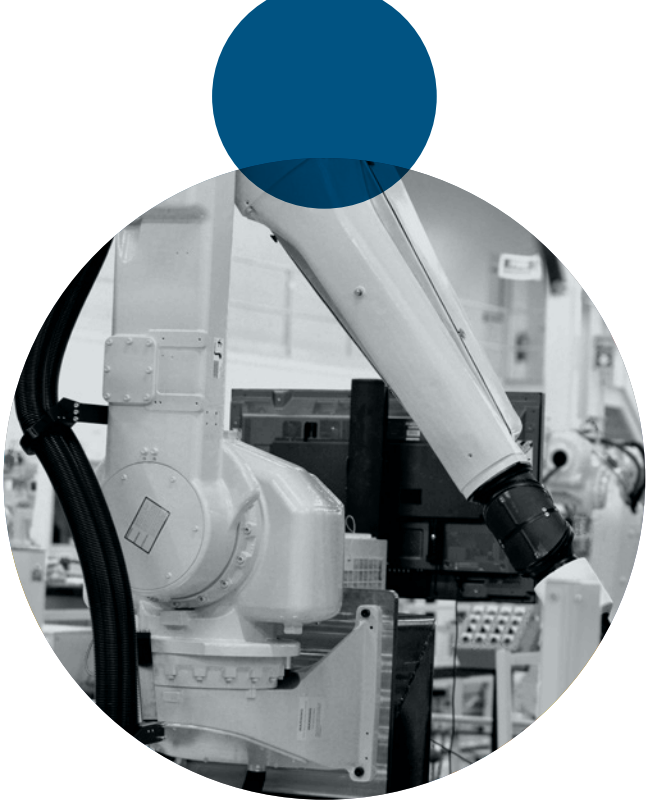

sfi Centre for Research-based Innovation

Certus

2016
Certus
Annual Report

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Contents

Boosting Software Validation and Verification with Artificial Intelligence

After having successfully passed through its midway evaluation in 2015, Certus has engaged in an ambitious plan for preparing an exit strategy in 2016. Preparing this strategy, it was necessary to set the scene correctly by adopting a stronger industrial leadership of the Centre Board. Working hand-in-hand with the Centre's administration, Jan-Christian Kerlefsen has accepted to conduct the Certus Board activities from 2016 with great professionalism, authority and enthusiasm. Accompanying the changes within the consortium with the departure of the Directorate of Customs and the arrival of the Cancer Registry of Norway(CRN), Jan Christian's leadership has advantageously boosted the convergence of many objectives, such as research excellence and industrial exploitation. In particular, the adoption of advanced research results on test suite optimization in the ambitious ABB's internal software modularity project has rooted a strong and fruitful collaboration between Simula and its industrial partners. Having CRN as a new partner in the consortium brought new challenges and opportunities for Certus researchers on the side of verification of healthcare and prevention systems, and it was important to set up priorities. It is worth noting that even as the consortium evolved, the vision remained untouched! More than ever, the Centre's activities are targeted towards making breakthroughs in software verification and validation research and innovation.

Noticeably, following a trend which revolutionises our day-to-day practices with digital applications, Certus has engaged in several research projects aiming at exploiting Artificial intelligence to boost software validation and verification practices. Recognising early the importance of topics such as constraint programming and symbolic machine leaning (more than two years ago) and building on existing results, Certus launched in 2016 three ambitious research PhD projects with the goal of improving test case selection with machine learning. Addressing challenging problems from Cisco, Kongsberg Maritime and ABB, Simula's researchers lead breakthrough research in the area of test execution scheduling and test suite management and optimisation. Looking at large-scale data-intensive software systems developed or considered by our partners Esito and CRN, our tools and technological platform CRYSTAL are being extended with machine learning techniques to address difficult problems that feature program understanding and combinatorial testing. In brief, we consider that boosting software validation and verification with Artificial Intelligence is a very promising research direction.

2016 has been an exciting year for Certus with a number of excellent publications, the identification of new scientific topics and new PhD students, new collaborative activities among the partners supported by innovative tools. This document reports on all these advances.

Arnaud Gotlieb
Leader of Certus SFI
Chief Research Scientist
Simula Research Laboratory

More than ever, the Centre's activities are targeted towards making breakthroughs in software verification and validation research and innovation.

Moving On

2016 was the first year of the second period of the Certus SFI. Having passed the mid-term evaluation with good margin, and secured funding for the final years of the SFI period, the focus is gradually changing towards the exit strategy of the centre.

Certus is regularly under review. In March 2016, we invited the Research Council of Norway (RCN) for their annual site visit, the purpose of which is for RCN to review the progress and give feedback to the centre. In December, we invited the Scientific Advisory Board (SAB) to review the Centre with a focus on research topics and direction. In the feedback from these reviewers, Certus continues to be acknowledged for its strong user interaction and for the high quality of our research. We are a successful SFI! Now we must secure the implementation of a good exit strategy, so that Certus will outlive the SFI funding period.

As always, the administration carefully considered the constructive feedback in the reviews, and are implementing changes accordingly. One of the concrete recommendations received in an earlier review, was to hire more PhD students. We have now hired three new PhD students as a direct result of this. Two of the students will be co-supervised and work closely with ABB Robotics.

Going forward, we want to make sure we transform the research into a notable contribution to the industrial and public administration domains, now and after the SFI period. The core of the exit strategy is to build a hub of technology and competence that will be attractive to the industry. We need to make the results of the research available to the consortium partners and possible future industrial customers.

In early 2016, we welcomed the Cancer Registry of Norway (CRN) as a new member of the consortium, bringing new and challenging research topics to the centre. Due to a large structural organisational change in Norwegian Customs, many responsibilities that were the basis for Certus collaboration have been transferred to the Norwegian Tax Administration. Because of this, Toll has decided to leave the consortium, and we will certainly miss them. However, changes in the composition of the consortium can also bring new vitality into the centre.

As mentioned above, we are a successful SFI. We will work hard to continue the success, and continue to create value for the industry by harvesting first class research results within the important technology field of software V&V.

Jan Christian Kerlefsen

Chair of the Certus Board

Managing director and R&D Manager, ABB Robotics

We want to make sure we transform the research into a notable contribution to the industrial and public administration domains, now and after the SFI period.

Vision and Goals

Cost-effective software validation and verification is highly challenging, as it requires a shift from traditional manual testing to fully automated testing in continuous integration processes. At Certus, we believe that the challenge can be addressed by using and reusing intelligent testing techniques, namely, techniques inspired from Artificial Intelligence. Embracing constraint optimization, machine learning and data mining research, we envision the design of future tools for facilitating the validation and verification of complex software systems.

Following up on five years of intensive cooperation in the domain of software validation and verification, the Certus partners maintain high levels of communication between the core group of academic researchers based at the host partner, Simula Research Laboratory, and the industry and public sector partners. The user partners represent a cross-section of industry and public sector applications in software: ABB Robotics, Cisco Systems, Esito, Kongsberg Maritime, Norwegian Customs, and The Cancer Registry of Norway (new partner in 2016). Our goal is to produce research that results in exploitable methodologies and tools for all the partners to test and utilize.

The scientific activities of the centre are focused on four projects, with another three dedicated to administration, communication, and dissemination. A final project is related to industrial exploitation.

Certus is now engaged in the preparation of a strong exit strategy together with its partners. The goal is to create a virtual testing laboratory which will serve as a technological platform to validate new releases of complex software-systems.

Key Figures

The Certus Centre annual accounts for 2016 shown below are presented in the standard setup used by the Research Council of Norway. In particular regarding funding, "Own financing" refers to funding provided by the host institution, other "public funding" refers to funding provided by the Norwegian Customs and Cancer Registry of Norway, while "other private funding" refers to funding provided by the remaining four user partners.

