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SICS is a research institute that provides new information and communication technology to Swedish industry, both small and large companies. The mission is to stay abreast of technological advances, where industry often lacks resources, to achieve innovations that improve profitability.

SICS’ job is to create value
SICS exists for the industry, not for its own sake. SICS does not distribute dividends to any shareholders. All the research efforts aim to make Swedish industry smarter and more efficient, innovative and profitable—quite simply, to create value. SICS’ task is to future-proof Swedish industry and make it more competitive.

World-class experts
SICS consists of around one hundred and twenty researchers who delve deeply into strategic areas as requested by the industry. They conduct world-class research in areas including cloud computing, interaction design, sensor networks, mobile services, process optimization and networked systems. SICS does not do work that can be done better by someone else. SICS researchers do what they do best and invite experts from their network to contribute complementary skills in the problem-solving process.

Win-win
The expertise found at SICS is built on a solid academic foundation that is challenged as it comes into contact with real life industrial problems. The research theories are cutting edge, but knowledge without practical application is of no interest. SICS constantly seek partnerships in which SICS can turn new technology into smart innovations, giving the customer a competitive edge. The customer gets solutions tailored to their needs; the researchers get real problems that make their research relevant.

Unique network
Working with SICS entails access to a unique network. SICS conducts research in conjunction with large global enterprises, small technology-intensive companies, public institutions and the international research elite, resulting in fruitful meetings for all parties involved and leading to new partnerships and new knowledge.

Partnerships result in knowledge transfer
Knowledge housed in the individual mind becomes infectious through collaboration. The projects are run so that industry engineers and specialists work with Swedish and international academic experts, as well as SICS researchers. Problems are attacked from various angles and solutions are tested imme-
diately in practical applications. Some projects are underway for several years, such as EU projects, while others solve more limited problems in a matter of weeks.

**Forms of collaboration**

Collaboration can take a variety of forms. SICS’ primary remit is to accept direct assignments from industry to solve difficult problems, including both large research assignments and more limited initiatives within new fields of technology. In other projects, the costs are covered to some extent—sometimes 100%—by VINNOVA or the EU, benefiting project participants. SICS’ experience with integrating and operating such major projects is a huge asset in these cases. SICS also organizes workshops in specific areas of technology in which people can participate for several days and gain valuable insights. Job rotation is another effective way to spread new technology and information to companies. Key individuals from your company can be based in a SICS office for a period of time and work closely with an issue in a setting conducive to generating new ideas.

**Welcome to SICS**

If you work with development in a technology-intensive company, large or small, and want to know what you can do together with SICS, please contact SICS at info@sics.se.

If you want to come to one of SICS open seminars, meet the researchers and gather the latest information in your field of technology, you are welcome to indicate your interest at www.sics.se/signup. You will then receive invitations to events such as SICS Software Week and SICS Open House.

*SICS is a part of Swedish ICT Research group, also including Acreo, Interactive Institute, Viktoria Institute, Imego and the SICS subsidiaries Santa Anna IT Research Institute and SICS Västerås.*
The fact that SICS has sharply increased the successful value-based partnership with Swedish industry over the past year is extremely encouraging. Around the world, business and talent are becoming increasingly competitive, which is a strong contributing factor to the strengthened climate of cooperation. To be successful today, businesses cannot rely on having all necessary skills internally; rather, they must have fast, reliable access to external skills. SICS is a leading partner in computer science with both substantial expertise and access to a global network of world-leading researchers.

What characterizes a good long-lived partnership? The most important starting point is that it is based on mutual business or operational needs, short-term and long-term. In addition, the parties must have the necessary expertise either themselves or in their networks. SICS has this required cutting edge expertise in a number of areas. At SICS, we must also understand technical needs and the underlying business logic. A partnership works best when the agenda and strategies of SICS and the company are in line with and strengthen one another. It must also take a non-bureaucratic approach and build on a mutual respect for and understanding of one another’s practices. Once that is in place, the conditions are set for talented employees to be motivated to the maximum and deliver results that exceed all expectations.

How is a solid, sustainable partnership established? At the foundation, trust must be built through flexibility and high-quality deliveries. In our experience, building trust is most successful when several methods of cooperation are used: seminars, long-term research, short-range delivery projects and job rotation of key individuals. These projects must also receive the attention they require via a professional method of follow-up.

For Sweden to continue being successful, it is important to constantly develop our cooperation methods to generate industrial and academic value, both short-term and long-term.

We look forward to 2012 as a year in which collaboration to create maximum value is front and center!
2011 has been a very active and prosperous year at SICS. A number of new initiatives have been taken and established activities have been positively evaluated by funders and partners.

**Cooperation with Industry**

SICS is continuing its initiatives towards closer collaboration with industry in Sweden. SICS activities in the area of availability and resource efficiency are coordinated in the newly established SICS Center for Industrial Efficiency. Moreover SICS’ collaboration with companies in the Västerås region and with Mälardalen University has strengthened, which has resulted in a new SICS office in Västerås, in partnership with Mälardalen University and Automation Region, funded by the City of Västerås and the county, Västmanlands län.

SICS and Ericsson have formed a joint SICS-Ericsson Software Lab focusing on mobile networks software, see page 12. This takes place against a background of strongly increasing collaboration in predevelopment projects over the last two years, reaching a volume of over 10 MSEK in 2011, and covering a wide range of topics in advanced software technologies.

SICS is active in three excellence centers where industry, universities, and research institutes work together, supported by multi-year funding from the Swedish Agency for Innovation Systems (VINNOVA), the Swedish Foundation for Strategic Research (SSF), the Knowledge Foundation (KK-stiftelsen), and the industrial partners. The centers are SICS Center for Networked Systems (led by SICS), see page 31, Mobile Life (led by Stockholm University), see page 36, and Wisenet (led by Uppsala University).

In October 2011 a new lab started at SICS, marking a new important research focus of the institute sought-after by the industry: The Software and Systems Engineering Laboratory. The lab will develop tools and methods for how to efficiently develop large scale software-intensive systems. More on this on page 29.

Swedsoft, the industry network for software intensive industry in Sweden, hosted by SICS, has written a proposal for the Government’s next four year plan for research funding in Sweden.

**Public Funding**

Some of SICS’ most important research groups have received substantial long-term funding. Professor Seif Haridi, has received 25 MSEK from the Swedish Foundation for Strategic Research (SSF) to continue his research in end-to-end distributed cloud computing at SICS and the Royal Institute of Technology (KTH). Associate professor Christian Gehrmann has received 20 MSEK, together with KTH, to build the next generation framework for fully verified, secure hypervisors for embedded systems. Professor Kristina Höök has received 10 MSEK in continuing funding from SSF for her research on emotions and man-machine interaction, an important part of SICS new initiative for the Internet of Things, involving mainly consumer oriented industry.

A number of projects are run in collaboration between SICS and its sister institutes within the Swedish ICT Research group. In 2011, one of these projects, Smart ICT for living and working in Stockholm Royal Seaport, received a 10 MSEK funding from VINNOVA for creating a generic ICT infrastructure for a new city district of Stockholm, see page 15.

**Cooperation with Academia**

SICS has a good position in the international research community. SICS scientists participate actively in national and international research collaborations. In Sweden, the bonds are particularly close with the Royal Institute of Technology (KTH), Stockholm University, Uppsala University, and Mälardalen University.

A number of university professors work part time at SICS, and several senior SICS researchers devote part of their time to supervising master’s and doctoral students, and teaching courses. In 2011, approximately 20 students completed their master’s thesis work at SICS and 10 of SICS employees were working on their doctoral theses. A total of 160 scientific publications were published by SICS researchers during the year. The Networked Embedded Systems group, led by Thiemo Voigt, got an impressive three papers accepted (out of 24) at their top conference SenSys 2011.

During 2011 three SICS researchers, Anders Gunnar, Preben Hansen, and Fredrik Österlind, received their Ph.D.
degrees (see page 10). Another four SICS researchers received their licentiate degrees: Fatemeh Rahimian, Amir Payberah, Shahid Raza, and Niclas Finne. Anders Holst was appointed associate professor at the Royal Institute of Technology, KTH CSC.

Adam Dunkels was program chair at the IEEE DCOSS conference in Barcelona. SICS and the Mobile Life Centre organized MobileHCI, the 13th International Conference on Human-Computer Interaction with Mobile Devices and Services, in Stockholm.

**International Cooperation**

SICS’s research collaboration and contacts within Europe are well developed. In 2011, SICS participated in 13 European projects and coordinated 1 of them.

There is a steady flow of researchers from abroad to SICS and SICS researchers visiting and working with our international partners. 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. SICS is also a core partner in EIT ICT Labs, which is an initiative aiming at turning Europe into the global leader in ICT innovation. There is collaboration with India and China as well. SICS is investigating the possibility to open an office in Hyderabad, India.

**Corporate Social Responsibility**

Building on the policy established at SICS in 2010, the CSR work has continued both through environmental off-setting and through research projects. 2011 is the second year a CSR report has been produced at SICS, and guidelines for year-to-year comparisons have been developed. CSR is tightly integrated with core business aspects at SICS, as social responsibility is often one of the goals for the research.

