

# SICS

ACTIVITIES 2015-2016

## SICS ICE DATA CENTER

The world's first open data center for large-scale experiments has opened in Luleå.

## A PRIMARY CARE CENTER WITH DIGITAL AMBITIONS

A system that responds to the needs of a modern society.

## BIG DATA TELLS US STORIES ABOUT REALITY

Anomaly detection along the Swedish coasts and efficient traffic flow on the roads.

# DIGITALIZATION – A POWERFUL SOURCE FOR CHANGE

## GAMING TECHNOLOGIES IMPROVE THE PROCESS INDUSTRY

How can augmented reality, virtual reality and smart sound be used to train employees to perform certain tasks?

SWEDISH  
ICT

SICS

# SICS Swedish ICT is the leading research institute for applied information and communication technology in Sweden.

## WHAT IS SICS?

SICS operates in the most expansive area of industry this century: the total digitalization of products, services and businesses. SICS is in the midst of this revolution, boosting the competitive strength of Swedish industry and the quality and efficiency of Sweden's public sector. We contribute with cutting edge technology within the fastest growing and most relevant areas of this revolution, including big data analytics, automation, security, and internet-of-things.

SICS Swedish ICT is not for profit and carries out advanced research in close collaboration with Swedish and international industry and academia. We constantly seek partnerships in which new technology can be turned into smart innovation, giving our customers and partners a competitive edge.

## SCIENCE AREAS

- Big Data Analytics, Machine Learning and Optimization
- Data Intensive Computing and Cloud Platforms
- Network Technology and Architectures
- Security, Trust, Privacy and Integrity
- Interaction and User Experience
- Software and Systems Engineering
- Computer Systems

## APPLICATION AREAS

We have deep domain knowledge and explicit goals in the following areas:

- Internet of Things
- Industrial Automation and Maintenance
- Automotive and Rail
- Telecom
- Digital Health
- Digitalization of Education
- Decision Support and Business Intelligence
- Data Centers

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**A TIME FOR CHANGE.**

Suddenly, digitalization is having impacts everywhere, and we're seeing the automatic generation of news, artificial intelligence in healthcare, the automation of transport, training via the web, and more. As individuals, we are all part of the digital era – one just needs to look around to see it.

The enormously positive impact of these systems lies in the fact that everyone is able to reap the benefits. Developing expertise doesn't require studying at expensive universities, but rather can be achieved by anyone through online training, provided the required IP infrastructure is in place. Building new digital services and products has never before cost less or been so simple. The price of hardware is continually falling, cloudification is providing access to tools and services that are razor sharp and often free, skills are available globally at low prices.

Business models are changing. For example, the way a business differentiates itself nowadays is not so much about individual components, but rather how these can be integrated into value-creating systems and solutions. The big trend that we're currently seeing is for nearly all products to be connected and intelligent, as well as for them to be integrated in different ways within the customer's and supplier's businesses, often under the name of Internet-of-Things systems. The technology for sensors, communication, cloud, data analytics, security

and so on already exists to a large extent. The question that many organizations are asking themselves is how they can use them and, perhaps even to greater extent, what will happen if they fail to use them.

What makes this transformation so challenging for organizations is that it affects everything from product development to business models and the sales organization. I believe that organizations need to find an integrating, experimental approach and to work continuously with insights and skills from across their entirety, in order for the transition to be successful.

SICS Swedish ICT is the perfect partner in this transformation, every step of the way from technology to innovation. Our operations have never before felt so crucial. Over the past year SICS has grown dramatically. We are increasingly in demand, both for our expertise and for our ability to drive complex projects involving many partners, such as eHealth and Smart Cities initiatives. We have established SICS North with a new data center in Luleå aimed at strengthening Sweden's position in this area of science. We're also investing heavily in operations within artificial intelligence and big data, with plans underway for a major initiative. We are taking on an increasing number of projects involving the Internet of Things, automation, systems of systems, vehicles, and eHealth, and we're growing within the areas of scalable learning and innovation.

Last but not least, things are going very well for our spin-off companies. These employed some 450 staff in 2015, producing a turnover of SEK 517 million.

How is this all possible? I think the simple answer lies in sharp, curious, and collaborative employees, as well as excellent customer relationships.

We look forward to an exciting 2016!

Christer Norström, CEO



**GLOBAL DEVELOPMENT AFFECTS US ALL, AND ONE OF THE CURRENT POWERFUL FORCES FOR CHANGE IS DIGITALIZATION.**



AN EXPANSIVE YEAR.

SICS SWEDISH ICT IS IN THE MIDST OF A PROCESS OF CHANGE THAT IS MAKING IT ALL THE MORE CLEAR HOW TECHNOLOGICAL RESEARCH CREATES VALUE WITHIN THE COMMUNITY AND INDUSTRY.

SICS's biggest customer is Ericsson. Advanced ICT continues to be one of the primary application areas for SICS's cutting-edge research within the cloud, networks, and data science. To enable large-scale experiments, SICS is now establishing a data center in Luleå in association with Luleå University of Technology and Upper Norrbotten regional authorities. The center is also open to other research organizations.

SICS's second largest focus area is automation, where we are working with a range of powerful domestic and international partners, including ABB, Boliden, Bombardier, SOBI, and Volvo. SICS's project portfolio is impressive, and SICS Västerås manages the Process Industrial IT and Automation (PiiA) strategic-innovation program. We work chiefly with efficiency and maintenance issues, security, user experience, and innovation.

The third major industrial sector in which we are involved is automotive. We work extensively with Scania and Volvo, with cooperation taking place in areas including architecture, testing, development methods, safety, and big data.

An emerging industry that is notable among our customer-base is based on data analytics, involving companies like Spotify, King, and Klarna and a somewhat different communications culture.

An emerging industry is based on data analytics, involving companies like Spotify, King, and Klarna.

SICS is becoming more active in the Öresund region through a growing office in Lund and close contact with Lund University.

SICS's offering as a strategic sounding board is becoming all the more clear to both industry and to community-service providers. We are now playing a leading role in meeting major societal challenges, primarily in the areas of health, education, transport, and city planning. Our focus here is more often related to service development and in orchestrating change, rather than in being at the forefront of research.

The introduction of the New Tools for Health initiative in Norrköping has added a new market with a focus on regional players across the whole country and political processes.

SICS is also taking a clearer role as an opinion leader and consultative authority for political decisions within the ICT field. We have strengthened our expertise in the area of privacy and surveillance, and we are investing heavily in data security through a rapidly growing security group in Lund.

All together, this has meant big changes in terms of skills, organization, and content. SICS's skills within the various focus areas have been completed by the addition of domain experts and project managers who are able to orchestrate complex projects. The needs of industry and the community are driving the direction of research, while at the same time our unique position as a neutral player without its own profit motive provides us with a high level of integrity and freedom to cooperate with all of the forces for good.

SICS OFFICES:

- LULEÅ
- LUND
- VÄSTERÅS
- NORRKÖPING
- LINKÖPING
- UPPSALA
- KISTA







**SICS MEETS DIGITALIZATION DEMANDS**

**SICS has recently developed a range of services allowing us to meet each customer at an appropriate level of engagement.**

**SICS HAS DEVELOPED A RANGE OF SERVICES TO MEET AN INCREASING NUMBER OF REQUESTS FOR ASSISTANCE IN RELATION TO DIGITALIZATION FROM BOTH INDUSTRY AND THE PUBLIC SECTOR.**

The continuous digitalization of society, in industry as well as in the public sector, promises a wealth of amazing opportunities.

For an individual organization, the digitalization process may lead to a limited and incremental change in isolated aspects of the business. Or alternatively, it may have a strong influence on all aspects of a company's operations, including its organization, business, technology use, communication, partnerships, and customer segments.

In recent years, SICS has received an increasing number of requests for assistance in relation to digitalization from both industry and the public sector, often as part of an overall strategic initiative by the management.

We receive questions from small companies with minimal IT use as well as multinational corporations specialized in IT and telecommunication. The realities that they describe are similar though: a world in motion posing great uncertainties, in which custom solutions are needed, thus calling for tailoring and experimentation.

As a result, SICS has recently developed a range of services allowing us to meet each customer at an appropriate level of engagement.

The simplest form may be an inspirational talk or workshop for the company's management and key employees. This is often enough to start a stimulating discussion about what digitalization could mean for the company, in the short term and in the long run.

In order to take the next step, the important question of why must be addressed. That includes understanding which effects are desired and the alternatives. What happens if nothing is done? This step requires greater effort, such as in-depth literature reviews and interviews with key employees, and is typically conducted in the form of a pre-study.

Following why comes what and how, spelled out as clear and concrete goal formulations or desirable future directions for the organization or the process. At this step, tailored solutions are required, depending on type of organization, line of business, digital maturity, digitalization ambition, etc. However, experience shows that our support typically amounts to requirements specification, process support or leadership, and evaluation with regard to IT procurement, communication, and technical experimentation.



## NEXT GENERATION MOBILE COMMUNICATION IN MINING

The project PIMM (Pilot for Industrial Mobile communication in Mining) addresses the challenges of improving safety, robustness and productivity of operations in underground mines. The aim is to evaluate new mobile communication infrastructures in this industrial context, and to validate new technology, applications and business models.

In early 2016, a state-of-the-art mobile network has been built in the Boliden mine Kankberg. Several applications will be implemented, tested and evaluated; from voice communications to machine control.

