration
The MOBASE framework has been developed to address this need. Short for MOdel-BAsed Systems Engineering, MOBASE fosters interdisciplinary interaction by aggregating shared design information from various input models, storing them in a shared repository, and making them available to the various stakeholders as needed. By defining appropriate views on the stored data, stakeholders are able to retrieve only the information that is useful to them.

The framework consists of a number of tools each having clearly defined responsibilities. This separation of concerns improves the extendibility and maintainability of the framework. The MOBASE tools interact on the basis of a predefined data exchange format which is currently implemented in XML. The graphical user interface (GUI) of the framework exposes the functionality of the underlying tools’ layer while providing users with visually appealing representations of the stored MOBASE data. The resulting detailed design diagrams are useful for inter-disciplinary communication, clarification of requirements, and implementation. The GUI also offers users the means to input additional information that is not present in the imported models.

By successfully automating the importation of paperpath information from the 2D CAD models that are created by mechanical engineers, as well as the hardware-software-interface (HSI) specification that is of interest to both electronics and software engineers, the scope of MOBASE has been extended to stakeholders from all three core disciplines that are usually involved in the product development process. Moreover, the different views defined on the stored MOBASE data are currently being used by various tools related to embedded software generation, automated regression testing, software-in-the-loop simulation, and sheet timing design, amongst others.
Challenges
The network of different stakeholders, the exact functionality of the tool, as well as the tool’s realization, were quite entangled and non-trivial. Therefore, challenges were found in most, if not all, of the views of the CAFCR architecting method: Customer, Application, Functional, Conceptual, Realization.

Results
The result is a set of extensions that allow the architects and designers to use the Design Framework in larger and more complex projects, connect to external sources of information, and provide more powerful visualizations of the information.

Benefits
It is now possible to work with a large project team, integrate information from external sources, search for information in the repository and create customized views of the information for the different stakeholders. As a whole, the development step that was taken has indisputably enabled the important industry-as-laboratory experiments that have to follow in the near future.
The Embedded Systems Institute’s mission is to advance innovation and excellence in systems engineering for high tech embedded systems. An important contribution to this mission is the integration of model-based methods into multi-disciplinary systems architecting, not only by working methods described in articles, but also by usable tools that support the architects in their daily work. As these tools are not readily available, ESI started prototyping the so-called Design Framework over the last years.

The Design Framework is a visual modeling tool that aims to help architects and designers to develop complex systems. The Design Framework accomplishes this mission by capturing the design rationales in the design process and by providing a mechanism for using information related to heterogeneous models.

First industrialization
The development of high-tech electromechanical systems is complex and requires a significant effort. In such environments it is evidently difficult to keep the key design information and rationales synchronized. The professional high-speed printers design is an ideal scenario where the Design Framework can be used. However, the size of the projects, the flexibility in creating views of the information, and the seamless integration with analysis models are some challenges to use it in such a scenario. The Design Framework Process Tailoring is an adaptation of the framework to be used in the design process of professional high-speed printers. The result is a set of extensions that enrich the Design Framework to be used in the design of high-tech printers and complex high-tech systems in other domains.

“This challenge fitted Martin very well. It fitted who he is as a person, with lots of energy, enthusiasm and open-mindedness to listen to problems... It fitted his technical competences at different levels... This all resulted in a very significant step in the development of the Design Framework.”

Dr. Roelof Hamberg
Embedded Systems Institute

Martin Palatnik Minguell PDEng
Design Framework Process Tailoring
Challenges
Creating a system that brings value to the domain of network virtualization, which was undergoing extensive innovation and development for the duration of the project, was a challenging task. The system had to remain relevant and unique in a changing landscape where new research and commercial network virtualization solutions were being revealed and cloud platforms were being modified, threatening to overlap with the system’s purpose or invalidate its functionality.
In addition, the system had to interface with multiple heterogeneous components and support various technologies, without being tightly coupled or limited to a subset of them. Supporting receiving network requests from any cloud platform, configuring arbitrary network devices, managing arbitrary network topologies, and supporting various network isolation mechanisms, all these variabilities had to be addressed with proper software architecture.