**Market Communications**

In addition to publishing its research in scientific journals and conferences, SICS presents its activities and results to Swedish industry and society in a number of ways. SICS researchers participate in courses, seminars and committees, and are often invited to speak to companies and at public events. SICS acknowledges a responsibility to be part of the public debate, as experts in identifying possibilities and threats with new ICT. One example was “Digitaliseringsrådet”, the council for a successful future digital society, led by IT minister Anna-Karin Hatt, where both Kristina Höök and former Chairman of the SICS Board, Staffan Truvé, were members. Another was when Markus Bylund gave a speech for the Swedish Parliament at “Riksdagens Framtidstag” (the Parliament’s Future Day) in January 2012.

SICS’s employees are frequently interviewed in media; in 2011, SICS featured in the Swedish and international media at more than 205 occasions. Adam Dunkels was listed one of 100 Top Thinkers in the world within the Internet of Things area, by Postscapes, and number two on the list of Sweden’s Super Talents by the magazine Veckans Affärer.

To understand the demands of industry and society and to create interest for and uptake of the research results, SICS organizes a large number of events every year where people can meet and discuss technology and application issues. In 2011 SICS organized workshops for technology areas such as Multicore, Cloud, and Virtualization and Verification for Security, as well as application oriented events such as Android Day, Industrial Efficiency Day, a seminar day on E-health, Mobile Life Centre and SICS Open House. Most of these events attract several hundreds of people. The Internet of Things Day in February 2012 holds the record with more than 500 participants.
SICS Expertise at Spotify

Stina Nylander spent four months as a guest researcher at Spotify during spring 2011. The stay was one of the five projects partially sponsored by the VINNOVA project Innovation-driven mobility between research institutes and industry.

The project goal was to provide Spotify with expertise in analysis of user behavior and to give SICS the opportunity to work with a medium-sized company in strong growth and development that has little experience of collaborating with research organizations.

The work was focused around log data and survey data to provide a rich basis for analysis of user behavior and attitudes toward the Spotify client within two main themes, discovery of new music, and social features of the Spotify client. Existing log data from 2010 was used while survey data was collected in two sets during the project.

The project results have influenced modifications of the Spotify client, and parts of the results will be published scientifically. The positive results have validated the project format—analysis of log data and survey data. Data centered projects can be run rather independently from a continuous development process and the results are easily integrated in the development.

Spotify has gained increased knowledge of how their product is used both with respect to what users actually do in the client and how they perceive it. The company has received tangible examples of how user behavior and users can be studied in a way that is easy to incorporate in the existing development process. The project has shown how empirical data on user behavior can play an important role in the product development process.

“It was interesting to work in this young and fast developing organization”, says Stina. “I learnt a lot about how research and industry can collaborate under those circumstances.”

CrowdCulture Wins International Competition

SICS participates in a project, called CrowdCulture, for crowd controlled micro financing of cultural projects.

The project has developed an infrastructure for financing cultural projects as a complement to the existing expert based financing. Every member in this public system points out his or her favorite among the presented project proposals and sends a micro payment to it. As a member’s vote also controls the distribution of much larger contributor funds, the system provides a leverage effect. This way, every krona you spend will grow to a much larger funding of the cultural project you support. The project CrowdCulture won the online entrepreneurial competition, Shine in Barcelona, 2011.

“One of the companies in the accelerator is Severalnines. Founded by MySQL veterans Vinay Joosery and Johan Andersson, Severalnines provides software and services for easily usable, highly available and auto-scalable cloud database platforms. In December 2011, Severalnines won the European Cloud Computing Award for Best Startup.

“The most important value for us has been all the spontaneous meetings with SICS researchers,” says Vinay Joosery, CEO.

In addition to coaching existing startups, SICS also aims to inspire budding entrepreneurs by arranging seminars, workshops and other activities within the Swedish Open Innovation Network (SOINK), an initiative funded by VINNOVA and run by SICS in collaboration with Stockholm University.

www.sics.se/seedaccelerator
Luca Mottola, Winner of Prestigious European Award

In 2011, SICS researcher Luca Mottola was selected from Europe’s best young researchers in computer science and applied mathematics as the recipient of the Cor Baayen Award.

Luca’s research focuses on programming wireless sensor networks. This knowledge is absolutely fundamental to the future vision of the Internet of Things, i.e., the new, expanded internet in which not just people, but also most objects are equipped with intelligence and linked to the network. In a field where software development usually takes place at the operating system level, Luca is among the first to succeed with high-level programming in real applications. His program is used in demanding safety-critical systems such as road tunnel control systems. Several major EU projects related to embedded systems and wireless networks are also built on his software.

Luca’s work has received several international awards, including two IPSN Best Paper Awards, a CONET Best Ph.D. Thesis Award and a SenSys Best Demo Award—all at important scientific conferences.

“It is an incredible achievement, one of the most elaborate (and long!) doctoral theses I’ve ever read,” said Professor Matt Welsh, known from Harvard and Google, about the dissertation at Luca’s thesis defense.

Luca Mottola, who works in the Networked Embedded Systems group at SICS, is the fifth SICS researcher to receive the award. Like Luca, two of the other recipients, Adam Dunkels and Kristina Höök, are behind SICS’ new focus on the Internet of Things, which includes several of SICS’ strongest research areas: sensor networks, interaction design, mobile services, cloud computing, and Big Data.

The Cor Baayen Award is given out annually by ERCIM (European Research Consortium for Informatics and Mathematics) to a promising young researcher in computer science and applied mathematics.

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SICS Västerås Makes the Innovation System Complete

SICS starts a new subsidiary in Västerås to strengthen the region’s innovation system. Helena Jerregård, process leader of the industrial network, Automation Region, takes the chair as CEO.

SICS has well developed relations with some of the most important industrial actors in Mälardalen; ABB and Bombardier. Now SICS takes one step closer to the industrial network of the region by establishing a subsidiary in Västerås. The initiative is taken in close collaboration with Mälardalen University and their strongest research environment, Intelligent Embedded Systems, and together with the industrial network Automation Region. Helena Jerregård will share her time between SICS and Automation Region.

“We are pleased to have Helena in this position. Her network and vast experience from Automation Region is very useful when building new relations between SICS, the University and the industry of the region,” says Christer Norström, CEO at SICS. “We are convinced this initiative will create new business and useful research for all parties.”

“SICS is like a treasure chest of competence,” says Helena Jerregård. “SICS Västerås will work as a link between Mälardalen University, industry in the area and SICS in Kista. It is a great challenge to find relevant connections between the companies and the research!”

Helena Jerregård. Photo: Alice Öberg.

SICS in Västerås
Dr. Preben Hansen:
Task-Based Information Seeking and Retrieval in the Patent Domain

Preben Hansen’s PhD thesis is about task-based information retrieval in the information-intensive patent domain. The thesis contributes to the insight of how patent examiners search. The methodology for collecting data involves on-site observations, log-analysis and electronic diaries. These methods help to unfold both implicit as well as explicit information handling processes and relationships between the levels of work task, information seeking task, and the information retrieval task. One of the major findings was that patent examiners are involved in collaborative information handling and information sharing and thus, support for this behavior is needed. This is vital in order to process patent applications more effectively and also as a means for knowledge management within organizations.

Dr. Anders Gunnar:
Aspects of Proactive Traffic Engineering in IP Networks

A communication network must be able to cope with large variations in traffic load and component failures. This thesis studies how a network can be configured to proactively meet a large variation of traffic situations with the same configuration. Anders identifies different sources of traffic variations and develops mathematical models for the variations. The models are incorporated in a mathematical optimization problem to find a suitable parameter setting such that performance is optimized for every traffic scenario captured by the model. To highlight the results he applies his methods on traffic data from operational IP networks.

Dr. Fredrik Österlind:
Improving Low-Power Wireless Protocols with Timing-Accurate Simulation

Resource-constraints make low-power wireless networks difficult to develop, resulting in increased development time and poor performance. Network simulators offer full non-intrusive visibility and control, and are indispensable tools during low-power wireless development.

In this thesis Fredrik argues that high simulation timing accuracy is important when developing high-performance low-power wireless protocols. He develops the simulation environment Cooja that simulates low-power wireless networks with high timing accuracy, and uses Cooja to develop a set of new low-power wireless protocols. The protocols are Conditional Immediate Transmission that improves on low-power device latency, and the radio duty-cycling protocol Strawman that improves on energy efficiency.

The Cooja simulation environment is available via Contiki: http://www.contiki-os.org
“It Has Been a Great Year!”

So says Professor Kristina Höök about the year of 2011. Most has gone her way—she has received an influential assignment, a new job, received several grants for her research and for commercialization.

Professor Kristina Höök’s research has always been about human beings in the new IT world. In a time when much of the research is centered on information technology and hardware to make them faster, and on services and solutions that will make us more efficient, she has focused on humans. For her it is natural to devote her research to people and their needs for entertainment and well-being, and how technology can contribute to this. In 2011, Kristina Höök received several research grants that prove that she really has been on the right path.