Cost in NOK 2016	
Payroll / indirect expenses	11 264 661
Equipment	150 432
Other operating expenses	7 617 529
Totals	**19 032 622**

Funding in NOK 2016	
Own financing	3 243 125
Other public funding	1 081 408
Other private funding	4 798 089
From the Research Council	9 910 000
Totals	**19 032 622**

Organisational Model

Certus Board

- Jan Christian Kerlefsen, Chair, ABB Robotics
- Are Magnus Bruaset, Simula
- Marius Chirstian Liaaen, Cisco
- Mette Wam, ETTO AS
- Katrine Langset, Directorate of Norwegian Customs
- Bjørn Ove Olafsen, Kongsberg Maritime
- Jan F. Nygård, Cancer Registry of Norway

Certus Administration

- Arnaud Gotlieb, Certus Centre Leader
- Tom D. Atkinson, Certus Administrative Manager
- Karoline F. Hagane, Certus Advisor

Partners

ABB, TOLL CUSTOMS, esito, CANCER Registry of Norway – Institute of Population-Based Cancer Research, KONGSBERG, CISCO, simula

Gender and Equality

The Certus Centre has throughout its existence strived to achieve a high ratio of female researchers in order to ensure a gender balanced working environment, and to create good role models for students and researchers in recruitment positions. In 2016, 33% of key researchers in the Centre were women, 25% of project leaders were women, and the board consisted of 28% women. In 2016, more than 50% of the five positions completed (Master's students and interns), were held by women, which we consider to be very positive for future scientific recruitment within the field of Software Engineering.

In 2016, Certus' host institution Simula Research Laboratory awarded a well-deserved promotion to Tao Yue, who is now a Chief Research Scientist, the highest scientific position at Simula. Gender is weighted in ongoing discussions on recruitment and promotions, and yet it is our experience that it is challenging to find and recruit female candidates in a field where only 15% of Master's students are female. All recruitment with Certus is done on an international basis, in order to have the largest possible selection of female candidates.

Certus Centre Partners

Scientific Projects

Project 2: Industrial Exploitation
Project 5: Model-Based Engineering for Highly Configurable Systems
Project 7: Testing of Data-Intensive Systems
Project 8: Testing of Real-Time Embedded Systems (RTES)
Project 9: Smarter Testing of Evolving Software Systems

> *"Being a partner in Certus provides the Cancer Registry with the means to pursue our vision of providing world-class data on cancer diagnostics and treatment, thus enabling medical research on improving cancer care"*

Jan Nygård, Managing Director of CRN. Photo: Bård Gudim

CANCER Registry of Norway
INSTITUTE OF POPULATION-BASED CANCER RESEARCH

Projects 5, 7

The Cancer Registry of Norway

- Organisation that maps cancer cases in Norway
- Performs clinical, screening-based and etiological research
- 160 employees
- Receives around 140 000 notifications related to cancer illness each year

In 2016, Certus expanded the consortium to include the Cancer Registry of Norway (CRN). Software systems are an integral part of the effective functioning of any medium to large-sized organisation such as CRN, but CRN is in a unique position due to the amount of medical data that must be processed confidentially, and kept constantly up to date.

The number of cancer cases in Norway increases every year. This increase implies that more men and women will need cancer treatment, thus escalating the burden of cancer care in our hospitals. The Cancer Registry of Norway's vision is to combat cancer and the suffering this disease inflicts on individuals and their relatives, as well as to mitigate the challenges cancer causes in society.

To improve the cancer care, high quality data on diagnostics and treatment given to cancer patients is needed. The Cancer Registry of Norway (CRN) collects, verifies and recodes these data by means of ICT-systems. It is vital that these processes are conducted correctly and without error.

As a partner in Certus as of 2016, the CRN wants to improve the internal ICT-systems by using model- based testing and model-driven engineering, including the usage of models for documenting the software development process, automatic generation of code structure and tests from models, and risk-based testing on critical parts of the ICT-system.

simula

Projects: 2, 5, 7, 8, 9

Simula Research Laboratory

Simula Research Laboratory is a non-profit public utility enterprise that performs leading international research within selected fields of information and communications technology (ICT). In 2012, Simula was ranked first in the national evaluation of ICT research conducted by the Research Council of Norway (RCN). Certus' long-term perspective and strong industrial profile give Simula a unique opportunity to further expand and enhance its position as a leader in software validation and verification research. The Certus centre is one of several research-based innovation projects at Simula within this field.

ABB

Projects: 2, 8

ABB

ABB Robotics is a leading supplier of industrial robots and modular manufacturing systems and services. Their work in the Certus Centre focuses on painting systems embedded in industrial robots. Robotics software is a complex, configurable, and highly distributed embedded system. ABB Robotics believes that the key features of a new testing infrastructure should include extensive automatic testing, continuous integration, and the smart selection of test cases. To address this, an ABB Robotics principal engineer started an industrial PhD in 2012 as part of a Certus project, supervised by centre leader Arnaud Gotlieb and University of Stavanger Professor Hein Meling. The PhD concluded in 2015 and the results were exploited at ABB Robotics. Moreover, ABB is also aiming at implementing this research within ABB Robotics' global research and development organization. ABB Robotics became a full partner of Certus in 2014 and will rely on continuous support from researchers at the centre for its implementation project.

CISCO

Projects: 2, 8, 9

Cisco

Cisco Systems Norway specialises in developing solutions for video collaboration and manufactures a broad portfolio of products designed for all types of meeting spaces. Cisco's collaboration solutions are business critical for a number of large customers across industries like public sector, oil and gas, and finance. As companies become more global with distributed teams, effective ways to support remote collaboration becomes essential to increase productivity and reduce travel.

TOLL CUSTOMS

Projects: 2, 7

Customs

Customs is an agency under the Ministry of Finance. Customs carries out a number of enforcement tasks related to the import and export of goods. Customs delivers and maintains a large portfolio of systems for handling customs in Norway. Their systems have high requirements regarding data integrity, availability, and security.

esito

Projects: 2

ESITO

ESITO is an ICT company that develops and market software tools supporting domain driven design and development. "g9" is a tool that mainly is used in development of mission-critical applications. ESITO's vision is to utilise domain knowledge captured in models and offer its customers tools that give lower lifetime cost and better quality by utilising models and domain driven design in their application development.

KONGSBERG

Projects: 5, 9

Kongsberg Maritime

Kongsberg Maritime is one of the largest suppliers of programmable marine electronics worldwide. They deliver systems for dynamic positioning and navigation, marine automation, cargo management and level sensors, maritime training simulators, and position reference systems. These products are paramount in ensuring the reliability and correct functioning of offshore and shipyard systems.

Project 5:
Model-based engineering for highly configurable systems

Innovation results

In 2016, project 5 aimed to investigate the feasibility of applying model-based engineering methodologies to address some of challenges of Cancer Registry of Norway, and communicate and share our knowledge and experience in applying model-based engineering methodologies in practice to a larger community via participating and contributing to various standardisation activities at the object management group (OMG).

In the context of the MBE-CR project (adjacent project 5) we have developed a model-based solution to improve the current practice of CRN in terms of their ICT-based automated cancer registry system. One interesting aspect of this solution is that we have proposed a web-based application, iOCL, to facilitate the specification of OCL constraints. iOCL is an interactive tool and aims to reduce the effort required to specify OCL constraints as users in CRN are from the medical domain. Some useful experience accumulated in the past indeed helped us to promote model-based engineering to a new domain, such as healthcare. In the future, we will gradually try other domains as appropriate opportunities arise, and further evaluate the applicability of iOCL and relevant frameworks at CRN.

Contributing to standardisation activities can be considered as an important initiative to publicise research work we have done, publicise the organization in general, and most importantly, to contribute to the model-based engineering community in large. We consider the effort we made in this direction to be worthwhile, and good foundations have been established for a span of standards at OMG which would be very useful from a long-term perspective.

