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Internet of Things, a Chance for Sweden

Everything is being integrated. The pace of developments in IT never slows down. In recent years, we have seen mobile Internet explode, and thus also the smart mobile phones with the associated flora of services.

I gave a lecture on Open Innovation for Swedsoft companies in May 2008, with the iPhone infrastructure as an exciting example. At the time, there were about 1,600 apps for the iPhone. Today there are hundreds of thousands of apps for both iPhone and Android.

What we now see coming with full force is the next step, the Internet of Things, that is, that even gadgets will be online. The word Things can be misleading, because these gadgets will also get into the social context, like Facebook. The challenge is obviously how we create an infrastructure to both develop, integrate and sell these applications in a simple manner, as we do with apps or webpages. The infrastructure will require us to manage mobile gadgets, tremendous data streams, data storage, analysis and information extraction from the huge amounts of data involved, and to easily build services. A research problem and business opportunity, when we are now talking about millions of sensors and associated data, are also security and privacy issues.

Sweden has to seize the business opportunities of the Internet of Things to remain competitive. Since SICS leads research development in Sweden in this area, we will together with our parent company, Swedish ICT, and IVA initiate a major investment in the exploitation of new technologies in both start-up businesses and existing sectors.

Within SICS we are increasing the focus on sensor networks, cloud computing and Big Data, data analysis, mobile services and software development support for these types of systems. We emphasize interdisciplinary cutting-edge research to create industrial value and new business that is good for Sweden.

Another noticeable change in direction for SICS, is that we have enhanced our cooperation with our industrial partners, including Ericsson, Saab and Bombardier – something we will continue to do in the future.
The Internet of Things Initiative

Over the next ten years the Internet of Things will happen and it will change our lives. Ericsson sees 50 billion new mobile connections by 2020 from the Internet of Things. Investments are already counted in billions of Euros worldwide and analysis see a number of emerging markets. Through companies such as Ericsson and research from SICS, Sweden is at the forefront of this development. We now have a unique opportunity to take the lead.

The Internet of Things technology spans several research disciplines. At the device level, power-efficient hardware and software is needed. At the network level, efficient communication protocols are required. In the cloud, new infrastructure technology for processing large volumes of data must be installed. For the users, the Internet of Things will bring entirely new interaction models. Thus the system as a whole prompts the development of new abstractions and concepts that can form an intellectual framing that enable new research directions.

Why Sweden?

Sweden has a unique opportunity to form close and strong relations between system developers, system integrators, and users for the Internet of Things. Compared to other markets, Sweden is open to the use of new technology to create new business.

At SICS, we have already established a strong research base on a number of areas in the Internet of Things area. SICS widely used Contiki Internet of Things operating system has pioneered many concepts now taken for granted in the Internet of Things, such as Internet Protocol-enabled low-power smart devices. SICS was one of the founders of the IPSO Alliance, one of the strong forces behind the Internet of Things. The MobileLife center has an established track record for user experience research.

Why Now?

Over the past ten years, the technology development in the IT field has accelerated. We are now at the point where anyone can be reached at anytime, anywhere. The next step is to be able to reach anything, anywhere. When the technology is available, the Internet of Things is bound to happen.

What’s Next?

The aim of the Internet of Things Initiative is to address the challenge of managing 50 billion connected things from a technical infrastructure perspective, from an application perspective, from a business model perspective, and also from a user and societal perspective. The Internet of Things Initiative gathers unique competence at the forefront of the developments in telecom, ICT, sensor networks, and user-centered design possessed by academia and industry in Kista and Sweden. Together, we strive to create new technologies, novel applications, and new usage patterns for the heterogeneous landscape of connected things, people, and services that will shape the future of our everyday life.
SICS Overview

2010

The Swedish Institute of Computer Science AB (SICS) is a research organization with the goal to contribute to the competitive strength of Swedish industry and the quality and efficiency of Swedish public sector. SICS carries out advanced and focused research in strategic areas of computer science, in close contact with Swedish and international industry and academia. The research is based on cutting-edge new technology and is stretching beyond the companies’ own R&D efforts. In 2010 SICS celebrated 25 years of customized research to the Swedish industry.