Six years ago she was appointed one of Sweden’s research talents in the Future Research Leaders program of the Swedish Foundation for Strategic Research (SSF) – the so-called Ingvar Scholarship. In 2011 she became one of six alumni who received continued funding under the Successful Research Leaders program, which is awarded to particularly successful research leaders. Kristina Höök will now focus on the new field of Internet of Things.

“The first six years with ‘Ingvar’ were the best years as a researcher I have had. It was a great confirmation and a proof that it has been worth all the hard work. And to now be able to continue means that we have the resources to further build up an important new research area,” she says.

Internet of Things

Internet of Things is also the topic in two other successful applications – and since it involves Kristina Höök the focus is on consumers. In 2011 she received her first grant ever from the Swedish Research Council’s call in science and technology, and within VINNOVA’s new major venture, “Challenge-driven Innovation”, she received funding for the first stage of idea development and formation building. Her goal is to build an Internet of Things center. “Sweden needs to have a strong vision and a determined effort on how we can use the future Internet of Things,” explains Kristina Höök. “So why not focus on consumers? That would be radically different from the usual technology focus. Also, in Sweden, we have a tradition to focus on people.”

Commercialization

Affective Health is a lifestyle-related mobile service that will enable people to better manage stress. Kristina Höök has developed this within the framework of the Mobile Life Centre. The service received half a million SEK in commercialization grants from the SSF and VINNOVA pilot program Verification of Research.

“The journey towards commercialization has been much more fun and exciting than I thought,” emphasizes Kristina Höök. “I am a scientist at heart, but the commercialization process has also been an exploration of people and the tools they want to use.”

New position

On April 1, 2012 Kristina Höök takes the seat as a professor in interaction design at the Royal Institute of Technology (KTH). She will direct the research group Media Technology and Interactive Design (MID) within KTH School of Computer Science and Communication. She will remain at SICS on part time.
SICS and Ericsson have established a long-term investment in software research in Kista for mobile networks. The lab will develop advanced software technology for the telecommunications systems enabling higher capacity, reliability, energy efficiency and lower development cost. The first results are just around the corner.

Initially, four researchers from SICS and an equal number from Ericsson will prototype software technology for the wireless communications systems to be used in the 2015–2020 time framework.

Karl-Filip Faxén is one of the lab’s scientists. He is currently in the final phase of a predevelopment project on a new scheduler for a RNC (Radio Network Controller), which controls up to several hundred base stations. This research includes five people, two from SICS and three from Ericsson. “It’s the RNC that controls traffic in 3G networks, this means that all traffic going in and out of a cell phone goes through the RNC. The big problem right now is the data traffic and the increasing capacity needed in the networks,” says Karl-Filip Faxén.

Today’s mobile network technology is based on single-core solutions. An RNC contains a large number of cards with a variable number of cores. When a mobile device connects to the network it is assigned a core before its capacity needs are known, and you cannot fill each core completely. With the current solution it cannot switch to another core that is better adapted to the need. The researchers have worked out a software structure based on multicore technology.

“Our goal is to get the most out of the hardware and get higher performance in mobile networks. With multicore technology, fewer cards are needed in a RNC, and the case becomes smaller. It is more efficient because it uses just as many cores as needed, the rest are turned off. It also saves energy,” explains Karl-Filip.

Karl-Filip Faxén expects that the research team will have a prototype ready during spring 2012. The researchers have already started talking about how to proceed, but on this point he is more secretive. It is quite clear though that Karl-Filip would like to continue the cooperation.

“It has been exciting to work with Ericsson on this project. We have learned a lot from each other and it is great fun!”
During 2011 EIT ICT Labs was established as a recognized European actor in ICT innovation. Activities and processes were started. In 2012 ST-Ericsson will join ICT Labs as the fourth Swedish core member of the Labs, alongside KTH, Ericsson and SICS.

ICT Labs of the European Institute of Innovation and Technology (EIT ICT Labs) is an initiative aiming at turning Europe into the global leader in ICT innovation. SICS is one of the three core partners of the Stockholm node. In 2012 ST-Ericsson will join as the fourth core partner.

To fulfill its mission ICT Labs strives to establish a new type of partnership between leading companies, research centers, and universities in Europe. Higher education will be transformed to promote creativity and entrepreneurial spirit. The ICT Labs community speeds up ICT innovation by bringing people together from different countries, disciplines and organizations, and stimulating a new generation of world-class ICT business via broader and faster industrialization of research results.

During 2011, research carried out within EIT ICT Labs focused on three strategic research action lines, with SICS participating in all of them:

- Computing in the Cloud
- Internet Technologies and Architectures
- ICT-mediated Human Activity

Examples of EIT contributions by SICS during 2011

Seif Haridi, professor at KTH and chief scientific advisor at SICS, is the leader of the research action line “Computing in the Cloud”. His tasks are to define the strategic direction and scope of research, to lead the selection of proposals to be funded by EIT, and to stimulate coordination of various activities to increase synergy and the creation of the cloud computing research community within ICT Labs. Professor Magnus Boman, at SICS and KTH, has led ICT Labs’ business intelligence activity called Innovation Radar which produced two Foresight Studies in 2011, one on smart energy systems, and one on future media and content delivery.

Professor Kristina Höök led an EIT-funded project investigating commercialization of her research in the health and wellbeing area, with focus on stress management, in close contact with Philips among others. Results of that work were presented as part of the EIT ICT Labs’ program at CEBIT 2012.

http://eit.ictlabs.eu/
In collaboration with Lund University, SICS researchers try to understand and model the function of the mammalian nervous system in order to reproduce it for industrial adaptive control systems. Contrasting to earlier attempts—which typically go top-down from cognitive behavior—they go bottom-up in the structural hierarchy of the central nervous system (CNS), and start on the molecular level. From there, they derive the function of neuronal microcircuits involved in motor control. These circuits engage motor centers, the spinal cord, the cerebellum, and the pre-cerebellar structures. A microcircuit is a combination of a small number of neurons operating together—it can be seen as the next level up, above neurons, in the hierarchy of the CNS.

SICS cooperates closely with a group of neurophysiologists led by Dr. Henrik Jörntell at the Department of Experimental Medical Science at Lund University. This group performs advanced electrophysiological experiments, where physical connectivity and signal transmission between neurons are recorded in vivo, allowing validation of the models.

A challenge is that the macroscopic operation of microcircuits depends critically on neuronal membrane molecular dynamics, which is directly affected by thermodynamic noise. Although noise in an electronic circuit is normally undesirable, it can clearly be seen that evolution has taken advantage of this in order to design robustness into circuit operation. However, the crucial function of noise in microcircuits requires a non-trivial mathematical treatment, and stochastic models of neuronal activity have been described as among the most advanced applications of the theory of stochastic processes in biology.

One of the goals is to find out why nature is so successful in controlling motion, despite the many degrees of freedom that must be synchronized. Nature tends to favor certain combinations of degrees of freedom, which are used particularly often. These are known as motor synergies, and an important question is how they are represented, developed, or learnt. Perhaps similar techniques can be used in order to control robots or industrial processes.
A Generic ICT Infrastructure for Stockholm Royal Seaport

Markus Bylund at SICS manages a Swedish ICT led initiative aiming to detail a generic information and communication infrastructure for Stockholm Royal Seaport, a much talked about new city district of Stockholm. The VINNOVA-funded project, Smart ICT for living and working in Stockholm Royal Seaport, engages about a dozen small and large companies from the telecom sector, construction companies, and the City of Stockholm. Here are his answers to the most frequently asked questions about the project.

What about the Stockholm Royal Seaport, what is it that makes that place so special?

The Stockholm Royal Seaport is an almost completely new city district in Stockholm with a very ambitious agenda regarding environmental, social, and economical sustainability. Working in this environment provides unique opportunities to co-create with a range of actors and stakeholders for an extended period, including the municipality, development companies, utility providers, IT companies, and most important, different end-user categories representing living, education, healthcare, etc.

What is SICS’s role in the project?

SICS provides technical expertise in a range of domains, from systemic effects to sensor networking and user experience. One of our primary interests concerns how to use IT to coordinate and orchestrate the very complex mesh of actors, stakeholders, technologies, and businesses, to deliver sustainable solutions not only in isolated settings, but across the whole complex system that a city district constitutes. A generic information and communication infrastructure shared by many of the actors is the key to such successful orchestration.

Why a generic information and communication infrastructure?

IT is an integral part of many of the mechanisms that promise to improve sustainability in future urban settings. Ranging from smart grids and energy use visualization, through waste handling, to healthcare applications, IT plays a central role. However, if each of these applications will have to carry the burden of caring for a proprietary information and communication infrastructure, the total cost for development, deployment, and maintenance will be very high. Both in terms of required financing, CO₂ emissions, and the use of chemicals and scarce resources. In contrast, a generic infrastructure, shared by many of the sustainability mechanisms present in a future city district, holds the promise to reduce both investment and environmental costs.

A shared infrastructure for information and communication also opens for a range of new business opportunities. Markets that previously have been closed due to high entry thresholds in terms of initial investment costs or required access to proprietary networks or technologies are opened up by a shared infrastructure. This increases the opportunities for both competition and collaboration between different actors. Not least, this opens the possibility for the large and very innovative group of habitants of the city to actively participate in the development of new applications and services.
Wireless Systems
– from Design to Deployment

The Contiki simulation environment supports rapid development of low-power wireless systems. The network simulator Cooja and the low-power device emulator Mspsim are connected to realize a powerful timing-accurate development environment going all the way from design to deployment.