The project focuses on how safety and productivity in a mine can be improved by using a 5G mobile system, and how this technology affects stakeholders, roles and business models. PIMM will also provide tests and assessments of applications for communication, operation, safety, automation and remote control over the 5G network. Finally, analysis of pilot installations and recommendations about future industrialization will be performed.

This is not only an important innovation within the mining industry, but will also benefit Sweden: Industries within Sweden are leading the way in industry digitalization and the global initiative for digital infrastructure for the process and manufacturing industry.

Project partners are: SICS Swedish ICT, Boliden, Ericsson, Volvo CE, TeliaSonera, ABB, Luleå University of Technology, and Wolfit.



**A digital wireless mine with autonomous vehicles and no people underground might sound like science fiction, but this is where we are heading with big leaps.**



## GAMING TECHNOLOGIES IMPROVE THE PROCESS INDUSTRY

The research team is testing how augmented reality (AR), virtual reality (VR) and smart sound can be used to train employees to perform certain tasks. This can either be done before they enter the production environment or during the production phase, and also helps them to perform difficult assignments by remote guidance.

“Our most important resource are our operators. By using new techniques, we will be able to make their working days safer and we will be able to better support them in performing difficult tasks. Training and introductions for new employees will be improved and made more simple and fun. We are convinced that this new technique will improve our working environment, and together with SICS Swedish ICT we want to investigate how it can improve the quality and efficiency in our production” says Anna-Carin Söderlund, World Class Manufacturing Champion, Gyproc AB Saint-Gobain.

Understanding and using modern technology in an efficient manner is critical in the competitive process industry. INCODE therefore focuses on the introduction of various modern techniques in three different scenarios:

- Operations in ABB FACTS are spread over widespread geographic areas. Significant resources are spent on sending expert assistance to various areas. We have shown that a system based on AR works very well for remote operations, and are now working on addressing the challenges associated with taking the system into operation.

- Dynamic information in the control room. We want to investigate how information adapted for situations and individuals can increase efficiency in the control room. The information will mainly be communicated through informative sounds known as smart sounds.
- Staff at Gyproc learn conversion routines by reading about the various tasks that should be performed. After that they accompany an experienced operator to see how it works in practice. By making use of VR tools, trainees will be able to perform difficult procedures in a testing environment without the risk of personal injury and financial risks.

“An important goal for the project is to show how the different technologies used in the scenarios can be used in different environments. We will also investigate combinations of technologies to improve quality, safety efficiency and working environment in the process industry,” says Stig Larsson, senior researcher and project manager at SICS Swedish ICT Västerås.

The project is led by SICS Swedish ICT Västerås in close collaboration with Interactive Institute Swedish ICT. Participating companies are Smurfit Kappa Kraftliner, Gyproc, ABB FACTS, ABB Corporate Research, Mälarenergi, XMReality, IFS, Ifa Production Development, and Automation Region.

In the project INCODE, technologies and tools from the gaming industry are now being used in new ways to improve and make the process industry more efficient. SICS Swedish ICT Västerås is leading the project, in close collaboration with Interactive Institute Swedish ICT.

### PIIA - PROCESS INDUSTRIAL IT AND AUTOMATION

SICS Västerås hosts the program office for PiiA, one of the large Strategic Innovation Programs for Sweden. PiiA, which stands for Process Industrial IT and Automation, is an area where several Swedish companies are world leading when it comes to developing, delivering, integrating and using automation technology.

The projects Incode and PIMM on pages 10-13 are examples of activities within the PiiA program.



## MATH & POLITICS

Victoria Svedberg's career began with a strong interest in theoretical mathematics. After completing a Bachelor's Degree in Engineering Physics at KTH Royal Institute of Technology she went on to study optimization and systems theory, attracted by the opportunity to work with applied mathematics. Now she holds a position as a Ph.D. student at SICS and expects to graduate in 2019. Her doctoral thesis is about the optimization of rail traffic, an area spanning both mathematics and economics. To achieve this, she is developing algorithms to find the perfect balance between political valued benefits and costs: How much is frequent commuter traffic worth? How can we use limited resources wisely?

Victoria is passionate about the opportunity to streamline public services with the help of mathematics.

"There are so many public resources that can be used more efficiently with the help of computerized optimization. This area is a gold mine to explore", she says.



## OPTIMIZATION OF RAIL TRAFFIC

**There is no doubt that computers are superior when it comes to calculating large data sets and optimization with constraints. SICS Swedish ICT has developed methods that can optimize the entire railway timetable in Sweden automatically and within minutes. But reality is full of soft values that have to be taken into account when streamlining public services. Good results are achieved by finding a balance between societal needs and mathematical optimization.**



Photo: Green Cargo

How can track time be distributed between competing companies and needs in a deregulated market? The basic rule is to squeeze in as many trains as possible while at the same time maintaining important social services, such as commuter traffic. But what do you do when many trains need the same time slot?

SICS's job in this project is to optimize the use of the rails, which is done in several steps. SICS suggests that a certain part of the track time is booked up for commuter trains as early as five years in advance. Based on existing traffic data and the results of existing methods for socio-economic valuation, SICS can calculate how these fixed bookings must be placed in the timetables to keep as much flexibility as possible for other trains. This is to ensure that important social services are maintained without taking up too much space for long distance trains, freight and even track maintenance. The most sought-after rail space that is not booked for commuter trains could then be distributed between competing operators such as MTR and SJ by auction. The remainder would be released on a spot market where operators can book later on. Here, the project will assist with methods that ensure that the auction and spot markets are fair and transparent. This increases the flexibility for the operators, and future freight traffic can be rescheduled on a daily basis if needed.



## SUPER-SMALL IP READY FOR COMMERCIAL USE

Internet of Things (IoT) has been called the second revolution of the Internet.

For many years SICS has been developing Contiki, a lightweight protocol stack and operating system to connect super-small devices to the Internet. Contiki is available as open source, and over the years many IoT applications have been built on top of it. Since 2011, SICS has been working in close collaboration with Yanzi, a small company producing easy to install IoT systems built on Contiki for homes and businesses, with the goal of taking Contiki from a research prototype to stable, production quality software. In 2015 Contiki took the step into commercial use, together with Yanzi and Intel.

## INTEL ENTERS THE IOT MARKET WITH SICS AND YANZI

The market for IoT will grow beyond our wildest imagination. Some say the number of IoT devices worldwide will increase from nearly 5 billion to 25-50 in five years.

In November 2015, Intel, the world's largest CPU manufacturer, entered the IoT arena, presenting an end-to-end Intel IoT solution at the Intel IoT Insights event in San Francisco. Intel demonstrated IoT devices running Contiki OS and the Yanzi software on a small Intel processor for embedded devices. This was a major event for the business. For the first time the new microprocessor, quark SE, was used to develop end-to-end Intel IoT services.

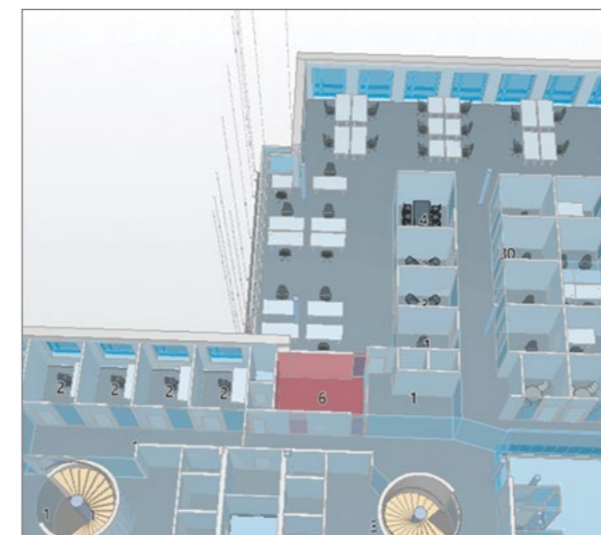
## 1000 "THINGS" INSTALLED IN LESS THAN FOUR HOURS

In June 2015, a system for office service and surveillance was installed at the company Tyréns' premises in Stockholm. More than 1,000 nodes were installed to monitor everything that needs to be controlled in an office building, ranging from alarm systems, room occupancy, light and temperature to service surveillance such as refills of coffee beans and copy paper. The entire installation was completed in four hours, including an app to control everything, reminders and alarm systems.