Some useful experience accumulated in the past indeed helped us to promote model-based engineering to a new domain, such as healthcare.

Dr. Tao Yue, Chief Research Scientist and project leader of Project 5.

Project 7:
Testing of data-intensive systems

Innovation results

Following-up on the long-term research project held together with the Directorate of Toll Customs, Simula's researchers have successfully conducted the technological transfer of Depict to Esito in order to prepare its general release and commercialisation. In particular, several adaptations required additional research activities that led to intensive discussions with all the involved partners during our User Partner Workshops.

FightHPV

Since the Cancer Registry and the Certus Centre partnered in 2016, the focus of this project has evolved from testing data-intensive systems to verifying and validating socio-technical systems. Socio-technical systems leverage the impact of software to the societal level. For instance, the organised cervical screening program in Norway is driven by a software system that aims to engage women to attend cancer screening and consequently reduce the cancer burden on the state. Measurable properties on people from the screening database help us extend V&V techniques to socio-technical systems. We have worked in collaboration with the Cancer Registry of Norway to:

a) nudge women to attend to screening using FightHPV and measure its impact from the screening and statistical bureau database

b) evaluate risk of re-identification in anonymised screening data that is shared for research

c) explore and mine risk patterns in patient trajectories observed in the screening database.

Portinari

Portinari is a data exploration and mining tool that was developed to help support the socio-technical system of cervical cancer screening. It was used to evaluate screening guidelines in Norway and discover possible causes for non-adherence to screening guidelines.

The tool was used on anonymised data from screening behaviour for 0.9 million women in Norway. Portinari revealed several insights into the validity of the screening guidelines, also known as the triage algorithm. Portinary showed that many women didn't get satisfactory results from their cytology examination. The cytology test was shown not to be an effective test for cervical cancer screening.

Portinari will be developed further to incorporate data mining techniques and lifestyle data from 30,000 women in 2017. The data mining will help us extract most frequent patterns among women who follow a certain trajectory vs. another.

Since the Cancer Registry and the Certus Centre partnered in 2016, the focus of this project has evolved from testing data-intensive systems to verifying and validating socio-technical systems.

Dr. Sagar Sen, Research Scientist, and project leader of Project 7

Project 8:
Testing of Real-Time Embedded Systems (RTES)

Innovation results

The ultimate goal of project 8 is to devise practical, scalable, cost-effective, automated, and optimised testing techniques for RTES that meet the requirements of industrial systems.

In 2016 we have designed a number of cost-effective testing techniques for addressing several testing challenges faced by our industrial partners, especially Cisco and ABB Robotics.

In collaboration with Cisco we have proposed a search-based resource-aware test case prioritisation approach, i.e., the availability of hardware (e.g., VCSs) should be properly taken into account when ordering test cases for execution. Moreover, we have contributed to the entire software testing community by proposing a practical guide in terms of choosing quality indicators for evaluating various evolutionary computation techniques (e.g., genetic algorithms). Such a guide can be employed when there is a practical need to apply search-based software engineering (SBSE) for addressing various software engineering problems.

Together with ABB Robotics, we have developed constraint programming models for automatically scheduling the execution of test cases for robotics systems. In addition, we have developed a software component for prioritising the execution of test cases in continuous integration processes. This component has been successfully deployed as part as the continuous process used at ABB to cost-effectively select and prioritise tests for testing complex robotised systems. An ambitious research task has also started to apply machine learning techniques to prioritise test cases in continuous processes.

In 2017, project 8 will continue investigating the industrial testing challenges from different perspectives, including:

1) developing a user-friendly module for prioritising and scheduling test case execution;
2) studying the large amount of test execution historical data and employing evolutionary computation techniques to cost-effectively generate and optimise test cases;
3) analysing the needs for automated testing of robotic control systems and proposing new techniques to automate the validation process and
4) exploring machine learning techniques and studying historical data to reducing the overall test cost, while not compromising test effectiveness.

Together with ABB Robotics, we have developed constraint programming models for automatically scheduling the execution of test cases for robotics systems.

Dr. Shuai Wang, Postdoctoral Fellow and project leader of Project 8.

Project 9:
Smarter testing of evolving systems

Innovation results

History-based recommendations for testing

Regression testing is performed after a software system is changed, to provide confidence that the changes do not negatively affect the behaviour of unchanged parts in the software. It is typically done by executing a test suite on a system before and after changes were made, with the explicit requirement that tests should have similar outcomes in both cases. However, as the software evolves, test suites tend to grow in size, become out-dated, or overlap with other parts, rendering it prohibitively costly to retest a complete test suite.

In response to this challenge, we have developed HaRT (History-based Recommendations for Testing), a novel technology that uses machine learning to recommend relevant test cases to execute based on changes made to the system, effectively maximising the value of the test suite while reducing overall testing costs. In 2016, we have refined the HaRT technology so that it can analyse changes and give recommendations at more fine-grained levels. In addition, we have developed techniques to improve recommendation quality by aggregating evidence from various sources, and empirically developed a set of practical guidelines for applying the technology in software projects. Finally, we have made a dedicated version of the HaRT technology available to industrial partner Kongsberg Maritime in the form of software-as-a-service (SaaS).

Activities for 2017 and onward include the transfer of the technology to Cisco Norway by means of git-recommend, an extension to the widely used git version control system, and extending the scope to other Kongsberg Maritime departments.

Anomaly Detection and Diagnosis

In addition to the "History-based Recommendations for Testing" research track, a new research track on "Anomaly Detection and Diagnosis" with a new PhD student, Carl Martin Rosenberg, was started towards the end of 2016. Initial activities include an internship of two weeks at Cicso Norway and the development of a doctoral research plan.

Activities for 2017 and onward include understanding the anomaly detection and diagnosis challenges that our user partners are experiencing, analysing existing detection and diagnosis procedures, identifying areas for improvement and assessing what techniques/improvements could help address some observed challenges.

We have developed HaRT (History-based Recommendations for Testing), a novel technology that uses machine learning to recommend relevant test cases to execute based on changes made to the system

Dr. Leon Moonen, Senior Research Scientist and project leader of Project 9.

Adjacent Activities in 2016

U-Test:
At the end of 2016, the U-Test-EU project completed two years of operation, marked by achievements from several angles. First, in terms of research, the consortium made great progress in terms of devising novel testing methods for testing Cyber-Physical Systems and demonstrated their applications to two industrial case studies from healthcare and logistics domains. Second, the process to start the standardisation of a new modelling standard called "Uncertainty Modelling" was kicked-off; Third, a concrete business plan for the technologies produced in the project has been prepared. Finally, the results of the project achieved so far were disseminated at a wide range of venues, including academic conferences, industrial conferences, industrial events, standardisation bodies, and consortium member internal events. The project will conclude in 2017 with extensive evaluations of the technologies produced in the project and their deployment at the industrial partners' location.

ABB software modularity:
In 2016, ABB launched an ambitious internal improvement project aimed at boosting the building and validation of complex robotics systems. The project involves several business units of the ABB group, the Simula Research Laboratory and Microsoft USA in order to create a continuous integration and testing infrastructure relevant for robotics software-systems. Certus researchers are involved in the project to deliver test prioritisation solutions that can be integrated within the continuous testing process of ABB.

Model-Based Testing For Cyber-Physical Systems (MBT4CPS):
MBT4CPS is an RCN-funded project aiming to devise novel model-based testing techniques to support functional and non-functional testing of CPSs with the specific focus on risky and uncertain behaviours. The ultimate goal of the project is to improve the quality and dependability of CPSs, which is very important to ensure since these systems have safety and mission critical applications. Sponsored by the Research Council of Norway's FRINATEK framework, the project started on July 1st 2015, and is scheduled to last until June 30th 2018.