Low-power wireless systems are difficult to develop. Low-power wireless is an active research area, and billions of devices are anticipated to be in use within a few years. But widespread adoption of the technology faces major challenges, as low-power devices have severe constraints on both hardware and software. For instance, the amount of memory in low-power devices is on the order of kilobytes, millions of times less than in a regular laptop computer. To further complicate things, applications require that these distributed systems must operate fully autonomously, and should last for decades on a single pair of batteries. These unique challenges have motivated a completely new set of development tools.

Back in year 2005, with the rising popularity of Contiki, the operating system of the Internet of Things developed by SICS, SICS researchers realized that the available development tools would not nearly suffice. Contiki users demanded an integrated development environment to guide them through the many hazards of embedded development, an environment that supported them during high-level design as well as in detailed experiments. The Cooja simulator was born with this purpose. Cooja is a network simulator; it simulates wirelessly interconnected low-power devices while allowing the user to inspect and control the execution. With help of Cooja, the users no longer need to upload and test their programs on real-hardware devices, resulting in shorter development cycles and ultimately in higher quality systems. In addition, the flexible design of Cooja allows users to gradually advance from simple and apprehensible models to complex and accurate simulated worlds.

Mspsim is a low-power device emulator. At its core lies emulation of the popular Texas Instruments’ MSP430 microcontroller. With help of Mspsim, Cooja can simulate the very same binaries that would otherwise be programmed onto real devices. The timing-accurate simulation environment Cooja/Mspsim was born, and quickly gained interest from the community. Contiki users could now emulate entire networks with unprecedented accuracy; radio transmissions are simulated at individually transmitted bits, and software execution at individual instructions. Moreover, Cooja and Mspsim are both freely available for download via the Contiki operating system:

http://www.contiki-os.org
Modern smartphones are really everything you need to build sensor networks, quick and easy, for a wide range of tasks.

Some years ago the word “sensor network” was on everyone’s lips. No matter if it was called Smart Dust, Motes or Sensor Confetti, the basic concept was that units consisting of radio provided microcontrollers, with one or more sensors configured in a widespread network, interoperating in creating a consistent picture of the surroundings. However, a smartphone of today can replace a sensor node in many situations.

Researchers at SICS have developed the idea of building sensor networks with smartphones only. Modern smartphones come with an abundance of sensors which could easily be used for this. In fact, the phones have become affordable enough to justify the use of them as nodes in a sensor network, even if you use only one or a few of the built-in sensors.

Also the phones have a wide range of communication capabilities (bluetooth, wifi, mobile data, etc.), which use standard protocols that the architecture of the sensor network can rely on.

Furthermore the computing power of smartphones is now sufficient for computing intensive tasks. Consequentially, the streams of pictures and sound initiating from their cameras and microphone can be locally analyzed which can provide an increased understanding of the environment surrounding the phone. And whenever more computing capacity is required, it is possible to offload part of the task to the cloud.

Smartphones have an intuitive user interface and can easily be configured to suit the task at hand through so-called apps. When the situation changes, there is no need to replace the hardware, instead a simple reconfiguration is sufficient.

Traditional sensor networks rely on low-power processing and communication units in order to work as long as possible without human intervention. However, this is not always necessary. There is a number of situations where power is easily available or where the sensor only needs to work for a short period of time. Modern smartphones are flexible and power-optimizing which can prolong battery life significantly.

Finally, the existence and easy access of a mobile data network at the outside opens up possibilities to the sensor network that would not otherwise be possible, e.g. access to the Internet in difficult locations and also the ability to use the Internet and its services as a sensor itself.

Smartphones can be used instead of traditional sensor networks in a wide range of domains. SICS researchers have been experimenting with sensor networks for home services, such as keeping track of energy consumption in houses or alarm systems for elderly.

Thiemo Voigt leads the Networked Embedded Systems Group.
Researchers at SICS investigate practical solutions for an IP-based Internet of Things. Application scenarios such as Smart Cities, Smart Toys and Critical Infrastructures are considered through collaboration with companies such as Disney, Thales, Cisco, and the startup Worldsensing.

The industry is converging towards an IP-based Internet of Things, in which the physical world is connected to the digital world using the Internet standards. With this approach, smart objects are interoperable—a key property enabling quick adoption and stimulating innovation. Together with the consortium of the EU-funded Calipso projects, SICS contributes in developing three complementary areas: Smart Cities, Smart Toys and Critical Infrastructures.

**Smart Cities.** In the near future, we will have city-wide smart networks for more green, easy-to-use and efficient urban services. This applies to public transport, city traffic, waste control, pollution monitoring, etc. For example, Worldsensing’s FastPark application will allow you to find and book from your phone the closest available parking space that fits your needs.

**Smart Toys.** Imagine toys that communicate with one another in a context-independent manner, used by children as an entertainment, assisting and educational device. At home, the toy can connect to set-up boxes or online games and deliver customized content. When visiting theme parks, it interacts with surrounding installations or with other children’s toys for an enriched experience.

**Critical Infrastructures.** Public health and safety in infrastructures such as airports, ports, oil and gas facilities, plants or military bases will also benefit from IP-based smart objects. Thales’ control systems for critical infrastructures put together sensing and actuation to detect intrusion or failures and trigger alarms, fire extinction, or other safety measures.

These applications, enabled by all-IP communication, need to conciliate interoperability and low energy consumption to achieve the longest network lifetime. To this end, there is a need to better understand the interaction between the low-power protocols, developed by the sensor network community without IP in mind, and the embedded IP stack (e.g. the RPL routing protocol and the CoAP application-layer protocol), designed without power-saving protocols in mind. Together with the Calipso consortium, SICS is facing this challenge by rethinking existing protocols, integrating data-centric communication in the IP stack and proposing the enhancements for standardization, towards an open yet efficient Internet of Things.
SICS and Swedish Winter Sport Research Centre at Mid Sweden University in Östersund have initiated a collaboration to demonstrate what cutting edge technology and advanced mathematics can do to develop new training methods to achieve new successes at the 2014 Olympics in Sochi. The tool measures how skiers move, and helps optimize training.

The new partnership consists of a “dream team” comprising the world’s most experienced sports researchers in biomechanics and physiology and the best skiers in the country, combined with the foremost experts in advanced mathematical modeling in Sweden. Swedish Winter Sport Research Centre at Mid Sweden University, led by Professor Hans-Christer Holmberg, who is also head of development at the Swedish Olympic Committee (SOC), known primarily for the development of cross-country skiing, accounts for the domain knowledge, while SICS and partners account for the technical solutions.

In brief, the service is a cell phone application that continuously registers and provides information about how the skiers move and their movement economy. The sensors that provide the information are in an ordinary Android phone that the skiers wear on the body together with a traditional heart rate monitor. The captured sensor data is transmitted via the Internet to processing in “the cloud” using advanced algorithms. It is then sent immediately back to the skier or
trainer in the form of useful, understandable information that can optimize training. “For those of us in skiing, this is an exciting new tool that provides major opportunities to develop and optimize training. A fundamental question for skiers today is movement economy, since the trend is to go faster and faster. This provides exciting opportunities to eventually speed up even more,” says Rikard Grip, coach of the Swedish women’s cross-country ski team.

“At SICS, we see the project as an outstanding chance to convert several new innovative technologies developed at SICS into a fun application that is in demand,” says Professor Christer Norström, CEO of SICS. “The service uses the latest sensor technology and new findings in interaction design, modeling and pattern recognition. Working with the most talented individuals in the sport—skiers, trainers and researchers—is one of the most stimulating components of the project. There are no margins here; every hundredth of a second counts!”

Hans-Christer Holmberg sees major potential in combining knowledge of physiology and biomechanics with the latest sensor technology to take training and results to the next level. Both Hans-Christer Holmberg and Christer Norström are extremely satisfied with how the collaboration has gained momentum.

“As head of development at SOC, naturally I see this collaboration as a way to achieve major successes at the 2014 Olympics in Sochi. But I can also see the results being adapted for several sports, including running, rowing and kayaking. By using the results in smartphones, exercise will be more enjoyable for more people, which will make Sweden healthier and more active,” says Hans-Christer Holmberg.

“We’re only at the beginning of an exciting development in what modern IT can do for the sport,” says Christer Norström, and Hans-Christer Holmberg agrees.

The project is a key component in the SICS initiative on the Internet of Things, the vision of an internet that connects not only people, but also objects in a context that improves and benefits life.
To collect data is one thing, to use the data is another. This is the focus of one group at SICS. Their goal is to connect the information flow all the way from low-level sensors to high-level planning and optimization.

In industry today there is much focus on collection of data, from various sensors and sources throughout the production system. Much effort is spent on measuring and storing “everything”, without much consideration of how to use the measurements. But for several years now a group of researchers at SICS have been conducting research on how to actually use the collected data in the operation. The goal is to connect the information flow all the way from low-level sensors to high-level planning and optimization. This will be even more important in the upcoming era of Internet of Things.