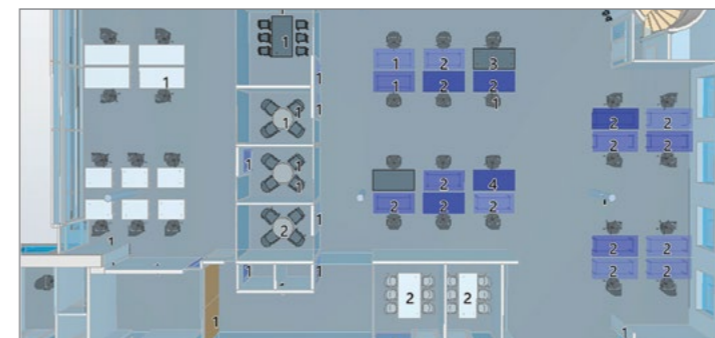
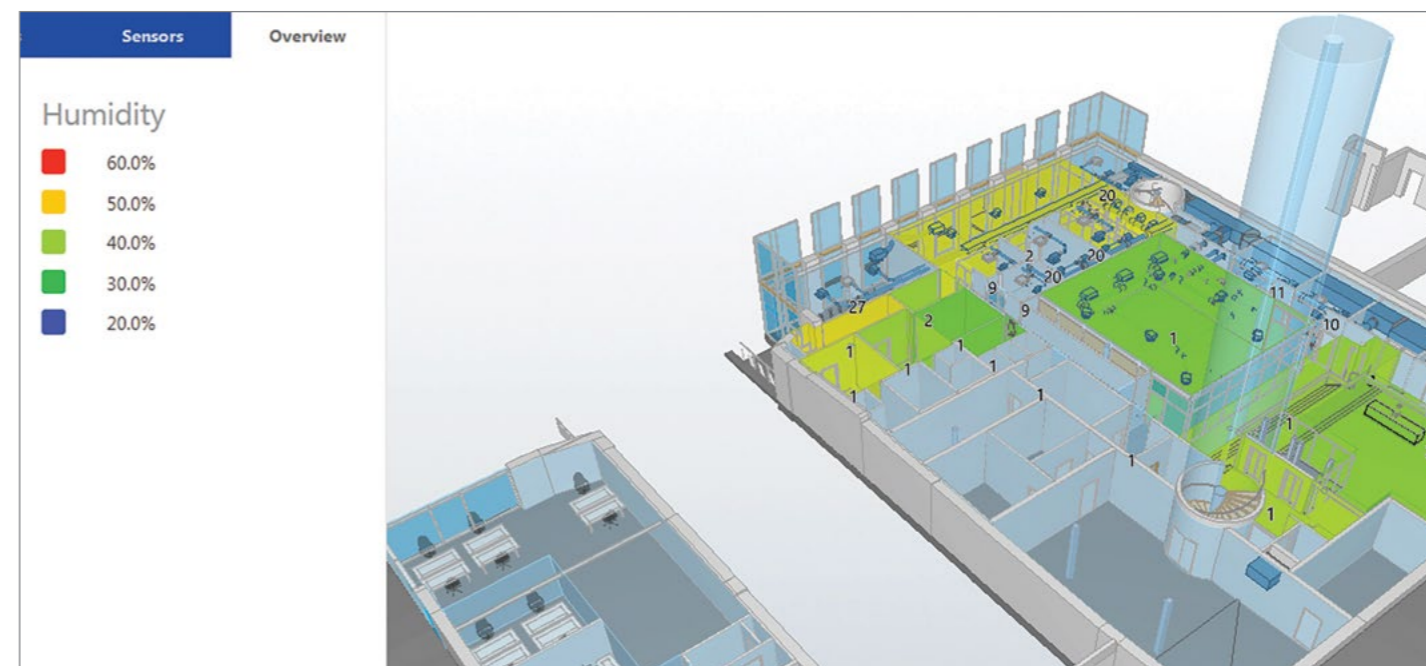
The 1,000 nodes were connected to the Yanzi cloud services and automatically integrated into a 3D visualization tool for asset management. Since time is a factor in most surveillance, the database was built with time as a central dimension: How are the conference rooms really used over the course of the day? When were the fire extinguishers last checked? How much longer will the coffee beans last? These may seem like little things that should be easy to monitor by office personnel, but on a larger scale there is a lot to keep track of. Office space is an expensive resource and there is much to gain from automatic surveillance.

The wireless communication was set up through 20 access points, and all the communication to the IoT devices made use of the Contiki 6LoWPAN stack.

The installation was arranged by Yanzi, Tyréns, Intel and SICS to prove that facilities are obvious candidates for streamlining.



The data is presented in a 3D BIM model (Building Information Modeling). One of the models, called heat-map, shows temperature variations in different parts of the building at any given time.



The Contiki source code is available at <http://www.github.org/contiki-os>



BODY AWARENESS AT IKEA

# SOMAESTHETIC EXPERIMENTS EXHIBITED AT SPACE 10, IKEA'S NEW LIVING LAB IN COPENHAGEN

**SICS AND MOBILE LIFE, TOGETHER WITH IKEA, HAVE EXPLORED HOW FURNITURE CAN BE DESIGNED WITH A SOMAESTHETIC\* APPROACH TO SUPPORT MEDITATIVE BODILY INTROSPECTION.**

We are surrounded by a plethora of new technologies: biosensors worn on the body, interactive clothes, and wearable computers, such as mobile phones equipped with accelerometers. A whole world of possibilities for gestural, physical, and body-based interaction is opening up.

Despite this, and despite all the work that has been done already on designing for embodiment, the actual corporeal, pulsating, living, felt body has been notably absent from both the theory and practice of design. Most design work has taken a rather instrumental

view of interaction: our bodies are there to be trimmed, perfected, and kept free from illness and harm.

IKEA has recently established "Space 10", a living lab in Copenhagen. Within this lab, SICS Swedish ICT and Mobile Life, together with IKEA's Home Lab, Boris Design Studio, and twelve designers from around the world, have been exploring the theme of body awareness. This group of creative individuals participated in a three-day Body Awareness Makerthon at Space 10, arranged by SICS and Mobile Life.

In the resulting installation, light and heat were used as modalities to subtly guide participants to turn their gaze inward to their own bodies. People who try the prototypes exhibited at Space 10, report feelings of relaxation, softer movements, and an increased awareness of their own breathing.

*\*Somaesthetics is an interdisciplinary field of inquiry aimed at promoting and integrating the theoretical, empirical and practical disciplines related to bodily perception, performance and presentation.*



Space10, located in the heart of Copenhagen, is an IKEA space dedicated to exploration and inspiration rooted in the idea that together we can co-create a better everyday life for the many people.





## SICS Swedish ICT cooperates with several SMEs in their transition from selling physical products to also selling digital products and services in order to create new revenue and value-producing opportunities.

SICS can help companies understand what is possible to achieve when introducing information and communication technologies in their products, and provide an understanding of state of the art in different ICT-areas. SICS can act as a neutral partner when discussing technologies and solutions. In addition, SICS can provide generalized knowledge from earlier projects concerning digitalization and the introduction of ICT. In return, SICS gets a better understanding of the challenges and adaptations needed when introducing information and communication technologies in different domains.

To illustrate, during spring 2015, SICS conducted two short projects helping two quite distinct companies: X-ponent Inredning AB and LUDA Elektronik AB. Despite their differences the development process in these projects followed the same basic structure:

- Deciding a set of first step features to be developed and tested.
- Prototype development for initial internal tests and to provide a better understanding of the technologies as well as details, difficulties, and potential pace of the process at large.
- Small-scale external tests with the company's closest customers as well as continued development, with or without the help of SICS.

- Initial dialogue based on the ideas and concepts of the company covering ways of digitalizing their business or a particular product.
- Discussion about new functionality that may be achieved, the value it may provide and how the company may need to adapt to be able to support the changed or extended business.

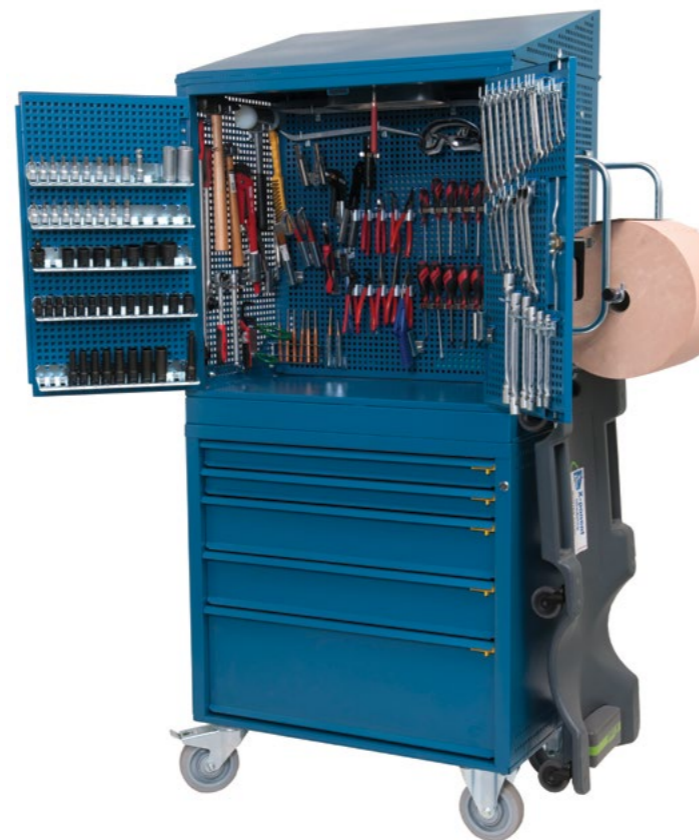


Photo by X-ponent Inredning AB.

## SMART FARMING

LUDA Elektronik AB, founded 2003, specializes in animal and farming surveillance. Their Smart Farming concept contains a modular platform made up of cameras and sensors that can be integrated in a user-friendly system to enable farmers to get full control over critical processes and events. The goal is that this, in the long term, will enable economic and environmental sustainability of the farm, while promoting a better work environment as well as improved animal upkeep.

In parallel with sensor development, a project was initiated with SICS with the goal of developing a system for receiving, recording,

presenting and acting upon sensor data. This system was specified and developed in collaboration with LUDA. Initial features and concepts of this system include:

- User and supplier web management
- Resource tracking system, e.g. diesel tank levels, silo filling degree, and electrical fence voltages
- Time series data collection
- Theft detection and alarms
- Possibility to invite suppliers (e.g. diesel and fodder) into the system for potential optimization and automation of deliveries.



Image by LUDA Elektronik AB.

## TOOL TRACKER

X-ponent Inredning AB, founded 1937, manufactures and sells high quality professional products for storing, displaying and managing tools and accessories. They offer their customers tailor made solutions as well as a large selection of components for individual configuration and adaptation. Their end customers include large companies such as Volvo Cars, AB Volvo and Scania.