Sweetzpot:
Sagar Sen co-founded Sweetzpot AS which was initially part of Simula's grunder garage. Sweetzpot AS develops sensor technology and interfaces for high-performance sports such as for measurement of breathing from an athlete's ribcage and force from sports equipment. These systems bring several challenges for V&V of cyberphysical systems developed for sports.

Zen-Configurator: interactive and optimal configuration of Cyber Physical System product lines:
The goal of the Zen-Configurator project is to increase the efficiency and effectiveness, and thereby reduce the cost, of configuring large-scale Cyber Physical System (CPS) product lines. To achieve this goal, we maximally automate error-prone and costly manual configuration activities and optimally assist the interactive configuration process. On one hand, the project relies on advanced technologies of constraint solving/evaluation, optimisation using search algorithms, and propose state-of-art algorithms to enable automated configuration activities. On the other hand, the project grounds itself in addressing real challenges faced by industry and proposing a practical and applicable solution and applying it in at least one application domain. Sponsored by the Research Council of Norway's FRINATEK framework, the project started on July 1st, 2015, and is scheduled to run until June 30th 2018.

SOIGNONS: SOcIetal Games to promote social Nudging in cervical cancer Screening:
SOIGNONS is a project in collaboration with Mari Nygård of the Cancer Registry of Norway (CRN). CRN will co-ordinate SOIGNONS with two partners: Simula Research Laboratory and the Icelandic Cancer Registry (ICR). The duration of the project is January 2015 to December 2017.

Social nudging is a concept in behavioural sciences which argues that positive reinforcement and indirect suggestions to try to achieve non-forced compliance can influence the motives, incentives and decision making of groups and individuals, at least as effectively – if not more effectively - than direct instruction, legislation, or enforcement. Can we leverage social nudging via gamification to boost coverage of cervical cancer screening? This is the question that SOIGNonS aims to address. SOIGNonS in French means, "to heal together".

The goal of SOIGNonS is to virally communicate health information concerning cervical cancer via gamification in mobile games. Games will present information as thought-provoking puzzles and incentives to the younger generation and actively involve them in order to improve the health-related behaviour of their mothers or grandmothers. The success of gamification will be evaluated using registry linkages available in Nordic countries. For instance, in Norway we intend to link the population registry and the cancer registry's databases to observe long-term improvement in screening attendance due to gamification.

SOIGNONS is a first step towards exploring V&V of Socio-technical Systems thanks to the social behaviour data available at the Cancer Registry of Norway. The goal will be to see if software developed and implemented realise certain social functions.

In 2016, SOIGNONS released an app called FightHPV to educate adolescents about the risks of cervical cancer in a game, and evaluate its impact through registry linkage data and data from Google Analytics. FightHPV is a social application and game to nudge people into taking action against cervical cancer. It contains characters representing biological and medical entities such as the epithelial cell, humanpapillomavirus, screening and the HPV vaccination.

We received regional ethical committee approval, and approval from the Data protection authority and the game has been released in Norway since December 2016. The game is available to those who have a Google/Apple account created in Norway. The game is available in Norwegian and is being translated to English.

We plan to run a study to see if sub-optimally screened people (those who didn't attend screening in the last 4 years) played the game and consequently went to screening. The study will compare behaviour of similar people from historical data (1 year earlier).

EvolveIT:
Adjacent to project 9 is the EvolveIT project, which is funded through the FRINATEK program of the Norwegian Research Council. The overall goal of EvolveIT is to conceive novel recommendation technology that supports engineers with the evolution of families of complex, safety-critical, software-intensive systems. In 2016, we focused on the generalisation and evaluation of the recommendation and aggregation technology described above on a selection of 17 large open source systems, in addition to the systems from Certus partners Kongsberg Maritime and Cisco Norway. These systems were also used for empirically investigating the impact of parameter tuning and project characteristics on recommendation quality that resulted in the practical guidelines for applying our technology.

MBE-CR: An innovative approach for longstanding development and maintenance of the Automated Cancer Registry System:
The innovation planned in this project is an add-on to the digitisation project currently being undertaken by the Cancer Registry of Norway (CR).
The project started in 2009 and aims to transform the current paper-based/manual system into an ICT-based Automated Cancer Registry System (ACRS). The planned innovation project aims to develop systematic, automated and cost-effective model-based approaches for ensuring the quality of the evolving ACRS system and therefore significantly improving the efficiency of the patient history registration process. This will positively affect all its end users, including researchers, patients, doctors, and government officials.

In this project (adjacent to project 5) we have developed a model-based solution to improve the current practice of CRN in terms of their ICT-based automated cancer registry system. In 2016, we proposed a web-based application, named iOCL, to facilitate the specification of OCL constraints. iOCL is an interactive tool and aims to reduce the effort required to specifying OCL constraints as users in CRN are from the medical domain.

Centre Highlights of 2016

Month by month

In March 2016, Certus expanded the consortium to include the Cancer Registry of Norway (CRN). The primary objective of the collaboration between CRN and Certus is to guarantee a high degree of quality to the data-intensive software system developed at CRN.

In May, researchers of Certus Project 9 (Smarter Testing of Evolving Systems) attended the 13th International Conference on Mining Software Repositories (MSR) to present their work on aggregating evidence from software analytics to improve change impact analysis and eventual testing recommendations. MSR is the premier conference on the use of software analytics and machine learning techniques to analyse the rich body of data that is produced during the software engineering process. The paper investigates various approaches for combining evidence and evaluates them on two large industrial systems (from Certus partners Kongsberg Maritime and Cisco) and four large open source systems. The evaluation results show that their proposed aggregation of evidence indeed leads to a significant improvement in the resulting recommendations.

In May, Dr. Shuai Wang participated in the top software engineering venue (ICSE 2016) in Austin, USA, presenting two papers based on the collaboration with Certus industrial partners. ICSE is considered the most prestigious software engineering conference, aiming at publishing high quality works covering the entire lifecycle of software development from requirement to testing. The two papers presented are the joint work between researchers in Certus (postdoctoral researcher Shuai Wang, senior research scientist Shaukat Ali and chief research scientist Tao Yue) and Certus' industrial partner Cisco Systems.

In June, the adjacent U-Test project was one of the H2020 CPS projects represented at the workshop Challenges and New Approaches for Dependable and Cyber-Physical System Engineering (De-CPS 2016). The aim of the workshop was to exchange results and ideas from the on-going H2020 CPS projects. Several projects participated in the workshop including INTO-CPS, AXIOM, and PROXIMA. The results of U-Test achieved so far were presented during the workshop, in addition to presenting the request for information for initiating the standardisation of U-Taxonomy.

In July, a team of researchers from Certus and SICS in Sweden were presented with the prestigious Best Paper Award at the 11th International Conference on Software Engineering and Applications, or ICSOFT-EA 2016. The team, consisting of Arnaud Gotlieb, Dusica Marijan and Alexandre Pétillon from the Certus Centre and Simula, and Mats Carlsson from SICS in Sweden, won the award for the paper "A New Approach to Feature-based Test Suite Reduction in Software Product Line Testing".

Also in July, following up on a Best Paper award won two years ago, Certus researchers and engineers were invited to co-author a paper for the Best Paper Sister Track of the International Joint Conference on Artificial Intelligence (IJCAI'16), one of the most prestigious scientific conference on Artificial Intelligence.

In August, Simula hosted a crash course in Machine Learning (ML), co-organized with Certus researchers. ML as an Artificial Intelligence discipline is becoming more important in software development processes, and Certus researchers believe that more and more interesting AI-based techniques will help to foster innovation in this area. Centre leader's Arnaud Gotlieb was one of the teachers of the course, and several Certus board members and partners (including researchers from Simula) attended, due to increased interest of Certus partners.