Results
The outcome of the project was the design and prototype implementation of a network virtualization platform that combines network topology management, network device configuration, negotiation with a remote system to control inter-cloud connections, and interoperability with major open-source cloud platforms. The system implements virtualizing basic layer-2 networks on top of arbitrary topologies and network devices, as well as extending them over inter-cloud connections. Its architecture provides the basic building blocks for extension with advanced functionalities, such as reserving network bandwidth or configuring advanced network switches.

Benefits
The system allocates network resources only where required by the network, improving scalability and performance compared to static configurations. In addition, the system can support new network devices and service offerings very easily, by making use of pluggable device drivers. Moreover, it is built to support major cloud platforms. This makes the system usable and capable to utilize any cloud infrastructure deployment.
Nikhef, the Dutch national institute for subatomic physics, provides infrastructure and develops software for the Worldwide LHC Computing Grid, the computing platform behind CERN experiments. Grid providers are investigating whether and how to incorporate virtualization and cloud computing elements to their infrastructure. Virtualization brings improved reliability and usability of computing resources, but it also introduces network resources, which are not easy to control and provision in a dynamic manner. The goal of the project for “Network Provisioning in IaaS Clouds” is to explore networking in Infrastructure-as-a-Service clouds and to create a system that can dynamically control network resources, both within a cloud site and over remote ones.

Network Virtualization

IaaS Clouds provide their users with virtual machines, storage, and network between them. Providing network essentially requires the virtualization of the physical network, i.e. its partitioning and isolation into multiple segments, perceived by the users as isolated local-area networks. These virtual networks are dynamically requested by users and can be from simple IP subnets to complex topologies including multiple subnets, Internet connectivity and firewall configurations. Such virtual topologies need to be automatically mapped onto the physical network infrastructure. Moreover, the same infrastructure needs to host multiple networks from different users in separation.

Bridging cloud platforms with network switches

Cloud platforms, software stacks that orchestrate the IaaS cloud operation, have a fundamental lack that hinders the provisioning of network resources: They cannot control the network switches, which typically comprise the network infrastructure of a cloud site, or network devices in general. Therefore, cloud platforms require static network configurations in order to virtualize networks and to provide additional services to the users’ networks, such as VPN connectivity or a firewall. Static configurations suffer from performance and scalability problems and require extensive human intervention. A network provisioning system was developed that alleviates these problems. The system acts as the intermediary between cloud platforms and network devices; it maintains and controls the physical network topology, and is able to translate user network requests into proper device configuration. It can also manage connections over different data-centers, connecting resources lying in remote locations (‘inter-cloud’ connections). Such a system allows for dynamic and optimal allocation of network resources, increasing performance and scalability over static configurations and allowing the dynamic creation of complex virtual topologies.
Challenges
The challenge in this project was to reengineer the interface between a legacy, Fortran-based, computation kernel and the multitude of applications leveraging its calculations. The code that previously handled this interface was specific to every project, generally using file I/O but sometimes leveraging TCP/IP connections or custom library bindings.

Results
The result was a complete service-oriented framework wrapping around the ALMOST computations and exposing them through a language-agnostic interface. This solution includes client libraries in all target languages, user level documentation and a deployment process to guarantee consistent output. All of these artifacts are backed by a test suite designed to guarantee the consistency of results between the old and the new interface.

Benefits
The emphasis on a service-oriented interface will help in avoiding fragmentation of the ALMOST codebase and the multithreading improvements help the legacy code perform better in a multi-core environment. Furthermore, the compartmentalization of the original Fortran code will allow researchers at TNO to extend the library without extensive reengineering of the tightly coupled Fortran code.
The Sonar group at TNO has been developing a computation kernel to estimate sonar performance for the last 30 years. This application, commonly referred to as ALMOST, is written in Fortran and interfaces with other applications through file I/O. With the years, this interface has proven very limiting and hence the decision was made to replace it. The goal of this project was to design and implement this new interface.