Over time the tools of X-ponent's end customers have become increasingly specialized, more expensive and their use more optimized. In part influenced by their customers own digitalization process. This results in a need for better control over the tools. X-ponent identified this need and a project with SICS was initiated to create

a system, Tool Tracker, that enhances the traditional tool storage solution with features such as:

- Automatic tool usage tracking
- Real-time alarms
- Usage statistics
- Remote-administered connected system

“SICS has the in-depth knowledge creating integrated systems. X-ponent runs its business selling premium products creating organized work places. The fruitful discussions opened up many new possible ways of selling services not only products”, says Daniel Jacobsson, Managing Director at X-ponent.





**“Digitalization is the key to better health for everybody in our society.”**

Per-Olof Sjöberg, Manager of Business and Innovation Area eHealth at Swedish ICT.

## A PRIMARY CARE CENTER WITH BIG DIGITAL AMBITIONS



**IN LATE 2014, HAMDAD AL-SAAID, ONE OF THE FOUNDERS OF RIDDARENS VÅRD CENTRAL OUTSIDE STOCKHOLM CONTACTED DAG FORSÉN AT SICS SWEDISH ICT. HAMDAD WANTED TO DISCUSS HOW TO BEST APPLY NEW DIGITAL TOOLS OFFERED IN THE GROWING E-HEALTH AREA, AS A MAJOR PILLAR OF THE NEW HEALTH CENTER HE AND HIS BROTHER WERE PLANNING TO BUILD.**

New solutions based on information technology are beginning to be available, and Hammad and Mohammad Al-Saaïd wanted to create a digital and easily accessible primary care center that really embodied the possibilities offered by modern IT-solutions. SICS supported the project with the aim of being a proactive force, helping to reach as far as possible into the future with the latest solutions.

One of the current challenges of primary care centers in Sweden, especially in areas with many immigrants, is accessibility. Being naturalized refugees themselves, the Al-Saaïd brothers have valuable insights into the needs of immigrants who seek care. They saw that linguistic, cultural and bureaucratic barriers pose difficulties for non-native patients.

Today, Riddarens appears as a pioneering example of a developed system that responds to the needs of a modern society. SICS has contributed to its development by introducing to the management of Riddarens a useful network of academic, social and business contacts in the e-health area. SICS has also provided advice on matters such as collaboration partners and available funding – for example, the care center has been granted funds from the SLL Innovation Fund.

Riddarens opened in May 2015, and since then the number of registered patients has grown rapidly. In order to improve accessibility and patient partnership, Riddarens offers very generous opening hours and uses the latest digital products and services.

In the spring of 2016, Riddarens will release their own patient facing mobile app which is an all-round solution for making appointments, delivering test results, doctor and patient communication, and much more. The patients, who log in using their Swedish "BankID", can choose times that are convenient for them to manage all contact with the doctors – a big step forward from regular primary care centers as we know them.



# 5G SECURITY IS CRUCIAL FOR THE FUTURE CONNECTED SOCIETY

**5G IS A NEW GENERAL INFRASTRUCTURE FOR RADIO COMMUNICATION THAT ENABLES THE INTERNET OF THINGS AND ENVISIONS PERVASIVE CONNECTIVITY FOR FUTURE MOBILE DEVICES. SECURITY IN THE 5G NETWORK IS A PREREQUISITE FOR THE EMERGING CONNECTED SOCIETY.**

We have all heard the prediction of 25-50 billion connected devices by 2020, a scenario that places completely new requirements on radio networks and network security. Today's 4G security may be insufficient for the next generation of mobile communications, not least because many of the future connected objects will be safety critical. Despite good security practices, several vulnerabilities have been found in the current system. In addition, many of the future sensors and actuators will have no SIM-card. How can we then identify and authorize them?

SICS has long conducted extensive research on the safety and security design of communication and virtualization, and has a head start in the field. SICS is currently involved in 5G ENSURE, a large European project that is investigating the inherent security needs of 5G with the goal of developing a set of non-intrusive security enablers for all relevant aspects of 5G.

The project aims to describe the enablers for a secure, resilient and viable 5G network. SICS is mainly engaged in three selected areas: Security architecture, AAA, SDN and network virtualization.

## 5G IDENTITY AND ACCESS MANAGEMENT SECURITY PROTOCOLS

AAA is a framework of protocols and stands for Authentication, "who are you?", Authorization, "what are you allowed to do?" and Accounting, "What did you do?". Authentication is the foundation of AAA, providing a secure identification of end-points and users. Today's authentication methods, however, will not scale with the expected boom of IoT devices. Furthermore, 5G needs to add support for SIM-less devices, an expected requirement in IoT. The novel use cases will also require new methods in authorization, as existing methods are insufficient to support resource constrained devices.

Lastly, the incremental evolution of the AAA protocols will continue in 5G, and newly discovered security weaknesses will be addressed. Altogether, the new AAA protocols will rely and build on the 5G ENSURE proposed 5G Security architecture.

## SECURE NETWORK MANAGEMENT

SDN stands for Software Defined Networking. A network infrastructure based on SDN is centrally controlled and can be configured independent of hardware. This allows the operators to overview the system and upgrade it centrally in order to add new functionality and security features.

Decoupling network configuration from hardware has another big advantage: it enables network virtualization. This allows the physical infrastructure (wires, switches and other network equipment) to be abstracted away and split up so that multiple users can independently build and operate wildly different network configurations using the same physical infrastructure.

It is hard to overestimate the importance of a secure 5G network for the future of our society. E-health and traffic communication are examples of business applications that will explode once the end-users and stakeholders can trust the network.



The recent years have witnessed a dramatic proliferation of smart solutions to control power consumption, generation and distribution. At the same time, the attacks against security critical infrastructures are becoming both more calculated and more frequent. SICS is involved in a European project taking a holistic approach to secure smart electricity grids.

## SECURITY SOLUTIONS FOR SMART GRIDS

Smart grids help consumers to control their power consumption, and suppliers to supervise their generation and distribution functionality. However, smart grids are persistent targets of cyber attacks, which can knock out power supply functionalities, or take control of them. In order to preserve security, smart grid systems have to be updated and upgraded every time a new power meter is added to the system, a new functionality has been added, or suspected security vulnerability has been found.

Rather than updating power meters separately, SICS's solution broadcasts the new software to all the power meters in an area at the same time. In order to also secure the upgrade operation itself, the distributed software has to be encrypted by means of a cryptographic group key. To this end, SICS has developed an advanced key management procedure, which can be used in every context where security critical information has to be delivered over broadcast/multicast communications.

All power meters in an area are connected to a concentrator, which collects the data from the meters and forwards it to the suppliers. The concentrator is built on a secure platform that isolates services from each other. This practice creates opportunities for third party suppliers, such as different home alarm services, that can be introduced into the system with no risk. Each service relies on its own separate channel, to ensure that the system cannot be compromised. The separation of channels is achieved by using a secure hypervisor, called HASPOC, developed by SICS.

This research project, called SEGRID, is a cooperation between Sweden, the Netherlands, Norway, Portugal, and Spain. SEGRID covers all the necessary aspects to create a truly useful solution: Use cases, risk analysis, privacy issues, tools to detect intrusions and vulnerabilities, resilient networks, a hypervisor and a group key management protocol developed by SICS, and finally a testbed to make sure that the new solutions work properly and effectively.





Smart self driving cars is not in a far future.

**SICS Swedish ICT and partners are working to place Sweden at the forefront of a major global paradigm shift based on AI, big data and Internet of Things. In 2016 the new Learning Machines Center is launched.**

#### **A NEW CENTRE FOR LEARNING MACHINES**

Data science technologies are recognized as key drivers of advanced digital transformation and innovation. They are at the foundation of a new breed of business based on autonomous vehicles, smart personalized services, intelligent management of connected users and devices, and automated management and control of complex systems such as 5G networks, industrial production systems, transportation systems, and large-scale Internet services. Most probably business based on the Internet of Things will amount to one thousand billion SEK within a few years.