From Research to Business

SICS develops technologies and innovations in collaboration with academia and industry. SICS strives to make its research results accessible and beneficial to society and industry. This has resulted in numerous new companies, standards, networks for collaboration, and open source software, besides the main flow of direct deliverables to our customers. The constant flow of experienced researchers moving from SICS to existing and new companies contributes to the uptake of new ideas and technologies.

Cooperation with Industry

SICS is taking a range of initiatives towards closer collaboration with industry active in Sweden. We have in 2010 developed a long term plan with Ericsson, our biggest customer, and defined joint projects for the near future. New collaborations have been initiated together with Bombardier and Saab. Saab has also doubled their contribution to SICS’ basic funding.

Swedsoft, the industry network for software-intensive industry in Sweden, has developed a strategic research agenda addressing the industries’ future need (see page 13).

SICS’ increased focus towards closer collaboration
with industry have led to a significant boost in the number and volume of joint projects and research contracts. The mix of projects funded by industry comprises both relatively long-term need-driven research, and shorter-term work addressing issues of importance for the bottom line of companies, especially when working with small and midsized enterprises.

In 2010, SICS has delivered very important results to the Swedish Transport Administration concerning the planning process for timetabling of the railway traffic. The new approach to the planning process will lead to considerable savings.

SICS is active in three research centers where universities, research institutes and industry 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 industrial partners. The centers are the SICS Center for Networked Systems (led by SICS) see page 32, Mobile Life (led by Stockholm University) see page 22, and Wisenet (led by Uppsala University). A number of projects have also been run in collaboration between SICS and its sister institutes within the Swedish ICT Research group. SICS is a founding member of The Swedish Multicore Initiative, a concerted effort between Swedish software-intensive industry and academia addressing multi-core challenges and opportunities. New members are invited to take an active part.

**Cooperation with Academia**

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

Moreover, 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 2010, approximately 15 students completed their master's thesis work at SICS and 10 of SICS employees were working on their doctoral theses.

During 2010, Petra Sundström from SICS received her Ph.D. degree from the University of Stockholm. A total of 110 scientific publications were published by SICS researchers in 2010.

**International Cooperation**

SICS' research collaboration and contacts within Europe are well developed. In 2010, we participated in 20 European projects and coordinated 3 of them. SICS received the ITEA Achievement Award gold medal for a “highly successful project with outstanding contributions” (see page 29). The project, which was coordinated by SICS and carried out with a consortium including ABB Corporate Research, was awarded for its combination of cutting-edge research and industrial value.

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 a new initiative aiming at turning Europe into the global leader in ICT innovation. There is collaboration with India and China as well. Currently we have two projects with Indian and one with Chinese researchers.

**Corporate Social Responsibility**

During 2010, a policy for the CSR of SICS has been produced. Apart from minimizing our own footprint and working on the social aspects of employment at SICS, we strive to take social responsibility through the actual research. Sustainability is in focus for several research projects and so is privacy and ethical aspects of the tools we provide for the future.

**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 acknowledges a responsibility to be part of the public debate, as experts in identifying possibilities and threats with new ICT. SICS researchers participate in courses, seminars and committees, and are often invited to speak to companies and at public events. SICS’ employees are frequently interviewed in media; in 2010, SICS featured in the Swedish and international media with more than 45 articles and several radio and TV appearances. Kristina Höök was one of the speakers in the Swedish delegation's trip to Beijing and
Mobile Mashups the Next Thing

In May 2010 Lars Erik Holmquist published an article about future mobile services, “The Age of the Mobile Mash-Up”, in TechCrunch, a leading technology blog with more than 10 million readers. The article argues that in the future, many mobile services will be “mash-ups” of existing services and device APIs, implemented as HTML5 web pages.