The approach is to gradually refine the information in several steps. The flow of information is schematically shown in the figure. The bottom represents the large amount of data and sensors measuring the condition and state of the system. As you move upwards in the figure, this raw data is analyzed into e.g. indications of service needs, diagnoses of detected problems, and prognoses of remaining operation time until service is required. This information in turn is input to planning of operation and maintenance of the system. Finally, the plans for different aspects of operation and individual units are synchronized into a global plan.

It is also important to consider uncertainties in the process. There may be noisy data or unexpected events. This means that much information has to be modeled as probability distributions. As time passes and more information is retrieved the plans should be dynamically updated. This will make maximum use of the information available at each moment, and at the same time provide maximum flexibility to changing conditions and unexpected events.

In a recently completed project, this concept was used in the context of condition based maintenance of railway vehicles. The project contained components at all levels in the refinement, showing that they can be connected all the way from sensors to plan; anomaly detection to find components with abnormal wear, prediction of future wear, optimal maintenance planning and packaging, and fleet level maintenance planning to avoid overload in the workshops.

www.sics.se/projects/dust
New SICS Center for Industrial Efficiency

The use of IT for making industrial processes more efficient is growing fast. New requirements on flexibility and specialization lead to more complex processes and drive a need for advanced support functionality. At the same time, high availability and resource efficiency are seen as Sweden’s main competitive edge. To meet these demands SICS’ activities in the area are now being focused under the SICS Center for Industrial Efficiency.

During 2011, the center was granted funding for research in the area of Sustainable Efficient Automation to develop ideas and build a consortium for the area. The well-received annual Swedish Industrial Efficiency conference was arranged for the second time. The conference settled that analysis of available data can be of great help to increase efficiency and effectiveness. As an example of this, new trains, now being delivered by Bombardier Transportation, are monitored and analysed using technology from SICS. Bombardier estimates that savings in the order of 5–10% can be made in maintenance cost reduction. Moreover, in 2011 SICS became a partner in a 12.9 M€ European research project, called ATAC. The project focuses on automated testing for software-intensive industry, which can significantly reduce costs due to quality assurance.

Rethinking Code Generation in Compilers

SICS, Ericsson, and KTH collaborate to improve code generation in compilers by using constraint programming as a state-of-the-art method for solving combinatorial optimization problems.

Code generation has tremendous impact on the resulting code’s quality; optimal assembly code can be several times more efficient than naive assembly code. However, combinatorial optimization techniques for code generation are typically dismissed as non-scalable. Instead, traditional optimizing compilers compromise code quality by decomposing code generation into separate stages that use heuristic approximation algorithms.

The project, called Unison, takes a radical departure from staged and approximative compilation. In Unison, the various tasks are translated into combinatorial problems that are then solved by constraint programming as a state-of-the-art method for solving combinatorial (optimization) problems. The two essential goals are:

- Achieving both robustness (the compiler can generate code for even the most complex programs) and possibly optimality with the very same combinatorial problems.
- Delivering a simple, correct, and good compiler for ever more complicated and rapidly changing hardware architectures.

The project has developed models that work for a wide array of hardware architectures. These models capture all aspects of code generation: instruction scheduling, register allocation, instruction selection, and instruction bundling for VLIW architectures. Solving the generated models establishes a robust baseline for parts of the standard SPEC CINT2006 program suite (including programs such as bzip2 and gcc). For the platform-independent part, Unison uses the state-of-the-art LLVM compiler infrastructure.

The project is funded by Ericsson, and from 2012 also by the Swedish Research Council.

www.sics.se/projects/unison
SICStus Prolog is a workhorse in the transport and logistics industries, running systems that handle a third of all airline tickets, and helping railways to operate their trains better. Sales of SICStus Prolog rose by 35% in 2011.

Transport and logistics is one of the big applications for SICStus Prolog. In other languages, you express what should be done. By contrast, a Prolog program defines a set of facts and rules, and lets the Prolog engine compute the correct answer. In the case of airline ticketing, there are rules for which airlines offer good prices to passengers from other airlines, how much time is needed for a connecting flight depending on the airport, terminal, time of day, etc. In effect, the Prolog system is used as an engine to process rules, and the programming of the system is greatly simplified.

“Most people probably have used SICStus Prolog without knowing it,” says Mats Carlsson, its lead developer. “One of our customers runs a flight booking system on SICStus which handles nearly a third of all airline tickets in the world.”

SICStus also has an extension for constraint programming, which is used to compute a set of possible solutions to a given problem. This is often used as one of the steps in an optimization process. This has been used by Tacton Systems, itself a spin-off from SICS, to build sales configuration systems for complex products such as industrial electrical engines and forklifts. Another application for the combined use of Prolog and constraint programming is SICS’ own work in the railway sector (see pages 26–27), where it has been used to reduce the need for locomotives and to optimize track utilization.

Another application for SICStus Prolog is natural language processing. NASA uses SICStus Prolog for a voice-controlled system onboard the International Space Station, ISS.
Based on collaboration work with Ericsson and Telia, SICS has developed a concept of probabilistic management for networked systems, in which decisions are based on probabilistic objectives and richer statistical monitoring information rather than on strict performance guarantees and measurements.

With the growing complexity of networked systems, consisting of millions of network elements operating under highly dynamic and unpredictable conditions, it is becoming increasingly apparent that future network management techniques must begin to address the inherent uncertainty in these networks. To make it possible to efficiently manage this uncertainty, SICS has developed the concept of probabilistic network management, where decisions are based on probabilistic objectives and richer statistical monitoring information rather than on strict performance guarantees and measurements. The work is based on results from projects in collaboration with Ericsson and Telia, and developed together with Cisco, California.

These probabilistic management approaches can be significantly more resource-efficient than deterministic ones, both due to the richer monitoring information and the flexibility of the probabilistic goals. Utilizing a consistent description of network state and its uncertainties, they enable better control and balancing of resources. By using the flexibility provided by the use of probabilistic objectives rather than deterministic ones, which often assume worst-case scenarios, the amount of resources consumed by the solutions can also be significantly reduced.

Probabilistic management approaches will change the way networks are configured, as goals can be stated as acceptable probability distributions over performance metrics, allowing for explicit control of uncertainties. Operators also benefit from getting a better understanding of where the uncertainties are in their networks and their consequences. In short, probabilistic approaches enable explicit management of uncertainty and noise in networked systems.

SICS is currently in the front line of studying the benefits and effects of adopting a systematic probabilistic approach to network management, while in close collaboration with Ericsson developing specific applications in the context of cloud computing, network virtualization, and next generation mobile access networks.

www.sics.se/projects/probman
SICS researchers have developed a new method to predict delays in train traffic. With the use of traffic history based on GPS data and probabilistic calculations it is possible to estimate, with good precision, when the trains will arrive and change of trains can be made.

It has not escaped anyone that train traffic is depending on weather and other factors that are hard to predict. Still, so far, Trafikverket (the Swedish Transport Administration) has had no tool to estimate arrival time with any precision. SICS has addressed this challenge and developed a new method which will make it much easier to know when a train can be expected to arrive and passengers and cargo can be delivered.

When the train is on its route, every new position given by the GPS on the train, narrows the span of time when the train can be expected to arrive at the stations along the route. Making such information more reliable, precise and available is of high value for traffic control, train operators, cargo customers and passengers. Cargo customers and passengers can for instance get the information through an app and Trafikverket can use it for a number of purposes. A specific goal of the project is to support train dispatchers with information, such as the trains estimated future progression, the uncertainty in the trains future positions and the risks of spread of delays.

The approach to use historical data for building statistical models of train behaviours is new for making train traffic prognosis. The project has developed a method that compares the current traffic situation with historical data and estimates a continuous future traffic development together with an uncertainty at some given risk level.

Besides prognosis this could also be a means to support time tabling, detect anomalous train movements, comparing different dispatching measures and warn when an unwanted event is at risk. The predictions do not only apply to normal situations. Also in severely disrupted situations, such as a downed overhead line, the approach may prove successful.
SICS has developed a prototype tool for automatic optimized shunting yard planning. This tool could not only improve shunting yard efficiency, but also make the planning process transparent and allow for scenario-planning and capacity investigations.

Efficient and qualitative freight transportations are essential for the Swedish industry. Hundreds of trains transport goods between a large number of origins and destinations on a daily basis. To cater for all origin-destination pairs, trains are assembled at certain yards where their cars are re-combined into new trains. This process is called shunting, and it often constitutes the bottle-neck of the freight system.

Hallsberg is the largest shunting yard in Sweden, and approximately 400 cars are sorted here each day. As opposed to many other countries, a booking system is used in Sweden, and transport buyers can book car-space on particular trains. Finding a shunting schedule that ensures every car departs with its booked train is a very complex problem, and failing to solve it will result in trains being delayed or cars missing their booked trains.

SICS has, together with ETH Zürich and RWTH Aachen, developed a prototype tool for automatic optimized planning of the Hallsberg yard. The tool is based on a Mixed Integer Programming model, minimizing the number of times the cars are rolled over the shunting-hump, and heuristic pre-processing steps. Currently a feasible week-long shunting schedule ignoring the car order within the departing trains can be found and graphically displayed in a few minutes.