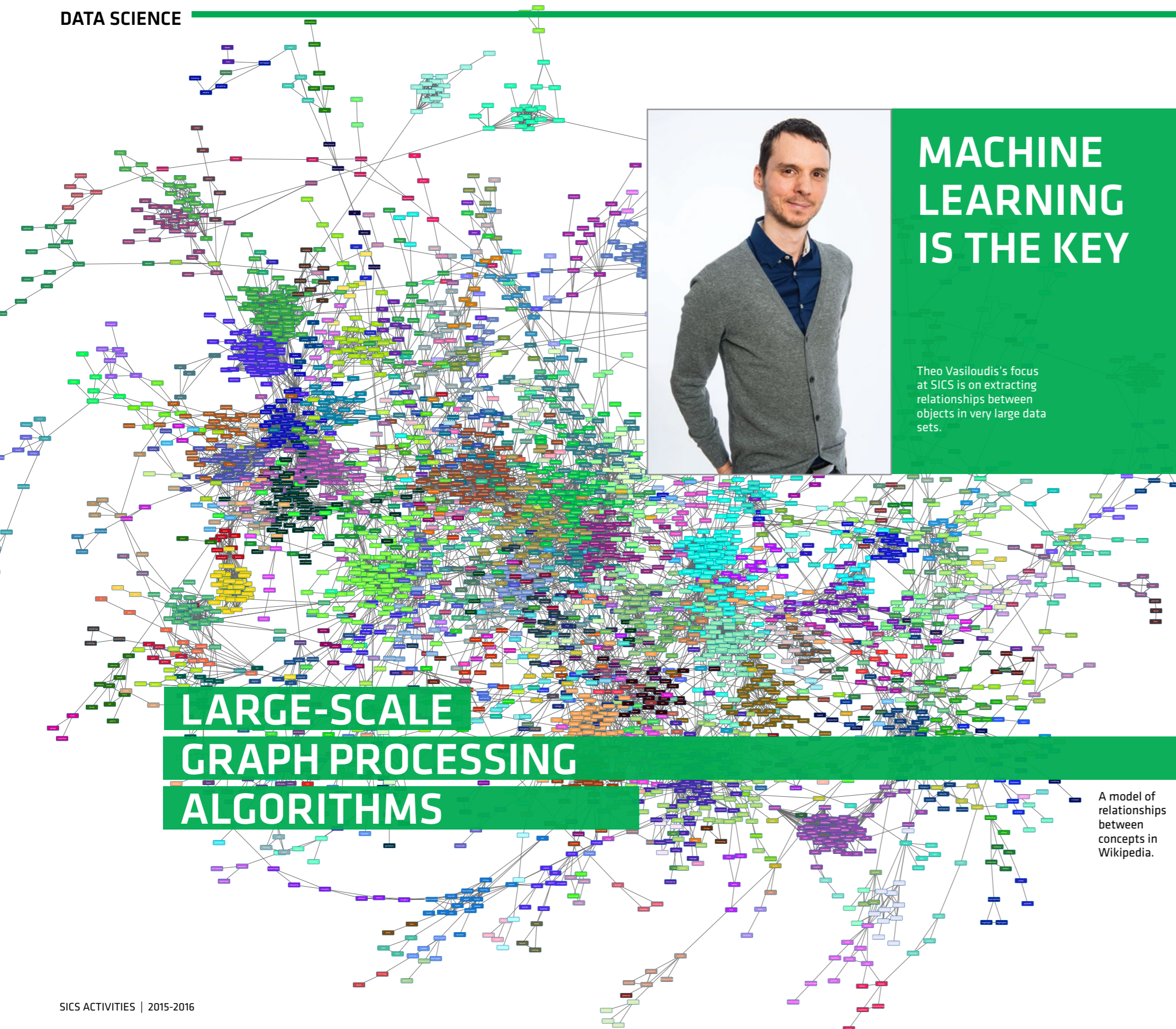
SICS and KTH Royal Institute of Technology are a major driving force for this paradigm shift in Sweden. We offer world-leading expertise on data science technologies at the intersection

of scalable systems for high-velocity real-time streaming analytics and advanced algorithms for analytics and machine learning. We explore these technologies in a wide range of applications together with progressive industry partners.

In 2016 the Learning Machines Center is established at SICS, in which center partners Ericsson, Husqvarna, King, KTH, Saab, Scania, SICS, the Swedish Tax Agency, and Spotify join forces to achieve the necessary critical mass and momentum for world-leading research and innovation efforts for the new data science based economy.

The Learning Machines Center will span an interdisciplinary field of methods and technologies from the areas of computer science, statistics, and artificial intelligence.





# MACHINE LEARNING IS THE KEY

Theo Vasiloudis's focus at SICS is on extracting relationships between objects in very large data sets.

After Theodore Vasiloudis finished his Bachelor's degree in Greece he wanted to attend a university where he could study machine learning, an area of science that was increasing in popularity. KTH Royal Institute of Technology was one of the few high profile universities in Europe that fitted the bill. During Theo's Master's, his professor at KTH put him in touch with Spotify where he spent a few months developing models for music recommendations based on the user's situation. The company wanted to investigate whether users prefer different music on weekends compared with workdays, and Theo developed a model to determine whether recommendation quality could be improved based on this assumption. From KTH the step was not far to SICS where machine learning is a central and growing research area.

## LARGE-SCALE GRAPH PROCESSING ALGORITHMS

A model of relationships between concepts in Wikipedia.

Theo's focus at SICS Swedish ICT is on extracting relationships between objects in very large data sets. He currently works with Olof Görnerup who developed an algorithm to group objects that are similar in the sense that they are interchangeable, based on the context of each object. Replacing the word Ronaldo with Messi in a sentence should still leave us with a meaningful sentence, since they refer to the same concept of a football player. This sounds simple, but the point is that his models are for semantic relations, which means they are not only between words, but between concepts or meanings. Using the models one can, for instance, figure out relationships between artists based on the way that users listen to them. Theo is also using the models to detect the roles of different codons (a sequence of three DNA or RNA nucleotides that corresponds with a specific amino acid), according to their substitution dynamics.



Olof Görnerup has developed an algorithm to group objects that are similar in the sense that they are interchangeable, based on the context of each object.

A very large set of data in itself will not help us to understand anything - it rather blurs the view. But large-scale graph processing techniques such as Theo's models can help to extract useful information from massive datasets in most areas where large data sets are, or could be, collected.



## A platform for real-time big data analytics

APACHE FLINK IS ONE OF THE LEADING DATA ANALYTICS SYSTEMS IN THE OPEN SOURCE SPACE. ITS MAIN AIM IS TO SIMPLIFY THE DEPLOYMENT OF DIVERSE COMPLEX DISTRIBUTED DATA PROCESSING TASKS UNDER A SINGLE DATAFLOW-BASED RUNTIME ENGINE. SICS AND KTH ROYAL INSTITUTE OF TECHNOLOGY ARE VERY ACTIVE IN THE APACHE FLINK COMMUNITY.

The Apache Flink software offers a declarative programming API that allows data analysts and engineers to easily express their complex application logic while alleviating the responsibility of controlling application state and time semantics. As of its last release, Flink 0.10 guarantees that application state will be consistent, even in the presence of failures, using a lightweight distributed checkpointing mechanism that has very low performance impact. Furthermore, it has established new standards in sliding window semantics for data streams, allowing data-driven windows and different time configurations, such as event time or ingest time to support late out-of-order events, which often occur.

The addition of these new fundamental features to Flink's already unique collection of native

features for efficient iterative processing and memory management makes Apache Flink a disrupting, sophisticated platform for rich data analytics that is powerful enough to subsume batch and stream-based analytical processing seamlessly. Apache Flink has already been widely adopted in the data analytics industry worldwide. It also serves as an execution engine for Google Dataflow, which is currently a strong candidate for Apache incubation, in a joint effort with Google to converge to a standard in dataflow analytics.

Several SICS and KTH researchers serve as active committers and PMC members in the Apache Flink project with core contributions such as distributed checkpoints, window semantics and the Graph (Gelly) and Flink-ML high level libraries.

## HOPS

HADOOP OPEN PLATFORM-AS-A-SERVICE (HOPS) IS A NEW DISTRIBUTION OF APACHE HADOOP THAT IS BASED ON A NEXT-GENERATION, SCALE-OUT ARCHITECTURE FOR HDFS AND YARN METADATA. HOPS IS PROVIDED AS SOFTWARE-AS-A-SERVICE FOR RESEARCHERS AND COMPANIES IN SWEDEN FROM THE NEWLY STARTED SICS ICE DATA CENTER IN LULEÅ.

One of the goals of Hops is to make Hadoop easier to use for researchers that may not be data engineers. To this end, we have developed a new user interface to Hops, called HopsWorks, that supports true multi-tenancy in Hadoop. That is, researchers and companies can securely share the same Hadoop cluster resources. This contrasts with existing models for multi-tenancy in Hadoop that limit organizations to running separate Hadoop clusters on virtualized or containerized platforms.

SICS model for multi-tenancy is based around projects. Users in HopsWorks can create projects, manage the quota for projects, control membership of projects, and securely share data between projects. They can make use of data analytics frameworks such as Apache Spark, Apache Flink, and MapReduce. HopsWorks also supports the popular Hadoop notebook Apache Zeppelin for interactive analytics, Elasticsearch for free-text search for files and directories in HDFS, as well as extended metadata.

Hops and HopsWorks are open-source projects and have been developed in collaboration between SICS and KTH.

Download it here <http://www.hops.io/>.

## FUTURE CLOUD SUMMER SCHOOL

In August 2015 SICS, KTH and EIT Digital organized the Future Cloud Summer School – a two weeks event open to EIT Digital's MSc students and EU Marie Curie ITN "iSocial" fellows as well as PhD students and postdocs from Europe. The goal of the summer school was to teach advanced topics related to algorithms and platforms for Big Data as well as to enhance the innovation and entrepreneurial awareness among the students.

Students attending the EIT Digital's Summer School in August 2015.





EXPERIMENTAL DATA CENTER -  
A STRATEGIC STEP FOR SWEDEN

In early 2016 the world's first open data center for research and innovation was launched, in Luleå.



Ibrahim Bayla, Minister for Energy, and Tor Björn Minde, CEO SICS North, at the minister's visit to SICS's new data center in February 2016.

**SICS, IN COOPERATION WITH LULEÅ UNIVERSITY OF TECHNOLOGY, HAS TAKEN THIS INITIATIVE TO PROVIDE A TESTBED FOR BIG DATA AND CLOUD RESEARCH, AND SUPPORT THE DIGITALIZATION OF SWEDISH INDUSTRY. THE FACILITY IS CALLED SICS ICE - INFRASTRUCTURE AND CLOUD DATA CENTER TEST ENVIRONMENT.**

Cloud technology and data analytics are important components of the government's new digitalization strategy. SICS's data center for large-scale experiments fills a major need. As the Minister for Energy, Ibrahim Baylan, visited the center in February 2015, he stressed the importance of data center expertise as part of the digitization effort in Swedish industry.