In December, Leon Moonen co-organised a workshop on technical debt analytics. The workshop addressed the following goals:

- Calibrating technical debt and technical wealth related terminologies and concepts that are used indistinctly and interchangeably in software engineering literature.
- Comparing, integrating, compiling and even reconciling empirical work on the effects of technical debt and technical wealth from economic and organisational perspectives.

Ongoing during 2016

In the adjacent project MBE-CR, Certus researchers designed an interactive object constraint language (OCL) specification tool named iOCL to reduce the effort and modelling knowledge required of medical experts, thereby facilitating the specification of cancer coding rules as OCL constraints. The tool is used by the Cancer Registry of Norway, and MBE4CR researchers have also demonstrated the tool at the ACM/IEEE 19th International Conference on Model Driven Engineering Languages and Systems.

In the course of 2016, Certus researchers developed, validated and released an app called FightHPV to educate adolescents about the risks of cervical cancer in a serious game. FightHPV can be seen as a socio-technical application to nudge people into taking action against cervical cancer and as such, its validation and verification falls into the competence area of Certus. The design of a constraint-based model based on Artificial Intelligence for this game was recognized as a key factor for a successful adoption of the tool and accepted for publication in a top-ranked conference on AI held in early 2017.

Dr Shuai Wang, project leader of Project 8, has throughout 2016 actively contributed to the European COST Action CA15140: Improving Applicability of Nature-Inspired Optimisation by Joining Theory and Practice (ImAppNIO) as management committee (MC) and participating in MC meetings and action workshops.

Researchers in Certus' Project 9 succeeded in enabling fine-grained analysis and recommendations, and successfully transferred the technology to KMA as a software-as-a-service. The researchers also started a new research track on anomaly detection and diagnosis.

Project leader Leon Moonen states: "*Up to now, we could only analyse and recommend at a relative course-grained level [files], but we are able to do a much more detailed method level analysis and recommendation for Java, C, C++ and C#.*"

In the course of 2016, Certus researchers developed, validated and released an app called FightHPV to educate adolescents about the risks of cervical cancer in a serious game. The design of a constraint-based model based on Artificial Intelligence for this game was recognized as a key factor for a successful adoption of the tool and accepted for publication in a top-ranked conference on AI held in early 2017.

International Collaboration in 2016

European collaboration

Inria (France) and CEA (France)
Following-up on a long-term collaboration with Inria, Certus Centre's leader Arnaud Gotlieb has agreed to co-supervise the PhD of Quentin Plazar, employed at Inria Rennes, together with Sebastien Bardin (CEA) and Mathieu Acher (Inria). The PhD topic extends an initial collaboration between Simula, Inria and CEA on constraint solving of array constraints by combining Satisfiability Modulo Theory and Constraint Programming.

Universities of Parma and Pisa (Italy)
In 2016, Professors Roberto Bagnara and Roberta Gori collaborated with the Certus Centre's leader Arnaud Gotlieb to develop and finalise theoretical results on the solving of constraints over floating-point computations, leading to
a publication in the top-ranked journal Journal of Computing (JoC).

SICS (Sweden)
Resulting from an intensive collaborative activity together with Mats Carlsson from SICS, Certus researchers Dusica Marijan and Arnaud Gotlieb published several papers on test case prioritisation using constraint programming. One of them was awarded Best Paper at ICSOFT 2016, the other one being the first Certus publication at a top-ranked Artificial Intelligence conference.

Mondragon University (Spain)
In 2016, PhD student Aitor Arrieta from Mondragon University paid a visit to Simula for one month, and two joint papers were produced on applying SBSE for addressing complex testing challenges of CPSs. The two papers were published at well renowned venues (i.e., GECCO 2016
and SPLC 2016).

University of Nantes (France)
In 2016, Certus research scientist Sagar Sen worked with the University of Nantes on re-identification risk analysis of anonymised data and testing of elasticity in cloud computing systems.

International collaboration

Beihang University (China)
This long-term fruitful collaboration has been further strengthened through several research perspectives such as empirical software engineering, requirements engineering, and model-based engineering since the start of Certus. In 2016, the collaboration focuses in particular on model-based product line engineering and model-based requirements engineering. Two PhD students from Beihang University visited Simula to work on their PhD theses in the scope of these two research paths, under the supervision of Tao Yue and Shaukat Ali. Several peer-reviewed conference papers and journals have been either published or submitted.

Loyola University, Maryland (USA)
Following up on his visit in 2015, Prof. Dr. David Binkley visited us for six weeks, funded through the Fulbright Scholar program and an NSF grant. Binkley is a Professor of Computer Science at Loyola University Maryland, and collaborated with Leon Moonen on an international collaborative research project on the evolution of software intensive safety-critical systems. The project identified synergies between Binkley's research, which focuses on semantic-based software tools that deeply analyse the meaning of small programs to identify potential issues in the code, and Moonen's research, which focuses on techniques and tools to support the evolution of large industrial software systems. This shared common ground and collaboration has been instrumental to the development and refinement of HaRT. Collaboration continued after Binkley's return to the U.S. and has resulted in four published conference papers and two journal article submissions.

Nasa Jet Propulsion Laboratory (USA)
During November 2016, Maged Elaasar, Computer Scientist from the NASA Jet Propulsion Laboratory, visited Simula in the context of the MBT4CPS project, an adjacent project of Project 5. Elaasar is a research collaborator on the project.

Albert Einstein College of Medicine (New York, USA)
Researchers in Project 7 collaborated with the Albert Einstein College of Medicine and CIDRZ, Zambia, on project VAPADZAM to run focus groups to FightHPV in Zambia.

Federal University of Minas Gerais (UMFG) (Brazil)
Researchers in Project 7 collaborated with Racquel Minardi and Wagner Meira from UFMG, Brazil, on interactive visualisation and data mining for Portinari, a project developed under Project 7 with the Cancer Registry of Norway

Visitors

In 2016, Certus received visits from several researchers from around the world:

Name	Organisation	Country
Aitor Arrieta	Mondragon University	Spain
Huihui Zhang	Beihang University	China
Yan Li	Beihang University	China
David W. Binkley	Loyola University	USA
Maged Elaasar	Nasa Jet Propulsion Laboratory	USA
Racquel Minardi	Federal University of Minas Gerais (UMFG)	Brazil
Wagnes Meira	Federal University of Minas Gerais (UMFG)	Brazil

Visit by the Scientific Advisory Board

In December 2016, the Certus' Scientific Advisory Board (SAB) visited Certus at the ABB office and factory located in Bryne, near Stavanger. The SAB consists of Prof. Antonia Bertolino from CNR-ISTI, Italy, Prof. Laurence Duchien from the University of Lille, France, and Prof. Franz Wotawa from Graz University of Technology, Austria. During their visit they had the opportunity to conduct a thorough investigation and to make suggestions on the future of Certus, including its exit strategy, which is increasingly relevant.

During the visit, current research at Certus was presented. The presentations covered the area of testing in the domain of industrial robotics, test case prioritisation, anomaly detection, fault localisation, and data validation based on rules in the domain of the Cancer Registry of Norway (CRN). Further presentations were devoted to extensions of research, featuring extraction from available software engineering artefacts, testing intelligent robotics systems, and testing socio-technical systems. The members of the advisory board found the presented research questions interesting and the preliminary approaches appealing. Even though some of the research projects were relatively newly started, the presented work was considered as already advancing the state of the art in their respective domains. The collaboration structure between Certus and the partners, where the partners have the opportunity to present their problems and collaborate with the researchers, was deemed excellent by the advisory board. Even though Certus has already established a good network of international cooperation with foreign universities, the SAB suggested extending collaboration into robotics and formal verification. In particular, the domain of autonomous systems and intelligent robotics, as well as quality assurance research, were identified as strategic areas of investment for Certus.