Tools like this could not only improve shunting yard efficiency, but also make the planning process transparent to all involved parties, which is important as many freight operators share shunting facilities. Further, the tool allows for scenario-planning and capacity investigations, which could support decision making when it comes to e.g. capacity investments. Also, as more European countries are currently looking into the possibility of implementing booking systems, the developed models and prototypes could not have come at a more appropriate time.

Sara Gestrelius and her colleagues at SICS have developed a tool for automatic optimized shunting yard planning.

www.sics.se/projects/ranplan
Architecture: a Key to Evolution of Software-based Systems

Most industrial software-intensive systems have a very long life span, and undergo many changes after their initial conception. To ensure that they maintain the desired system-level properties, it is essential that their architecture is also updated to reflect the added functionality. Researchers at SICS have developed several techniques that can help companies improve their architecting practices, in particular for embedded systems.

Research shows that many companies are immature when it comes to architecting, and lack structured methods and processes. This is in particular true for handling the evolution that occurs in many systems. Therefore, SICS together with Mälardalen University and industrial partners, have developed several methods that can assist companies in improving their architectures:

- The Evolutionary Architecture Maturity Model lets an organization rapidly assess its current practices, and provides a roadmap for improvement.
- The Evolutionary Architecting Process is a blueprint process that can be taken as a starting point for making architecting a structured activity.
- The Architecture Life-Cycle Effect Analysis is a tool for analyzing the pros and cons of a particular architecture proposal, taking all the product’s life-cycle phases into account.

In addition to this, we have developed guidelines and methods for modeling the architecture of embedded systems from different perspectives, which is a key activity to allow structured analysis.

These research results have also been applied in practice. One example is a propulsion control system for trains at Bombardier Transportation. This is a large, distributed real-time safety-critical system which supports a wide variety of train types, meaning that adaptability to changing requirements is a key feature of the architecture.
In 2011 a new lab started at SICS, marking a new important research focus of the institute: The Software and Systems Engineering Laboratory. The lab focuses on successful development of software-based systems for the information society.

Jakob Axelsson, the director of the new lab, explains: “We provide knowledge and services in areas such as systems architecture, process development, and quality assurance. An underlying theme is ways of handling increasing complexity. Our projects span from helping large industrial companies to develop the next generation of a mature system to issues caused by new technologies such as federated embedded systems-of-systems, over systemic issues related to the deployment of systems in society. In all these situations, we often come across ‘wicked problems’ with no clear definition and no right or wrong answer, which lead to challenging new research questions. We also create co-operation opportunities among our partners, in particular through the industry initiative Swedsoft, which is hosted at the laboratory.”

www.sics.se/groups/SSE
In the summer of 2011, during the Saami reindeer calf marking, SICS and the Skuolla Internet Café project deployed a Delay Tolerant Networking (DTN) system in the Skuolla valley in Swedish Lapland.

Lapland is very remote and lacks access to traditional communication infrastructure, requiring special technology to provide network access. Past projects have worked with the same group of people to design and build a DTN system for that region to provide Internet connectivity. This project built on the work and experience from those projects, and brought in competence about the new networking paradigm Information Centric Networking (ICN). The researchers extended the previous work and also considered how the concepts of DTN and ICN can be combined to enhance the experience for the reindeer herding families, allowing them to stay connected, while still embracing their cultural heritage of reindeer husbandry.

The project developed software for on-demand video distribution in challenged environments. As communication opportunities are few and bandwidth scarce, it is important that the same data (e.g., the same video program) is not sent multiple times over the same link. Leveraging ideas from the ICN paradigm to the protocols used in DTNs, the researchers were able to use the store-carry-and-forward nature of DTNs to cache data and reduce resource waste.

Previous experience with this user group has shown that social networking services are much desired in this environment. Therefore, a Facebook over DTN gateway, that allows users to access their Facebook information and post updates over the DTN connection, was also implemented. This service was very popular among the users (especially the younger ones).

Deploying a communication system like this in a real challenged environment, allowed the researchers to identify issues that do not appear in lab tests, making the final system more robust for use in real situations. Furthermore, collaboration with real system end-users ensures that their needs can be met and cultural and practical considerations are not overlooked.

The project was carried out in collaboration with Trinity College Dublin and Tannak AB. Financial support came from the SAIL FP7 EU project and the .SE Internet Fund.

www.sics.se/projects/SAIL
“The Center has successfully built a platform for collaboration across companies, academia and the research institute SICS.” These words summarized the Scientific Advisory Board’s annual evaluation of SICS Center for Networked Systems, in November 2011.

2012 will be the last year of the Center’s six years lifetime. The results have been many. In 2011 Ericsson filed a patent on self-configuration of tracking area lists with optimized paging in cellular mobile networks. The research within the center on information-centric networking (ICN) has contributed to standardization in the IETF and its research branch. New business opportunities have emerged. T2 Data, for example, has initiated a new collaboration with SICS spin-off company Telcred through the center.

“The Center is important for the industry,” says Kjell Svensson, Director Portfolio Management at Saab and Chair of the SICS CNS Board. “We get insights in the latest findings in the research community and new ideas for our product development without doing all the investment work ourselves. The innovative networking between the partners involved in the Center is also an important bonus. Several opportunities for further collaboration constellations have been identified.”

A project started in 2011, called Trustworthy networked platforms, is increasingly relevant for ABB, which has lead to greater involvement and expectations for 2012. ABB is also involved in the project Standard-based Networked Embedded Systems, and is very positive about the work on localization that has been initiated during 2011.

“The Center research on visualization has direct impact on ABBs products,” says Mikael Gidlund, Global Research Area Coordinator at ABB. “It has resulted in more efficient maintenance through the ability to efficiently search through logs and more easily identify problems.”

During 2011, T2 Data has participated in the Trustworthy Networked Platforms project. The goals of the project matches T2 Data’s interests and the participation in the project will strengthen research and development of T2 Data’s products. Results from this period can be identified in T2 Data’s security product that is now offered to multiple computer architectures. Furthermore T2 Data’s patented embedded security solution will expand and develop towards cloud and virtualization.

“The Center is strategically important for the company in terms of research, interaction with industry partners, business development and marketing,” says Ronny Engelin, Vice President at T2 Data.

Another outcome of the center is that Anders Gunnar, who defended his Ph.D. thesis as a SICS researcher in spring 2011, joined CNS partner Saab, where he now develops tactical routers for military radio communication networks. Many of the problems these networks face can be addressed by results from research activities in CNS.

www.sics.se/cns
The paradigm shift to information-centric networking (ICN) implies that you access named data as opposed to accessing data from named devices. The ICN architecture developed by SICS and partners makes the global network infrastructure cope with vastly increasing traffic volumes by integrating storage for caching in the network infrastructure.

The concept of information-centric networking is a significant result from several international research projects on the future internet. This work is motivated by the challenges from advanced media applications which drive a never-ending increase in traffic volumes—especially given the proliferation of networked devices and things in the Internet of Things, which already by far outnumber the amount of people on the Internet.

The principal paradigm of ICN is accessing named data objects. In contrast, the paradigm of current networks is conversations between named devices (servers, PCs, mobile handsets, etc.). Information-centric networks have a receiver-driven communication model where storage for caching is integrated in the network infrastructure, resulting in a network that is more efficient for large-scale media distribution and that is more resilient to disruptions and other network failures.

(Cont.)
The ICN architecture developed by SICS and partners is called Network of Information. The major components are:

- A naming scheme for data objects consisting of two components: authority and label.
- A hybrid name resolution and routing scheme for the naming scheme where the authority field is used to look up a set of routing hints that then are used to route requests towards available copies of the named data object.
- Security functions that tie the object names to the content, making it possible to trust a copy received from an untrusted server.
- Packet-level forwarding that make use of in-network caching to efficiently distribute named data objects to multiple receivers.

Together these features lead to a network infrastructure better adapted to media applications which dominate network traffic.

www.sics.se/projects/netinf

Cloud Solutions for Data-intensive Computing

SICS leads the work on computational storage in Vision Cloud, a European project on cloud computing. The novel storage and computational infrastructure is designed to meet the challenge of providing for tomorrow’s data-intensive services.

The two most important trends in information technology today are the increasing proliferation of data-intensive services and the digital convergence of telco, media and information and communication technology (ICT). A growing number of services aggregate, analyze and stream rich data to service consumers over the Internet. We see the inevitability of media, telecommunications and ICT services becoming merged into one operating platform, where content and ICT resources (including storage, network, and computing) are integrated to provide value-added services to users. The growing number, scale, variety and sophistication of data-intensive services imposes demanding requirements that cannot be met using today’s computing technologies. There is the need to simultaneously service millions of users, accommodate the rapid growth of services and the sheer volume of data, while at the same time providing high availability, low maintenance costs and efficient resource utilization.

The two critical ingredients to deliver converged data-intensive services are the storage infrastructure and the computational infrastructure. SICS participates in the project Vision Cloud which is developing a distributed and federated cloud architecture and reference implementation. SICS provides an architected solution where storage and computation are tightly coordinated and designed to work together, maximizing data locality, minimizing network traffic and providing for good and flexible utilization of resources. Use cases are taken from the domain of telco, media, health, and business intelligence.