The combination of national interest and strong support from the region of Upper Norrland provides the conditions for a large-scale investment that can give Sweden a lead in data center technology.

"We need to build skills in all areas of data center knowledge from ground to cloud", says Tor Björn Minde, CEO at SICS North, who heads the center.

When we capture and analyze more data, an energy issue emerges. Consequently, the most important research issues in the data center are optimized data analytics and energy efficiency.

"It is a matter of squeezing as much data analytics as possible out of each kWh", says Tor Björn Minde.



## DEEP LEARNING

# One of the latest technologies to be explored and put into practice at SICS Swedish ICT is deep learning. But what is deep learning? And what can it do for us?



Erik Ylipää

Traditionally, computers have been solving problems by specifying rules in a computer program. This is particularly challenging when problems are hard to specify, such as recognizing patterns in data. Many important problems such as detecting things in images or converting speech to text are this type of problem.

Machine learning is a different way of solving these kinds of problems without specifying rules. Machine learning is about building models that learn to solve problems by looking at examples. Deep learning is a particular kind of machine learning which in recent years has become the most successful method for image and speech recognition.

The central idea of deep learning is to solve problems in multiple steps or layers, each step

using information from the previous step. The multiple steps, which earned the technique its name "deep learning", allow the model to solve complex problems.

Deep learning is successful, in part, due to the availability of vast amounts of data. Another key factor is the computational power of Graphical Processing Units (GPUs). These devices were originally developed for accelerating 3D games but are very good for the kind of parallel computations used by deep learning.

Much of the current research is focusing on using deep learning in new application areas such as machine learning and reinforcement learning. Other scientific fields like physics, biology, and medicine are also starting to use deep learning methods as part of their research.

A recent spectacular deep learning success from Google DeepMind was an artificial intelligence which defeated the European champion of the board game Go, a game known for being very difficult for computers to play well. We will likely see more examples of deep learning being used as a component of more capable artificial intelligences in the near future.

At the SICS Learning Machines group our goal is to build learning machines that can reason about the problem they are designed to solve and interact with their environment to learn more. We believe that deep learning, combined with statistical models and higher order symbolic representations, will be an essential part of such learning machines.



**“One single rescue of a larger vessel, and the environmental consequences that are at risk, would outweigh the cost of this project several times”**

**THE SWEDISH COAST GUARD IS NOW DEPLOYING THE DATA ANALYTICS MODULE THAT HAS BEEN DEVELOPED AT SICS OVER SEVERAL YEARS TO DETECT PROBLEMATIC ANOMALIES IN VESSEL TRAFFIC ALONG OUR COASTS.**

At any given moment, about 8,000 ships are operating off our shores. Approximately every ten seconds, data from each of these vessels is updated in a data analytics system, developed by SICS Swedish ICT. The module analyses the data, looking for anomalies of several different types, based on either rules or historical data. Currently three types of anomalies are identified, but more may be added in the future.

#### **ANOMALY TYPES**

##### **1. Movement patterns**

When a ship starts to move in an uncharacteristic way, e.g. turns unexpectedly or stops too frequently, the alarm will go off. For example, in December 2014, a large passenger ship was en route from Poland to Ystad in the south of Sweden in rough weather. The system detected that the ship had lost the ability to steer and drifted for several hours without contacting the Swedish authorities. A drifting ship poses a great environmental risk and can be costly to rescue in a crisis situation. It can also be dangerous for the people on board, an important factor that was not even an issue at the time of the project set up, which was before the refugee crisis.

Patterns of movement that do not match the boat type can reveal that the ship is doing something illegal. A “cruise ship” that behaves like a fishing boat may be evading the fishing quotas. A recreational boat that zigzags over an area may be scanning the seabed for ship wreckage where this is illegal.

##### **2. Meetings at sea**

When two boats meet at sea, it may be indicative of fraudulent activity - usually smuggling, but it

can also mean that fishing boats are unloading catches to avoid fishing quotas. A different kind of meeting is two boats running in parallel, indicating that they may be trawling, which is not permitted everywhere.

To check every ten seconds whether any of the 8,000 ships is meeting any of the other 8,000 ships is a challenging computational task, which could not have been solved without the advanced techniques of big data analytics.

##### **3. Risk of grounding**

A vessel that moves off the fairway and approaches waters shallower than the depth of the keel will receive an alarm about three minutes before the grounding will happen, which will give it time to maneuver away. Since the grounding of oil tankers is one of the most serious threats to our oceans, the possibility of real-time monitoring is a highly valued functionality.

#### **FALSE ALARMS**

Much work has been done to minimize false alarms. A system that gives too many false alarms will soon be ignored. Therefore, the goal has been that the false alarms must not exceed the number of real events – a very high ambition in fact, as the reality is not as clean and neat as a research environment.

#### **AN INDUSTRIAL SOLUTION**

Anders Holst, project manager at SICS, believes that the long and close cooperation with the Coast Guard has given SICS a domain knowledge that makes the solutions adaptable to the real world and useful in practice. Furthermore, it will save tax money. Peter Ryman, Maritime analyst at the Swedish Coast Guard agrees:

“One single rescue of a larger vessel, and the environmental consequences that are at risk, would outweigh the cost of this project several times”, he says.



BIG DATA TELLS US STORIES ABOUT REALITY

“We already keep track of everything in the vehicle. We are now eager to hear the stories about reality that are hidden within these data.”

**THE TIME HAS COME FOR HEAVY TRAFFIC TO BE DIGITALIZED. REAL LIFE DATA FROM THE VEHICLES, THE ENVIRONMENT AND THE TRAFFIC SITUATION WILL PAVE THE WAY FOR BETTER SERVICE FROM THE TRUCKS, MORE EFFICIENT TRAFFIC FLOW AND REDUCED ENVIRONMENTAL IMPACT.**

The Swedish vehicle manufacturers, Volvo Cars, AB Volvo, and Scania, together with the Swedish Transport Administration (Trafikverket), Fordonskomponentgruppen, and SICS Swedish ICT, have started a strategic program for preparing the automotive industry and society for benefiting from advances in big data technology. When real data are used as a basis for decisions, the manufacturers and traffic planners can develop new services based on the real needs of the customers. The initiative is financed by the governmental agency Vinnova and the vehicle industry (through FFI) and focuses on environment and safety.

Per Werthén, manager of the project at Volvo Cars, says big data analytics is the obvious next step in vehicle development.

“We already keep track of everything in the vehicle. We are now eager to hear the stories about reality that are hidden within these data.”

So far, big data analytics has mainly been used for human-generated data. Now, as digitalization affects all areas of society, we

can ask which data can be harvested from the physical environment to tell us what is really going on there, too. In a vehicle this can be the story of brake pedal behavior, driving patterns, the driver’s eye movements, fuel consumption or air condition in the cab. In the traffic we can learn about what causes accidents, optimization of traffic flow, environmental impacts etc.

Decisions in for example traffic management and transportation are currently generally based on experience and standards. When decisions are instead based on current data from actual situations, we will achieve models that better match reality. We already have much of the required data, which is picked up by different sensors. The challenge, in addition to storing and managing the data, is to develop algorithms that extract the value-generating information for the specific application and business model. This requires: careful selection of relevant data sources for the application; finding the right algorithms and analytics models to apply; and matching it with an appropriate choice of computational platform and infrastructure.

With the many years of experience and research in big data analytics conducted at SICS, SICS’s researchers will strike the required balance, mapping up what can be done with big data analytics and creating innovative technical algorithmic solutions for the Swedish automotive industry.



Rebecca Steinert



**A new group has been formed at SICS Swedish ICT that will focus on applied machine learning and data analytics for the telecom domain. The Network Intelligence group at the DNA-lab is headed by Rebecca Steinert.**

## MANAGING INTELLIGENT AND PROGRAMMABLE NETWORKS

At SICS, the combination of machine-learning, software-defined networking and virtualization techniques are central in the work towards programmable network management systems. Data-driven mechanisms capable of learning network behavior are fundamental for creating autonomous and intelligent network functions, and provide novel ways of exposing the network state in abstract terms, suitable for network programming and automation.

An increased general interest in programmability, automation and network softwarization\* has led to a burst of open source developments for various platforms such as OpenStack, OpenDaylight and communities such as OPNFV for accelerating network function virtualization. Obviously, code development and contribution to open source communities have become increasingly important components of the research activities, and offer many compelling opportunities to showcase novel research results within the network management field.

Over the past two years, we have expanded the theoretical research to encompass development

of open source code in several projects carried out together with Ericsson, Telecom Italia, Deutsche Telekom, Politecnico di Torino and other partners throughout Europe. The methods and open source tools we develop are aimed at supporting automated processes for deploying and operating virtualized and software-defined infrastructures in programmable networks. For SICS, releasing code compliant with established open source platforms increases the visibility of our research, in addition to publications, and has already created new collaboration opportunities with established partners as well as new ICT enterprises.

The current line of network management research will aim to develop techniques required to support convergence technologies for fixed and mobile networks. Our research activities and participation in 5G-PPP work groups and the H2020 COHERENT project, have established SICS as a leader in this field with the capacity to influence the direction of emerging technologies for the next generation of information and communication systems.

### \*SOFTWAREZATION

The term Network Softwarization refers to the transition from the use of dedicated network equipment to software-defined infrastructures and virtual network functions deployable on commodity hardware. The management of softwarized and programmable networks requires novel tools that support programming and debugging of virtual infrastructures and services.