Recommendations

On the whole, the SAB recommend that Certus consider gaining further synergies between its projects, and couple research activities with the exit strategy in order to provide the basis for a sustainable CT-lab.

The SAB recommended that Certus further develop its communication strategy, which should support the Certus exit strategy. Furthermore, The SAB recommended that the Certus administration further elaborate an advanced business model and consider multiple funding opportunities.

Analysis

The Certus administration took notice of the excellent recommendations of the SAB and started to take actions to implement the suggested improvements. In particular, some Certus partners already got involved in project proposals targeting intelligent robotics validation where new partnerships could be created, and an even stronger exit strategy for Certus could be devised.

Personnel

Centre Director

- Gotlieb, Arnaud - Centre Leader – Chief Research Scientist

Key researchers

- Ali, Shaukat - Senior Research Scientist
- Ieva, Carlo - Senior Research Engineer
- Marijan, Dusica - Research Scientist
- Moonen, Leon - Senior Research Scientist
- Sen, Sagar - Research Scientist
- Yue, Tao - Chief Research Scientist

Guest researchers

- Li, Yan - Beihang University, Beijing, China.
- Aitor Arrita Marcos - University of Mondragon, Spain
- Mottu, Jean Marie - University of Nantes

Research engineers with financial support from other sources

- Hammad, Muhammad[1]

Postdoctoral researchers with financial support from the CERTUS Centre budget

- Wang, Shuai[2]

Postdoctoral researchers working on projects in the CERTUS Centre with financial support from other sources

- Alesio, Stefano Di[3]
- Nguyen, Phu-Hong[4]
- Lu, Hong[5]

PhD students with financial support from the CERTUS Centre budget

- Rosenberg, Carl-Martin[6]
- Pradhan, Dipesh[7]
- Spieker, Helge[8]

PhD students working on projects in the CERTUS Centre with financial support from other sources

- Safdar, Safdar Aqeel[9]
- Rolfsnes, Thomas Gramstad[10]
- Ma, Tao[11]
- Zhang, Man[12]
- Li, Yan[13]

Research trainees working on projects in the Certus Centre

- Ribiero, Manoel[14]
- Louarn, Marine[15]

Administrative personnel with financial support from the Certus Centre budget

- Bjerke, Christian[16]
- Hagane, Karoline[17]
- Atkinson, Tom David[18]
- Bruaset, Are Magnus[19]

[1] 100% funded by MBE-CR
[2] 40% funded by Certus, 60% by MBE-CR
[3] 100% funded by EvolveIT
[4] 30% funded by U-Test, 70% by MBT4CPS
[5] 58% funded by ZenConfigurator
[6] 29% funded by Certus
[7] 100% funded by Certus
[8] 25% funded by Certus
[9] 100% funded by ZenConfigurator
[10] 53% funded by EvolveIT
[11] 100% funded by MBT4CPS
[12] 100% funded by U-Test
[13] 20% funded by U-Test
[14] 26.06.2016-06.08.2016, working 13% on Software engineering and modelling
[15] 15.03.2016-15.09.2016, working 50% on Software engineering and modelling
[16] Working 2% on Certus until 31.01.16
[17] Working 20% on Certus
[18] Working 20% on Certus
[19] Working 20% on Certus

Supervision of Master's Students

An important part of the Certus concept is to support research in higher education. To that end Certus researchers supervise Master's studies in the field of software engineering.

Female master's students

Name	Supervised by
Dongjing Liu	Marius Liaaen (Cisco systems) Morten Mossige (ABB) Andreas Skaar (University of Stavanger)
Marine Louarn	Arnaud Gotlieb (Certus) Sagar Sen (Certus)

Male master's students

Name	Supervised by
Waqas Moazzam Butt	Sagar Sen (Certus) Magne Jørgensen (Certus)

Chairs and Scientific Activities

Certus researchers have been selected to chair and participate in several scientific committees. Committee membership is not merely volunteer work. Membership is by invitation only, and these invitations are some of the hardest to come by in the software engineering world.

Arnaud Gotlieb

Track Co-Chair:

- CP'16: 22nd Int. Conf. on Principles and Practice of Constraint Programming, Toulouse, France, Sep. 2016

Program Committee Member:

- COMPSAC'16: 40th IEEE Annual Int. Computer Software & Applications Conf., Atlanta, USA, Jun. 2016
- QRS'16: IEEE Int. Conf. on Software Quality, Reliability & Security. Vienna, Austria, Jul. 2016
- TAP'16: 11th Int. Conf. on Tests and Proofs, Vienna, Austria, Jul. 2016
- MET'16: Int. Workshop on Metamorphic Testing, Austin, USA, May 2016
- iFMCloud'16: Int. Workshop on Formal Methods for and on the Cloud, Reykjavik, Iceland, Jun. 2016
- CP meets Verification Workshop at CP'2016, Toulouse, France, Sep. 2016

Invited Talks:

- Constraint-Based Test Suite Optimization. In 28th International Conference on Testing Software and Systems (ICTSS'16), Oct. 17-19, Graz, Austria, 2016.
- Constraint-Based Testing: An Emerging Trend in Software Testing. In XVI Jornadas sobre Programación y Lenguajes (PROLE 2016), Salamanca, Spain, 14-16 Sep. 2016.
- Software Testing Applications with Constraint Optimization. In SICS, Smart Programming Day, 2016, Nov. 29th, Stockholm, Sweden.

Tao Yue

Program Committee Member:

- MODELS'16: ACM/IEEE 19th Int. Conf. on ModelDriven Engineering Languages and Systems, Saint Malo, France
- MODELSWARD'16: 4th Int. Conf. on Model-Driven Engineering and Software Development, Feb. 19-21, Rome, Italy
- RE'16: 24th Int. Conf. on Requirements Engineering. Beijing, China
- SPLC'16: 21th Int. Systems and Software Product Line Conf.. Beijing, China
- QRS'16: IEEE Int. Conf. on Software Quality, Reliability & Security. Vienna, Austria
- COMPSAC'16: IEEE 40th Annual Int. Computers, Software & Applications Conf.. Atlanta, Georgia, USA

Dusica Marjan

Invited Participation:

- Dagstuhl seminar on Software Performance for DevOps, September 2016, I. Weber, A. Hoorn, P. Jamshidi, P. Leitner.

Shaukat Ali

Program Committee Member:

- MODELS'16: ACM/IEEE 19th Int. Conf. on Model Driven Engineering Languages and Systems, Saint Malo, France
- ECMFA'16:12th European Conf. on Modelling Foundations and Applications
- ICST'16: 9th IEEE Int. Conf. on Software Testing, Verification and Validation
- SPLC'16: 20th Int. Systems and Software Product Line Conf.
- SAM'16: 9th System Analysis and Modelling Conf.
- SSBSE'16: 8th Int. Symp. on Search-based Software Engineering
- SPLC'16: Doctoral Symp. at the Systems and Software Product Line Conf.

Other Certus-Related Scientific Activities:

Shaukat Ali was invited to two conferences in Pakistan for invited talks including IEEE 10th International Conference on Open Source Systems & Technologies (ICOSST), Lahore, Pakistan and 14th International Conference on Frontiers of Information Technology (FIT) Islamabad Pakistan. Government of Punjab, Pakistan funded the trip.

In the context of COST Action IC1404, Tao Yue, Man Zhang, and Shaukat Ali were invited for talks for a workshop hosted by University of Malaga, Spain in November 2016.