The storage service encapsulates objects together with their metadata. Metadata is used by many different actors at various levels. The metadata of a data object characterizes the object from different points of view. The storage service also offers search facilities whereby objects with given metadata tags and values may be found. The computational model is storage-system aware, computations may be triggered by metadata changes, and may be used to analyze uploaded storage objects, tagging them with the appropriate metadata for that particular content. One example is a transcoding function which—once defined and uploaded into the cloud—can on-the-fly transcode video sequences for specific device formats upon data access.

www.sics.se/project/vision
Together with Ericsson, SICS addressed the security issues of the Infrastructure-as-a-Service cloud computing model by researching novel principles for secure launch and migration of virtual machines in the cloud.

In recent years, there has been a tendency to migrate IT services into the cloud due to cost and maintenance benefits. Several different cloud sourcing models exist. According to a common business principle, the cloud consumer is able to deploy full software systems (including the operating system) on a shared common infrastructure. This is often referred to as the Infrastructure-as-a-Service (IaaS) cloud computing model. One major obstacle for the IaaS model is the lack of security guarantees when moving a service to an IaaS cloud.

Together with Ericsson, SICS addressed the IaaS security issues by researching novel principles for secure launch and migration of virtual machines (VMs) in the cloud. The developed protocols are built upon trusted computing technologies and allow a user to securely bind the VM to a trusted computer configuration in such a way that the clear text VM (non-encrypted) only will be available to run on a platform that has been booted into a trustworthy state. This capability builds user confidence and can serve as an important enabler for creating trust in a public cloud.

The joint SICS and Ericsson, VINNOVA financed, project on trust in cloud computing started in early 2010. A careful analysis of existing solutions for securing virtualized platforms was done and major security research challenges in cloud computing were identified. A first system design for secure launch of virtual machines was then presented. In spring 2011, this design was verified in a prototype system implemented on an Ericsson commercial platform (GEP3). The prototype shows secure launch of a virtual machine protected with the help of a tamper resistant trusted platform module. Next, the project continued with enhancing the design covering secure VM migration as well. The research team has the final goal of creating a solution compatible with the open source cloud software OpenStack.

www.sics.se/projects/TESPEVS
Pic-In is a new concept app, which combines crowdsourcing and sensor-data. It allows you to check-in on the location-sharing service foursquare by simply taking a picture, and the service will recognize where you are.

The Mobile 2.0 project at the Mobile Life Centre is interested in location-sharing services, location-sharing practices, and location-sharing user experiences. After studies on how people use location-sharing services such as Foursquare, they have also looked at the experience of the check-in process. In a previous project, 2D-barcodes were printed and set up at venues to be scanned in order to check in. This requires an infrastructure of barcodes before it is useful and comes with concerns for owners of public venues. Although it allows for a faster check-in process, the next project tries to get rid of the need for these barcodes all together.

Pic-In allows you to check-in on the location-sharing service foursquare by simply taking a picture. Your venue is recognized based on your photo and your mobile phone's position. The traditional way of checking in can sometimes be a time consuming task. You normally get a list of nearby venues, and if you are lucky the venue you are at is the one on the top. When it is not however, you need to search for the list, or type in a query to search manually for the venue. With Pic-in, all you have to do is take a picture, and the service will recognize where you are.

Pic-In is one of Mobile Life’s new concept apps, and combines crowdsourcing and sensor-data. If the venue you take a picture of is not recognized, the server will learn so that the next time you go to the venue, it will be recognized. The server needs the photos submitted by users, with which new photos taken are compared to the database to recognize the venue. This in combination with your location helps determine where you are, and the venue is recognized.

Pic-In shows the potential of using computer vision techniques in mobile applications to create new user experiences, and usage of the mobile camera as a sensor to detect objects and places.

In May 2011 Pic-In was awarded third price in the Ericsson Application Awards. Ericsson Application Awards is a student and company competition where Ericsson wants to see new concepts realized using enablers of their technologies. SICS entered Pic-In in the company category and ended up on third place!
Mobile Life – a Research Center with a ‘Wow’ Factor

The Mobile Life Centre was founded in 2007. In 2011 the activities at Mobile Life Centre were evaluated by an international team of both scientific experts and generalist evaluators. They remarked that the center has to “be congratulated on its interdisciplinary and innovative research ideas. The research environment appears to be excellent for nurturing and mentoring junior researchers and establishing senior researchers as international leaders”.

Ericsson is one of the partners in the Mobile Life Centre and, Martin Körling was chair of the board until October 2011: “There are many very important reasons for us to be involved in the Mobile Life Centre. Ericsson is a key player within mobility, and for us the center provides important feedback in terms of our development in that area,” he says.

“This collaboration has given us both knowledge and inspiration. The collaboration also plays an important role in our development with our increased focus on end-users that are important to Ericsson, and we need to have a competent partner to discuss these issues.”

www.sics.se/mobilelife

Nature – a Source for Design

Human beings are a part of nature. Nature can be total perfection into the smallest structure, but it can also be ugly and disgusting with rotten wood and smelly soil, just as we are as human beings. SICS researchers use nature for inspiration in their design of technology for people.

Nature as a source does not aim at one specific solution but it has several purposes: It can be used for problem solving, as inspiration in specific form-giving tasks and simply to free your mind. Researchers at the Mobile Life Centre do part of their design work, such as workshops, reflection, and ideation, in nature to become part of its ever changing body, move through the scenery, and play around with experiences of touching, feeling, smelling and listening.

From the work they have done using nature as a source for design it has been obvious that it affects the outcome in a positive way. EcoFriends, on the opposite page, is one of the projects where this has been helpful.
The Ecofriends application was designed to engage people in reflecting on their everyday grocery shopping from social and ecological perspectives.

Ecofriends portrays the season of various groceries as socially constructed, emphasizing subjective dimensions of what it means for a product to be in season, rather than attempting to communicate it as an established fact. It provides the user with unexpected information (news, weather, blog posts and tweets) about the place where the product was grown, and visualizes how the product’s popularity shifts throughout the year, among the user’s friends, among chefs and other food experts, and among the general public. Some key findings from users’ first encounters with the system are presented. In particular aspects of trust, sense of place, and how several of the participants were provoked by the system’s portrayal of season have been discussed.
Efficient Safety Alarms

The project “Efficient safety alarms” approaches the safety alarm area from a broad usage perspective. A goal is to understand needs among different user groups such as elderly, relatives and care giving organizations at the municipalities and Emergency centers. Companies developing the alarms are also included in the project.

This project is a cooperation between SICS and a number of Swedish municipalities. The project has its starting point in that many existing solutions today do not meet the demands the users have. For example, in many cases the same alarm is used for calling for help with everyday tasks as for calling for help in emergency situations. This leads to a fear that emergency situations will not be taken seriously. In addition many of the alarms lack feedback to the caretaker regarding if an alarm actually has been received at the alarm center or not. Finally, most of the alarms are only for indoor usage, which further contributes to the isolation among older people.

The project’s objective is to investigate needs and demands on existing and future safety alarms. The project will result in a list of requirements regarding functionality of safety alarms. The list could be used by municipalities when purchasing alarms, and also by companies developing safety alarm solutions.

The project also addresses questions such as differences between municipalities, and between different contexts regarding demands on safety alarms. Further, the project will investigate demands between different groups of users, and how safety alarms can be adjusted to fit different stages of the ageing process. As privacy aspects are an important aspect in the use of safety alarms, this issue is also included in the work.

The project is funded by Länsförsäkringsbolagens forskningsfond.

www.sics.se/projects/trygg
Home Treatment of Patients with Chronic Respiratory Insufficiency

SICS leads a project making a telemedicine solution for treatment of COPD patients at home happen in reality. All aspects such as technical implementation, economic viability, medical processes, as well as acceptance of new technology by the patients and medical professionals, are taken into consideration.

COPD, Chronic Respiratory Insufficiency, (KOL in Swedish) is a lung disease causing severe suffering for the patient. 700,000 people suffer from the disease in Sweden and it is very costly for Swedish society: 9 Billion SEK annually. A small portion of the patients is associated with a large part of the cost.

Significant improvements for the lung clinic and for the patients could be attained if a telemedicine solution for treatment of oxygen patients at home could be introduced. This means introducing measurements at home and a distant control of, for instance, oxygen equipment. The solution also includes video communication between the patient at home and the care giving lung clinic.

In this project, all aspects of a telemedicine solution—practical, technical, economical and patient related—are taken into account, leading to a broad implementation. To develop and get acceptance from all parties on telemedicine solutions many areas need to be investigated, modified and integrated. A secure communication solution from the home to hospital needs to be introduced. Further, the solution needs to be integrated into the hospital system together with modified clinical processes. The right parameters need to be measured at home in an efficient and acceptable way for the patients. Quality of life, in conjunction with introducing new technology for the patients, needs to be studied.