## DIGITAL TECHNOLOGY FOR LEARNING

**SICS Swedish ICT is active in several areas of education, with a focus on technology that drives pedagogic renewal. SICS's own online platform Scalable Learning supports the popular and highly efficient flipped classroom teaching method; the platform has been used by over 15,000 students and many hundreds of teachers at all levels.**

SICS has partnered with KTH Royal Institute of Technology in using Scalable Learning for university courses as part of the university's ongoing renewal of education through technology enhanced learning. The School of Electrical Engineering has signed an agreement with SICS to provide Scalable Learning for the whole faculty and students.

The need for efficient continuous, life-long learning is on the rise. Digitalization transforms society and industry, changing the contents of human work, and challenging the very notion of work itself. Both industry and individuals can stay competitive by leveraging new technology for education. SICS takes an active role in this development as partner in the PROMPT project,

which develops a modern technology-enhanced distance Master's program for software professionals.

The digitalization of education also offers great opportunities for schools. Within the Läraktiv project SICS works with Swedish secondary schools, helping teachers to use digital tools for active learning and a flipped classroom.

Although not a university, SICS cares deeply about education. Learning is vital for our society, underpinning a better quality of life for all. Technology may induce each and every one of us with the wish to improve, learn and develop.



# It's been a busy year for SICS's startups.

The first to spin off from SICS in 1998 was Tacton Systems, developing software for product configuration, pricing and quoting. In 2015 Tacton increased its revenue by 39% to 170 MSEK, employs about two hundred people and continues to recruit. It is now expanding into the US market.

Gavagai, which builds software for language processing, raised new funding, recruited Per Laredius as new CEO, and launched several new web-based products.

Axiomatics is bringing its dynamic authorization software to the US market, and the founder and CEO, Babak Sadighi, moved to Chicago to lead the charge. The move seems to be paying off: the company just announced that revenue for 2015 increased by 90%. The top three market segments are financial services, health care and pharmaceuticals.

Telcred has shifted focus to being a pure software company, while partnering up with Axis Communications for hardware. This has broadened the market and also let the company pursue new customers.

Prindit is the newest start-up of SICS, spinning off from SICS's subsidiary SICS Västerås. It got off the ground in late 2015. The focus is on boosting team performance through a super simple measurement tool that takes less than a minute per week to use. It already has hundreds of users.

In March 2016, Prindit won the prize for "Innovator of the year" at Guldstänk, the Västerås business awards.



## THE SPIN-OFFS OF SICS

### Tacton Systems

Founded: 1998  
Configuration management software

### Virtutech

Founded: 1998  
Simulation of computer hardware. Acquired by Intel in 2010; its product Simics is heavily used within Intel for development of processors and low-level software and for other customers.

### Axiomatics

Founded: 2007  
Business: Dynamic access control for IT-systems (Attribute Based Access Control, ABAC).

### Peerialism/Hivestreaming

Founded: 2007  
Business: Peer-to-peer-based video distribution. Used, for example, in Skype for business.

### Gavagai

Founded: 2008  
Business: Language technology.

### Jfokus

Founded: 2009  
Business: Sweden's largest developer conference.

### Telcred

Founded: 2009  
Business: Physical access control.

### Biosync Technology

Founded: 2012  
Business: Stress management solutions.

### Locusense

Founded: 2013  
Business: In-door positioning.

### WeMeMove

Founded: 2013  
Business: Motion analytics for sports, in particular cross-country skiing.

### Prindit

Founded: 2015  
Business: Team performance software.

WeMeMove has collaborated with the Swedish cross-country ski team Lager 157 to develop their digital real time sport coach service. The WeMeMove coach has an app for smartphones and a heart rate belt with a built in sensor for movement.

On the left:  
Britta Johansson Norgren  
On the right:  
Jörgen Brink





## REFUGEE SITUATION ENGAGES AND INSPIRES TO NEW SOLUTIONS

The current refugee situation has recently been dominating public debate in Sweden and Europe, with many people wanting to participate and help find solutions. The employees of SICS and Swedish ICT have become involved in various ways.



Professor Magnus Boman, head of sustainable business at SICS.

At least 35 different nationalities are represented amongst Swedish ICT staff. When Christer Norström, the CEO of SICS, sent an e-mail asking for ideas about how the group could assist refugees and non-governmental organizations, the employee response was overwhelming.

Magnus Boman, head of sustainable business at SICS, saw this as an important Corporate Social Responsibility (CSR) issue and offered to devote some of his CSR time as well as his spare time to coordinating everything:

“We already have a good foundation for multicultural activities, and our employees have expertise in many different fields. Some are good at observing and identifying bottlenecks. Others are good at programming and so on. What’s more, we found that many people were already involved in their private time.”

The first step was an internal workshop to identify the ways in which employees could contribute. Individuals offered to contribute in

different ways ranging from writing political debate articles to developing special refugee apps.

An external workshop was organized for anyone who needed help with the IT side of things in their work with refugees. The participants included politicians, representatives from the Red Cross and Refugee Welcome Stockholm and other volunteers.

“After the workshop, the Red Cross got in touch with us, and we are currently developing digital solutions to make it easier for their volunteer coordinators, who are stationed throughout Sweden, to share their experiences”, says Magnus Boman.

“We are also working on involving refugees with engineering qualifications in internships in various projects. Participating in our projects would give them an opportunity to demonstrate their knowledge and skills and they would also receive a reference to use in job applications.”



# WELCOME TO OUR OPEN EVENTS!

## SICS ORGANIZES A NUMBER OF ANNUAL EVENTS:

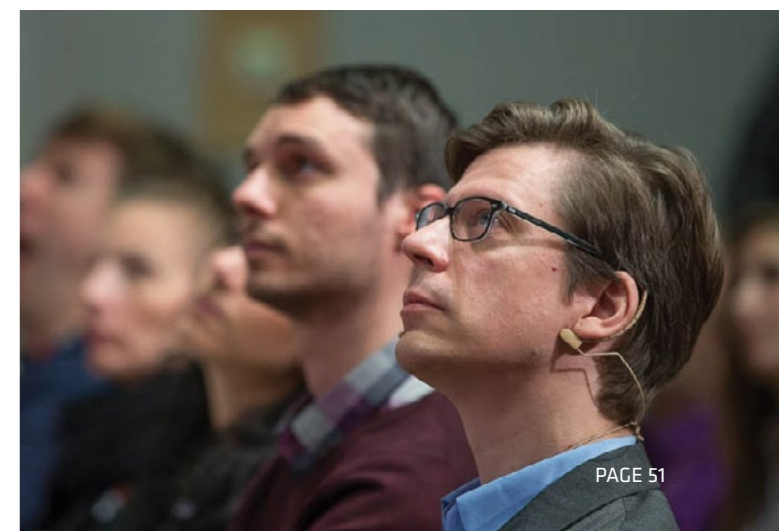
- SICS Open House
- SICS Software Week, which in 2015 included Multicore Day, Data Science Day and Digital Health Developer Day
- SICS Industrial Efficiency Day
- Security Day

These events typically attract a couple of hundred people. The open events at SICS are based on our belief that people need to get together to understand what they can create together. We are proud to be the hub where professionals from universities, large and

small companies, public services, as well as other institutes get together and find common interests.

If you would like to attend one of SICS's open events, please send an email to [signup@sics.se](mailto:signup@sics.se) and you will be on the list for the next invitation.

Apart from the large annual events we organize technical seminars and workshops almost every week at SICS's office in Kista. These are usually open for anyone interested and announced at [www.sics.se/events](http://www.sics.se/events). They may be talks by visiting researchers, dissemination of research results by SICS researchers, or Master students presenting their theses work performed at SICS.





# SICS is a not for profit organization with the mission to support industry in Sweden by taking their technology one step further.

## MISSION AND FUNDING

SICS's core funding comes from a group of large industrial corporations (below) and the Swedish government through RISE Research Institutes of Sweden. The main sources of competitive project funding are currently the Swedish Agency for Innovation Systems (Vinnova), the Knowledge Foundation (KK-stiftelsen), the Swedish Foundation for Strategic Research (SSF), and the European Commission.

## INDUSTRIAL PARTNERS IN 2015

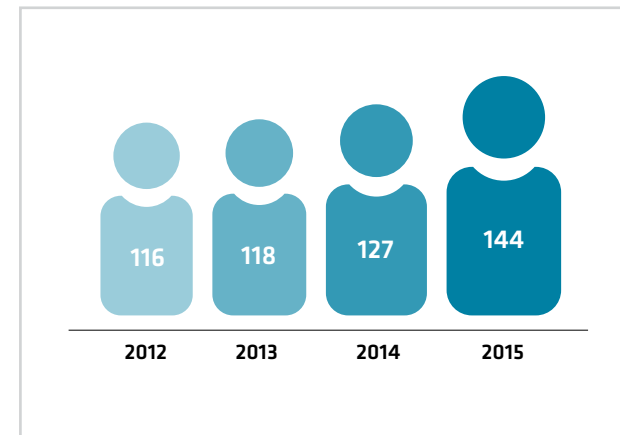
- ABB
- Bombardier
- Ericsson
- Green Cargo
- Saab AB
- TeliaSonera

Other notable customers and industrial collaboration partners over the year include IKEA, the Swedish Transport Administration (Trafikverket), the Swedish Coast Guard, Scania, Volvo Cars, Volvo AB, and a number of Swedish SMEs including Yanzi Networks, Tomologic, Gavagai and T2Data.