There were a few main requirements that shaped the design of the solution: a need for cross-language support (since ALMOST is in use in many applications and projects), a need for a network transport for the interface and the need for a solution that discouraged fragmentation. Furthermore, given that the accuracy of the results was of paramount importance, a comprehensive test-suite was also an important need.

Therefore, the solution centered on a service-oriented architecture, aimed at providing simple interfacing over network and language barriers and preventing fragmentation by exposing a language-agnostic interface. The subsequent layered interface consist of commands and parameters to isolate sections of Fortran code, followed by abstractions to facilitate extracting performance from the underlying calculations and finally by exposing a Thrift-based service interface that can be used from a long list of supported languages.

“Jonathan’s creativity was tested during the architecture and design phases, in which he had to develop an architecture which was easily extensible and accessible by the other applications using the model [...] it became clear that the chosen architecture and design had been studied carefully and the correct design decisions had been made.”

ir. Frank Benders PDEng TNO

Connecting ALMOST to the world around it, from Fortran file I/O to a service oriented architecture
Challenges
The main challenge of this project was the huge amount of source code of ECE which was around 265MB including 83 models. The source code was the working results of hundreds of people during 6 years. Another challenge of this project was the management changes of Ericsson. During this project, many people that gave me supports and tasks had left Ericsson including my supervisor.

Results
The actor model could not help to improve the performance of the core of ECE. The shared state is the bottleneck of ECE because it was shared by all the sessions and may even be accessed across clusters.
The session application component should be carefully used. It spends around 25% CPU time which is not necessary for RESTful services of ECE.
The design of new execution agent was made and implemented by applying Akka’s remote actors. The new design allowed execution agents to be added to or to be removed from the composition engine at runtime without increasing the communication time between the core of ECE and execution agents compared to the current design.

Benefits
This project’s results pointed out the real bottleneck of ECE which could contribute to the development of the next version of ECE. Akka, the actor model implementation, was also investigated which provide developers of Ericsson a technical alternative solution. The new design of execution agent will benefit the usability of ECE.
Ericsson R&D in Rijen is worldwide responsible for the development of the Ericsson Composition Engine (ECE). ECE is an open, versatile, J2EE based telecom platform. ECE enables service providers to create and combine new and existing Value Added Services applications, regardless of vendor and access technology. ECE allows components from different platforms and technologies to be mixed within a single composite service. The project investigated the performance improvement of ECE and proposed a new design of the ECE execution agent.

Performance optimization of ACE
Adding new hardware is the easiest way of performance improvement, but the distributed computing is required to keep load balance and distribute data. Currently, ECE used Session Application Component which applied Hazelcast to distribute data to different clusters and keep load balance. During this project the experiments were made to test the overhead of this procedure, and experimental results proved that the overhead is around 25%. For REST service of ECE this overhead could be removed and response latency could be improved.

The Java thread pool was applied by both J2EE server and session component to implement concurrent computing. Although the thread pool is a powerful mechanism for structuring multithreaded applications, it has drawbacks such as synchronization errors and deadlock, and a few other risks specific to thread pools as well, such as pool-related deadlock, resource thrashing, and thread leakage. The Actor Model, which was first proposed by Carl Hewitt. This model takes a different approach to concurrency, which avoid the problems caused by threading and locking. This project compared the performance of Akka actor model implementation with the Java thread pool and approved that Akka uses less thread and has better performance.

This project also did software profiling with ECE and proved that shared state of ECE was the real bottleneck of ECE.

New Execution Agent Design
This project also proposed a new design of execution agent for the new proposed API of ECE. This new design enables execution agent be registered, distributed and relocated at runtime without sacrificing the system performance. Furthermore it lowered coupling between the core of ECE and execution agents.
Credits

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