A consortium of different actors is gathered in this project. Medical doctors at the Lung Clinic at Karolinska University Hospital are part of the project and participate as problem owners. The patient organization Hjärt- och Lungsjukas Riksförbund is part of the project as requirement owners. Altogether the group has all the expertise needed to develop a total solution with the patient in the center. The solution will be altered for different home care situations and for other community services as well. New research will be included in the project and results and experiences from other projects will be taken into account.

www.sics.se/projects/kol
Experiences from Twelve Step programs for alcoholism recovery may be the key for understanding how we can use mobile technology to support people in maintaining a lifestyle change for life.

Many of us would like to make changes in our lifestyles, be it to exercise more, eat healthier, or be a more organized person. It does not sound too hard and we basically know how to do it. Still, most New Year’s resolutions about diets and running fail miserably before the end of January.

Lifestyle change is a continuous work that is carried out in all kinds of situations in life. It does not end when we have decided to make a change, taken the first steps toward our goal, or even created a new stable habit. To reap the benefit of a lasting lifestyle change the work continues. Therefore mobile services and devices are excellent tools to help us in this work, since we carry them almost everywhere.

In this project, SICS researchers wanted to learn how mobile technology can be used to support people in maintaining a lifestyle change over years or even a lifetime. To get inspiration for this, a number of people were interviewed, who have managed to make significant changes in their lives and keep that change up for many years. Eight people, who were recovering in Twelve Step programs, were recruited and asked about their recovery work.

Their stories told about the importance of routines and how to fit routines into their everyday life, how they found motivation in their recovery work from listening to others, sharing their recovery stories, and helping others to recover, as well as how they dealt with stressful situations and risks for relapses.

Based on these interviews the researchers will look further into two themes: routines and stressful situations. For routines they will explore how to create support for reflection to help users think about their routines and how they fit into everyday life. Since lifestyle change might take place over years, life will change and routines have to change with it. For stressful situations they will explore various forms of individual expression and sharing to support people in breaking negative patterns.

www.sics.se/projects/tolv
What Can We Learn from Twelve Step Recovery?
# Financial Report

## Statement of Profit and Loss, KSEK

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2010</th>
<th>2009</th>
<th>2008</th>
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<tr>
<td><strong>Income</strong></td>
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<td></td>
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<tr>
<td>Net Sales</td>
<td>117,800</td>
<td>109,157</td>
<td>100,744</td>
<td>91,88</td>
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<tr>
<td>Other operating income</td>
<td>0</td>
<td>201</td>
<td>801</td>
<td>1359</td>
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<tr>
<td><strong>TOTAL INCOME</strong></td>
<td>117,800</td>
<td>109,358</td>
<td>101,545</td>
<td>92,547</td>
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<td><strong>Operating expenses</strong></td>
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<tr>
<td>Other external costs</td>
<td>-36,034</td>
<td>-29,867</td>
<td>-26,642</td>
<td>-27,883</td>
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<tr>
<td>Personnel</td>
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<td>-77,924</td>
<td>-74,536</td>
<td>-64,386</td>
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<tr>
<td>Depreciation and write-downs of tangible assets</td>
<td>-630</td>
<td>-545</td>
<td>-382</td>
<td>-304</td>
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<td><strong>Operating profit/loss</strong></td>
<td>-1,982</td>
<td>1,022</td>
<td>-15</td>
<td>-26</td>
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<td>Result from financial investments</td>
<td>3,531</td>
<td>136</td>
<td>323</td>
<td>1,266</td>
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<td>Profit after financial items</td>
<td>1,549</td>
<td>1,158</td>
<td>308</td>
<td>1,240</td>
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<tr>
<td>Other taxes</td>
<td>-589</td>
<td>-383</td>
<td>-183</td>
<td>-317</td>
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<tr>
<td><strong>NET PROFIT FOR THE YEAR</strong></td>
<td>960</td>
<td>775</td>
<td>125</td>
<td>923</td>
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</table>

## Balance Sheet, KSEK

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>ASSETS</strong></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Fixed Assets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tangible assets (machinery)</td>
<td>1,409</td>
<td>1,227</td>
<td>1,405</td>
<td>276</td>
</tr>
<tr>
<td>Financial Assets</td>
<td>146</td>
<td>162</td>
<td>209</td>
<td>351</td>
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<tr>
<td><strong>Total fixed assets</strong></td>
<td>1,555</td>
<td>1,389</td>
<td>1,614</td>
<td>1,627</td>
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<tr>
<td>Current assets</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Ongoing projects</td>
<td>19,297</td>
<td>12,542</td>
<td>5,517</td>
<td>7,878</td>
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<tr>
<td>Current receivables</td>
<td>33,144</td>
<td>16,523</td>
<td>18,051</td>
<td>13,759</td>
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<tr>
<td>Short-term investments</td>
<td>0</td>
<td>21,019</td>
<td>21,019</td>
<td>6,000</td>
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<tr>
<td>Cash and bank deposits</td>
<td>40,429</td>
<td>35,275</td>
<td>24,890</td>
<td>39,902</td>
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<tr>
<td><strong>Total current assets</strong></td>
<td>92,870</td>
<td>85,359</td>
<td>69,477</td>
<td>67,539</td>
</tr>
<tr>
<td><strong>TOTAL ASSETS</strong></td>
<td>94,425</td>
<td>86,748</td>
<td>71,091</td>
<td>69,166</td>
</tr>
</tbody>
</table>

## EQUITY AND LIABILITIES

|                      |              |              |              |              |
| Equity               |              |              |              |              |
| Share capital        | 100          | 100          | 100          | 100          |
| Statutory reserve    | 21,908       | 21,908       | 21,908       | 21,908       |
| Profit brought forward| 3,097 | 2,321 | 2,197 | 1,274 |
| Profit for the year  | 960          | 775          | 125          | 923          |
| **Total Equity**     | 26,065       | 25,104       | 24,330       | 24,205       |
| Current liabilities  | 68,360       | 61,644       | 46,761       | 44,961       |
| **TOTAL EQUITY AND LIABILITIES** | 94,425 | 86,748 | 71,091 | 69,166 |
| Employees, full-time equivalent heads | 99 | 96 | 86 | 86 |
Facts & Organization

Basic Facts
In December 2011 SICS had 120 employees, (99 full-time equivalents; 48 PhDs). The turnover was 118 million SEK. The organization’s head office is located in Kista (Stockholm) and there are smaller offices in Uppsala, Lund, and Västerås. SICS’ core research is financed by the SICS industrial partners in FDF (below) and the Swedish government through Rise Holding AB. The main sources of competitive project funding are currently the Swedish Agency for Innovation Systems (VINNOVA), the Swedish Foundation for Strategic Research, and the European Commission.

SICS is a core partner of the European Institute of Innovation and Technology, EIT ICT Labs

Industrial Partners
About 30% of SICS’ research is financed by the industry, including contributions from SICS’ industrial partner association, FDF. Members of FDF in 2012 are:

• ABB
• Bombardier
• Ericsson
• Swedish Defense Materiel Administration (FMV)
• Green Cargo
• Saab Systems
• TeliaSonera

Other notable customers over the year were the Swedish Transport Administration, the Swedish Coast Guard, and a number of Swedish SMEs.

Organization
SICS is jointly owned by Swedish industry and the Swedish government through Swedish ICT Research. Swedish ICT Research also includes Acreo, Interactive Institute, Imego, and Viktoria Institute. SICS is in turn the parent company of Santa Anna IT Research Institute in Linköping and the new subsidiary SICS Swedish ICT Västerås.

SICS participates in three Excellence Centers
• SICS Center for Networked Systems (led by SICS)
• Mobile Life (led by Stockholm University)
• Wisenet (led by Uppsala University)

Directors of the Board 2011
Hans Hentzell, Swedish ICT Research (Chairman)
Olle Viktorsson, Ericsson
Göran Olofsson, TeliaSonera
Kjell Svensson, Saab Systems
Gunnar Hult, FMV (deputy)
Viesturs Vucins
Maria Yregård, Cap Gemini
Agnete Jacobson, Ivar Jacobson International
Jonas Söderberg (staff representative)
Gunnar Eriksson (staff representative)

Contact
Managing Director: Christer Norström
Chief Scientific Advisor: Seif Haridi
Business Manager: Janusz Launberg/Niklas Rudemo
Financial Manager: Charlotte Jörsäter
Communication Manager: Kersti Hedman

Production: Kersti Hedman
Photos by Joel Höglund on pages: 1, 3, 5, 8 left, 9 left, 10, 11, 12, 14, 16, 18, 23, 29, 31, 33.
Photos by Mikael Röör on pages: 4, 28, 36, 43
Graphic Design: Grace Communication
EXCELLENT AND RELEVANT
SICS is Sweden’s leading industrial research institute for applied information and communication technologies. SICS is a non-profit organization, with the purpose of developing technology for companies operating in Sweden, to contribute to their global competitiveness.

FOCUS AREAS
• User-driven services and products
• The future Internet
• Industrial systems
• Software and systems

OFFER
• Expert assignments and contract research
• Joint public-funded research projects
• Participation in SICS centers
• Seminars
• Courses in cooperation with seats of learning

CONTACT
Christer Norström, cn@sics.se
Niklas Rudemo, niklas@sics.se