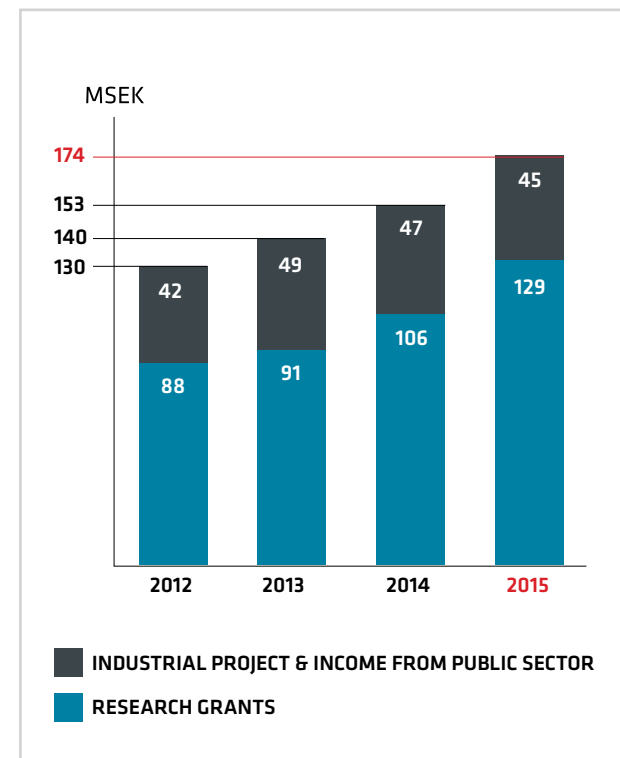
In 2015 SICS was active in Mobile Life Excellence Centre funded by Vinnova and led by Stockholm University.

SICS Västerås hosts the program office for Process Industrial IT and Automation (PiA), one of the large Strategic Innovation Programs for Sweden with almost 100 participating organizations. It is a crucial strategy for maintaining SICS's scientific standing and for supplying cutting edge technologies and solutions to our industrial partners.

## EMPLOYEES FULL TIME EQUIVALENT (SICS SWEDISH ICT WITH SUBSIDIARIES)



## NET INCOME (SICS SWEDISH ICT WITH SUBSIDIARIES)



## ACADEMIC COOPERATION

The success of SICS continues to depend on a strong position in the scientific community. Working closely with leading academic partners is a crucial strategy for maintaining SICS's scientific standing and for supplying cutting edge technologies and solutions to our industrial partners.

## PROFESSORS AT SICS

8 full + 1 associate + 3 adjunct KTH Royal Institute of Technology  
 5 full Linköping University  
 1 full Uppsala University  
 2 full + 1 adjunct Mälardalen University  
 1 adjunct Luleå Technical University  
 2 adjunct Lund University  
 1 full Norges Teknisk-Naturvitenskapelige Universitet, Norway  
 1 associate Politecnico Milano, Italy

SICS has a particularly close relationship with KTH Royal Institute of Technology. Eight KTH professors have part-time appointments at SICS and lead research groups that span both organizations, and three researchers at SICS are adjunct professors at KTH. Three groups are co-located at SICS and KTH, forming a thriving and vibrant joint research environment. SICS hosts many KTH PhD and Master students who also receive supervision from SICS researchers. Both organizations benefit greatly from the resulting critical mass of expertise, and from collaborating closely in both academic and industrial projects.

Collaboration with other Swedish Universities is also vibrant. The new experimental data center in Luleå was created in collaboration with Luleå Technical University, and strong links exist with Linköping University, Mälardalen University, Uppsala University and Lund University.

In addition, Christian Gehrmann has received an adjunct professor position at the department of electrical engineering in Computer Security at Lund University.

- SICS had 40 PhD students.
- 30 students completed their master's thesis work at SICS.
- 122 scientific publications were published by SICS researchers.

## ACADEMIC WORK AT SICS IN 2015

Eighty-three of the researchers at SICS hold a PhD. The PhD graduates of 2015 include:



Tomas Olsson  
 Thesis: A Data-Driven Approach to Remote Fault Diagnosis of Heavy-duty Machines.



Anna Ståhl  
 Thesis: Designing for Interactional Empowerment.



Pedro Sanches  
 Thesis: Health Data: Representation and (In)visibility.

## INTERNATIONAL COOPERATION

SICS participated in 29 European projects in 2015, including 13 EIT-projects.

SICS is a core partner in EIT Digital, an initiative aiming at turning Europe into the global leader in ICT innovation. In 2015, SICS's funding from EIT Digital was 15 MSEK.

SICS is the Swedish member of the European Research Consortium for Informatics and Mathematics (ERCIM) and hosts the Swedish Office of the World Wide Web Consortium, W3C.

## CORPORATE SOCIAL RESPONSIBILITY

CSR efforts are carried out in coordination with the entire group of institutes within Swedish ICT and affect the community and environment primarily through the results delivered by the research projects. ICT is an important enabler to meet global challenges and make our society more sustainable. Sustainability is thus a key element of the research.

## PUBLIC DEBATE

In addition to publishing its research in scientific journals and conferences, SICS acknowledges a responsibility to take part in public debate, as experts in identifying possibilities and threats with new ICT. SICS researchers participate in courses, seminars and committees, and are often invited to speak to companies and at public events.

For instance, in 2015 SICS was one of the consultative bodies for the Data Storage and Privacy Act (Datalagringsutredningen) and SICS researchers gave talks at several seminars in Almedalen, the Internet Days, the Digitalization Commission (Digitaliseringskommissionen), and the Royal Swedish Academy of War Sciences.

## EVENTS & SEMINARS

SICS organizes a number of annual events:

- SICS Software Week – which in 2015 included Multicore Day, SICS Data Science Day and SICS Digital Health Developer Day
- SICS Open House
- SICS Security Day

These events typically attract hundreds of people. If you would like to attend any of SICS's open events, please send an email to [signup@sics.se](mailto:signup@sics.se) and you will be invited to the next event.

## SUBSIDIARIES

In 2015, SICS established a new subsidiary in Luleå, making a total of three subsidiaries:

- SICS East Swedish ICT AB in Linköping, CEO prof. Sture Hägglund.
- SICS Swedish ICT Västerås AB, CEO Helena Jerregård.
- SICS North Swedish ICT AB in Luleå, CEO prof. Tor Björn Munde.

In all, SICS has offices in Kista, Linköping, Luleå, Lund, Norrköping, Uppsala and Västerås.

## LABORATORIES

Computer Systems Laboratory (CSL)  
 Lab manager:  
 Dr. Sverker Janson

Decisions, Networks and Analytics Laboratory (DNA)  
 Manager: Dr. Daniel Gillblad

Digital Health Lab (DHL)  
 Manager: Per-Olof Sjöberg

People Technologies (PPL)  
 Manager: Dr. Markus Bylund

Security Laboratory (SEC)  
 Manager: Prof. Christian Gehrmann

Software and Systems Engineering Laboratory (SSE)  
 Manager: Prof. Jakob Axelsson

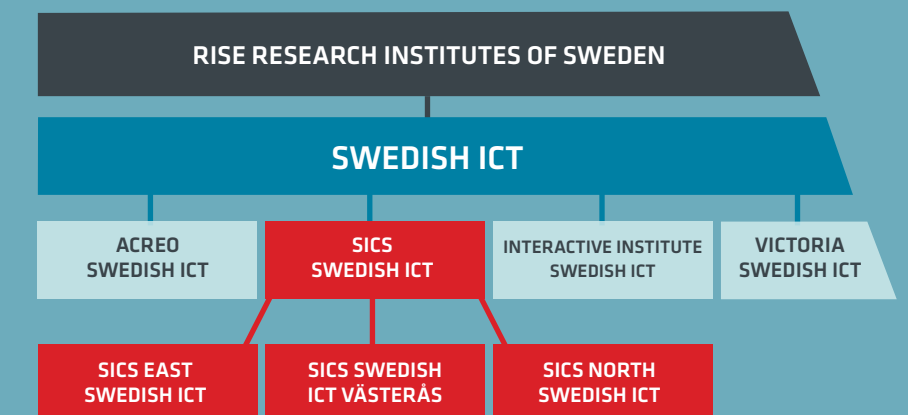
## DIRECTORS OF THE BOARD

Hans Hentzell, Swedish ICT (Chair)  
 Anders Caspár, Ericsson  
 Monica Ericsson  
 Sverker Hannervall  
 Agneta Jacobson  
 Kjell Svenson, Saab AB  
 Viesturs Vucins  
 Jonas Söderberg, employee representative  
 Tomas Olsson, employee representative

## MANAGEMENT

CEO: Prof. Christer Norström  
 Chief Scientific Advisor: Prof. Seif Haridi  
 Business Manager: Dr. Björn Levin  
 Financial Manager: Charlotta Jörsäter

## ORGANIZATION



## ABOUT THE FOLDER

SICS ACTIVITIES 2015-2016  
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## WELCOME TO SICS

SICS Swedish ICT is a research institute in the most expansive area of industry this century: the total digitalization of products, services and businesses. We contribute with cutting edge technology within the fastest growing and most relevant areas of this revolution, including big data analytics, automation, security, and internet-of-things.

SICS Swedish ICT is not for profit and carries out advanced research in close collaboration with Swedish and international industry and academia. We constantly seek partnerships in which new technology can be turned into smart innovation, giving our customers and partners a competitive edge.

Welcome to SICS!

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