Sagar Sen

Program Chair:

- SER&IP'16: 3rd Int. Workshop on Soft. Eng. Research and Industrial Practice,
- ISSRE'16: 28th IEEE Int. Symp. on Software Reliability Engineering
- iFMCloud'16: Int. Workshop on Formal Methods for and on the Cloud, Reykjavik, Iceland, Jun. 2016
- SANER'16: 23rd IEEE Int. Conf. on Software Analysis, Evolution, and Reengineering,

Shuai Wang

Program Committee Member:

- SAC'16: 31st ACM/SIGAPP Symp. on Applied Computing
- MODELSWARD'16: 4th Int. Conf. on Model-Driven Engineering and Software Development, Rome, Italy
- A-MOST'16: 12th Workshop on Advances in Model Based Testing, Chicago, USA.

Leon Moonen

Steering Committee Member:

- IEEE Int. Working Conf. on Source Code Analysis and Manipulation (SCAM, chair)
- Int. Workshop on Patterns Promotion and Anti-patterns Prevention (PPAP)

Program Committee Member:

- MMHS'16: 3rd Int. Workshop on (Meta)modelling for Healthcare Systems
- ICPC'16: 24th IEEE Int. Conf. on Program Comprehension
- SCAM'16: 16th IEEE Int. Working Conf. on Source Code Analysis and Manipulation
- ICSME'16: 32nd IEEE Int. Conf. on Software Maintenance and Evolution

Stefano di Alesio

Program Committee Member:

- CSTVA'16: 7th Int. Workshop on Constraint Solvers in Testing, Verif. and Analysis
- WoSoCer'16: 6th IEEE Int. Workshop on Software Certification
- A-MOST'16: 12th Advances in Model based Testing Workshop

Certus Publications

Articles in International Journals

1. Exploiting Binary Floating-Point Representations for Constraint Propagation
   R. Bagnara, M. Carlier, R. Gori and A. Gotlieb
   INFORMS Journal of Computing (JoC), vol. 28, pp. 31—46, 2016
2. A Systematic Test Case Selection Methodology for Product Lines: Results and Insights From an Industrial Case Study
   S. Wang, S. Ali, A. Gotlieb and M. Liaaen
   Empirical Software Engineering, vol. 21, pp. 1586—1622, 2016
3. Analyzing and Visualizing Information Flow in Heterogeneous Component-Based Software Systems
   L. Moonen and A. R. Yazdanshenas
   Information and Software Technology, vol. 77, pp. 34—55, 2016
4. Modelling and Verifying Combinatorial Interactions to Test Data Intensive Systems: Experience with Optimal Archiving at the Norwegian Customs and Excise Directorate
   S. Sen, D. Marijan, C. Ieva, A. Grime and A. Sander
   IEEE Transaction on Reliability, pp. 1—14, 2016
5. Practical Minimization of Pairwise-Covering Test Configurations Using Constraint Programming
   A. Hervieu, D. Marijan and A. Gotlieb
   Information and Software Technology, vol. 71, pp. 129—146, 2016
6. Zen-ReqOptimizer: A Search-based Approach for Requirements Assignment Optimization
   Y. Li, T. Yue, S. Ali and L. Zhang
   Empirical Software Engineering, vol. 22, pp. 175—234, 2016
7. Assessing the Quality of Industrial Avionics Software: An Extensive Empirical Evaluation
   J. Wu, S. Ali, T. Yue, J. Tian and C. Liu
   Empirical Software Engineering, 2016
8. Model-based Incremental Conformance Checking to Enable Interactive Product Configuration
   H. Lu, T. Yue, S. Ali and L. Zhang
   Information and Software Technology, vol. 72, pp. 68—89, 2016
9. Model-Based Security Engineering for Cyber-Physical Systems: A Systematic Mapping Study
   P. H. Nguyen, S. Ali and T. Yue
   Information and Software Technology, vol. 83, pp. 116–135, 2016
10. Tackling Uncertainty in Cyber-Physical Systems with Automated Testing
    S. Ali, T. Yue and M. Zhang
    ADA User Journal, vol. 37, 2016
11. Introduction to the Special Issue on Software Maintenance and Evolution
    L. Moonen and L. Pollock
    Journal of Software: Evolution and Process, vol. 28, pp. 510—511, 2016
12. Introduction to the Special Issue on Program Comprehension
    C. K. Roy, A. Begel and L. Moonen
    Journal of Software: Evolution and Process, vol. 28, pp. 838—839, 2016
13. Naming the Pain in Requirements Engineering: Contemporary Problems, Causes, and Effects in Practice
    D. M. Fernandez, S. Wagner, M. .Kalinowski, M. Felderer, P. Mafra, A. Vetrò, T. Conte, M.-T. Christiansson, D. Greer, C. Lassenius, T. Männistö, M. Nayabi, M. Oivo, B. Penzenstadler, D. Pfahl, R. Prikladnicki, G. Ruhe, A. Schekelmann, S. Sen, R. Spinola, A. Tuzcu, J. L. de la Vara and R. Wieringa
    Empirical Software Engineering, 2016

Edited Books

1. Proceedings of the Third International Workshop on Patterns Promotion and Anti-patterns Prevention
   L. Moonen, F. Khomh, H. Washizaki, Y.-G. Guéhéneuc and G. Antoniol
   IEEE, 2016
2. Proceedings of the First International Workshop on Technical Debt Analytics (TDA 2016)
   A. Yamashita, L. Moonen, T. Mens and A. Tahir
   CEUR Workshop Proceedings, 2016

Refereed Proceedings

1. Generalizing the Analysis of Evolutionary Coupling for Software Change Impact Analysis
   T. Rolfsnes, S. Di Alesio, R. Behjati, L. Moonen and D. Binkley
   in 23rd IEEE International Conference on Software Analysis, Evolution, and Reengineering (SANER), 2016
2. Automated Regression Testing Using Constraint Programming
   A. Gotlieb, M. Carlsson, M. Liaaen, D. Marijan and A. Petillon
   in Twenty-Eighth Conference on Innovative Applications of Artificial Intelligence (IAAI-16), Phoenix, AZ, USA, Feb. 2016, 2016
3. Enhancing Test Case Prioritization in an Industrial Setting with Resource Awareness and Multi-Objective Search
   S. Wang, S. Ali, T. Yue, Ø. Bakkeli and M. Liaaen
   in The 38th International Conference on Software Engineering (ICSE), Software Engineering in Practice (SEIP) track, 2016
4. Improving Change Recommendation using Aggregated Association Rules
   T. Rolfsnes, L. Moonen, S. Di Alesio, R. Behjati and D. Binkley
   in 13th International Conference on Mining Software Repositories (MSR), 2016
5. A Practical Use Case Modeling Approach to Specify Crosscutting Concerns: Industrial Applications
   T. Yue, H. Zhang, S. Ali and C. Liu
   in International Conference on Software Reuse (ICSR), 2016
6. Generating Boundary Values from OCL Constraints using Constraints Rewriting and Search Algorithms
   S. Ali, T. Yue, X. Qiu and H. Lu
   in IEEE World Congress on Computational Intelligence, 2016
7. Test Case Prioritization of Configurable Cyber-Physical Systems with Weight-Based Search Algorithms
   A. Arrieta, S. Wang, G. Sagardui and L. Etxeberria
   in Genetic and Evolutionary Computation Conference (GECCO), 2016
8. MBF4CR: A Model-Based Framework for Supporting An Automated Cancer Registry System
   S. Wang, H. Lu, T. Yue, S. Ali and J. Nygård
   in 12th European Conference on Modelling Foundations and Applications (ECMFA 2016), 2016
9. Understanding Uncertainty in Cyber-Physical Systems: A Conceptual Model
   M. Zhang, B. Selic, S. Ali, T. Yue, O. Okariz and R. Norgren
   in European Conference on Modelling Foundations and Applications(ECMFA), 2016
10. A Practical Guide to Select Quality Indicators for Assessing Pareto-Based Search Algorithms in Search-Based Software Engineering
    S. Wang, S. Ali, T. Yue, Y. Li and M. Liaaen
    in the 38th International Conference on Software Engineering (ICSE), 2016
11. Generating Tests for Robotized Painting Using Constraint Programming
    M. Mossige, A. Gotlieb and H. Meling
    in Int. Joint Conf. on Artificial Intelligence (IJCAI-16) - Sister Conference Best Paper Track, 2016
12. A New Approach to Feature-based Test Suite Reduction in Software Product Line Testing
    A. Gotlieb, M. Carlsson, D. Marijan and A. Petillon
    in ICSOFT-EA 2016, 11th Int. Conf. on Software Engineering and Applications, Lisbon, July 2016, Awarded Best Paper, 2016
13. Search-Based Test Case Selection of Cyber-Physical System Product Lines for Simulation-Based Validation
    A. Arrieta, S. Wang, G. Sagardui and L. Etxeberria
    in International Systems and Software Product Line Conference (SPLC), 2016
14. Optimal Performance Tuning in Real-Time Systems using Multi-objective Constrained Optimization
    S. Di Alesio
    in The 22nd International Conference on Principles and Practice of Constraint Programming (CP 2016), 2016
15. Practical Guidelines for Change Recommendation using Association Rule Mining
    L. Moonen, S. Di Alesio, D. Binkley and T. Rolfsnes
    in IEEE/ACM International Conference on Automated Software Engineering (ASE), 2016
16. STIPI: Using Search to Prioritize Test Cases based on Multi-Objectives Derived from Industrial Practice
    D. Pradhan, S. Wang, S. Ali, T. Yue and M. Liaaen
    in The 28th International Conference on Testing Software and Systems (ICTSS), 2016
17. Search-Based Cost-Effective Test Case Selection within a Time Budget: An Empirical Study
    D. Pradhan, S. Wang, S. Ali and T. Yue
    in Genetic and Evolutionary Computation Conference (GECCO), 2016
18. Evaluating Variability Modeling Techniques for Supporting Cyber-Physical System Product Line Engineering
    S. A. Safdar, T. Yue, S. Ali and H. Lu
    in System Analysis and Modelling (SAM) Conference, 2016
19. Towards Mutation Analysis for Use Cases
    H. Zhang, T. Yue, S. Ali and C. Liu
    in ACM/IEEE 19th International Conference on Model Driven Engineering Languages and Systems (MODELS), 2016
20. iOCL: A Interactive Tool for Specifying, Validating and Evaluating OCL Constraints
    H. Muhammad, T. Yue, S. Ali and S. Wang
    in Tool Demonstrations Track, ACM/IEEE 19th International Conference on Model Driven Engineering Languages and Systems (MODELS), 2016
21. Exploring the Effects of History Length and Age on Mining Software Change Impact
    L. Moonen, S. Di Alesio, T. Rolfsnes and D. Binkley
    in International Working Conference on Source Code Analysis and Manipulation (SCAM), 2016
22. Effect of Time Window on the Performance of Continuous Regression Testing
    D. Marijan and M. Liaaen
    in 32nd IEEE International Conference on Software Maintenance and Evolution (ICSME), 2016
23. A Model-Based Approach with Tool Support to Facilitate the Cancer Registration Process in Cancer Registry of Norway
    S. Wang, H. Lu, T. Yue, S. Ali and J. F. Nygård
    in European Telemedicine Conference (ETC), 2016
24. Coverage-based Test Prioritization for Regression Testing of Configurable Software
    D. Marijan and M. Liaaen
    in IEEE 27th International Symposium on Software Reliability Engineering (ISSRE), 2016
25. Report on the First International Workshop on Technical Debt Analytics (TDA 2016)
    A. Yamashita, L. Moonen, T. Mens and A. Tahir
    in Joint Proceedings of the 4th International Workshop on Quantitative Approaches to Software Quality (QuASoQ 2016) and 1st International Workshop on Technical Debt Analytics (TDA 2016), 2016

Certus Publications (Continued)

Technical Reports

1. Uncertainty Modeling Framework for the Integration Level V.1
   M. Zhang, S. Ali, T. Yue and P. H. Nguyen
   Simula Research Laboratory, 2016
2. Towards Mutation Analysis for Use Cases
   H. Zhang, T. Yue, S. Ali and C. Liu
   Simula Research Laboratory, 2016
3. Conceptually Understanding Uncertainty in Self-Healing Cyber-Physical Systems
   T. Ma, S. Ali and T. Yue
   Simula, 2016
4. Practical Guidelines for Change Recommendation using Association Rule Mining - TR
   L. Moonen, S. Di Alesio, D. Binkley and T. Rolfsnes
   Simula Research Laboratory, 2016
5. An Integrated Modeling Framework to Facilitate Model-Based Testing of Cyber-Physical Systems under Uncertainty
   M. Zhang, S. Ali, T. Yue, R. Norgren and O. Okariz
   Simula Research Laboratory, 2016
6. Interactively Evolving Test Ready Models with Uncertainty Developed for Testing Cyber-Physical Systems
   M. Zhang, S. Ali, T. Yue and R. Norgren
   Simula Research Laboratory, 2016
7. Uncertainty-based Test Case Generation and Minimization for Cyber-Physical Systems: A Multi-Objective Search-based Approach
   M. Zhang, S. Ali, T. Yue and Malin Hedman
   Simula Research Laboratory, 2016
8. Modeling Healing Behaviors of Cyber-Physical Systems with Uncertainty to Support Automated Testing
   T. Ma, S. Ali and T. Yue
   Simula, 2016
9. Specifying Uncertainty in Use Case Models in Industrial Settings
   M. Zhang, T. Yue, S. Ali, B. Selic, O. Okariz, R. Norgren and K. Intxausti
   Simula Research Laboratory, 2016

Talks

1. Model Based Testing of Cyber-Physical Systems in Practice: Challenges, results, future directions from multiple projects
   T. Yue
   The 12th Advances in Model based Testing Workshop @ICST 2016, Chicago, USA, 2016
2. Generating Boundary Values from OCL Constraints using Constraints Rewriting and Search Algorithms
   S. Ali
   IEEE World Congress on Computational Intelligence, 2016
3. Constraint-Based Testing: An Emerging Trend in Software Testing
   A. Gotlieb
   XVI Jornadas sobre Programación y Lenguajes (PROLE 2016), Salamanca, Spain, 14-16 Sep. 2016, 2016
4. Constraint-Based Test Suite Optimization
   A. Gotlieb
   28th International Conference on Testing Software and Systems (ICTSS'16), October 17-19, 2016, Graz, Austria., 2016
5. Software Testing Applications with Constraint Optimization
   A. Gotlieb
   SICS, Smart Programming Day, 2016, Nov. 29th, Stockholm, Sweden, 2016
6. Model-Driven Testing of Cyber-Physical Systems with the Explicit Consideration of Uncertainty
   S. Ali
   MPM4CPS WG meetings in Malaga, Spain, 24-25 November 2016, 2016
7. Testing Cyber-Physical Systems in Uncertainty
   S. Ali
   IEEE 10th International Conference on Open Source Systems & Technologies (ICOSST), Lahore, Pakistan and 14th International Conference on Frontiers of Information Technology (FIT)
   Islamabad Pakistan, 2016

Statistics on Certus Publications
2011–2016

The Development Of Certus Publications

	October 2011	2012	2013	2014	2015	2016	TOTAL
Journal articles	3	12	13	10	10	13	61
Edited books			1	2		2	5
Proceedings, refereed	11	24	35	22	13	25	130
Book chapters	1	1	1	1	2		6
Talks, keynote		1		3		2	6
PhD Theses		3			2		5
Proceedings, non-refereed		1					1
Posters		1			1		2
Technical reports	4	8	3	3	3	9	30
Talks, invited		1	1	1	6	3	12
Talks, contributed		3	1	5	5	2	16
Master's theses	1						1
Miscellaneous		1	1				2
TOTAL							277

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