The SpotisSquare service, developed by Mattias Rost and Henriette Cramer at SICS, is one example which combines Spotify and Foursquare to create location-based playlists.

The article drew a lot of positive response, and Lars Erik was invited to organize the closing keynote of AppNation, a new conference and expo on mobile business in San Francisco.

SICS annual Open House attracted more than 300 participants despite the fact that many were stuck in airports around the world waiting for the ash cloud to blow over.

A seminar for industry and academia was organized to present and discuss the research agenda of Swedsoft.

The annual Multicore Day, organized by SICS and the Swedish Multicore Initiative, gathered nearly 400 people.

A group of small and medium-sized companies met at their annual Sensornet Days at SICS.

IVA and Swedish ICT through SICS organized a workshop on Internet of Things within the ICT for Sweden project.

The second annual conference on Availability and Resource Efficiency in Industry was organized with participants from companies like Sandvik, Alcro-Beckers, FMV, Stora Enso, Volvo, Siemens, and AstraZeneca.

Towards the end of the year Mobile Life Industry Day was organized.

At the beginning of 2011, the first conference on Trusted Computing – Virtualization and Security was organized, which was immediately met with great interest.

Jfokus, the Java conference where SICS is one of the organizers, grew to 1200 participants at Stockholm Waterfront in February 2011.

If you are interested in SICS’ open events, please register at www.sics.se/signup.
New Meeting Points for E-Commerce and Real Estate

SICS has teamed up with Sweden’s largest project management company, Hifab, and the marketing agency Artspace to investigate the possibility of providing new meeting points, both physical and virtual, in public spaces such as airports, shopping centers and office buildings. The collaboration between IT, design and architecture encourages the development of a range of new services such as e-commerce and services for real estate stakeholders.

www.sics.se/projects/meetingpoints

Assisting Ericsson in the Telecom Capacity Race

Smartphone, tablet computer and other wireless broadband use is increasing very rapidly. With this growth follows dramatically higher requirements on telecom system capacity, which all vendors have to meet or surpass.

SICS works closely with Ericsson on exploring novel software technologies and tools for telecom system products. These may improve the capacity and energy efficiency of products, as well as the engineering efficiency of their designers.

Since 2010, previous collaboration in the 3–5 year research timeline has been complemented with shorter-term projects that seek to provide deployment paths for new technologies directly into development projects.

In these, SICS researchers are joined by colleagues from KTH, Uppsala University, and Mälardalen University, who together under the umbrella of SICS offer Ericsson a broad range of world-class expertise in advanced software technologies and tools. This way of working has proved to be very successful.
Dogan Yazar Received Bengt Asker Award for Best Master Thesis

In October 2010, Dogan Yazar received the Bengt Asker award for best MSc thesis in the area of embedded and real-time systems. The award was given at Embedded Conference Scandinavia, in Stockholm.

Dogan’s thesis, RESTful Wireless Sensor Networks, presents an implementation and evaluation of the concept of using, Representational State Transfer (REST), the architectural style of the World Wide Web, for wireless sensor networks and the Internet of Things. Dogan’s results show that a RESTful architecture is feasible and efficient for power-constrained sensor network nodes. These results are important as the field turns towards standardization and commercial adoption.

The Bengt Asker award is annually awarded by SNART, the Swedish National Real-Time Association.

A Grant for Privacy and Ethical Research

Pedro Sanches has received a personal Ph.D grant from Fundação para a Ciência e Tecnologia, a Portuguese governmental research promoting organization, to come and work at SICS. He is currently participating in privacy and ethical requirements analysis in several projects at SICS. One of the projects, in collaboration with Ericsson Research, aims for ways to refine mobile communication traffic data into patterns of human mobility, without keeping track of each individual person. Another project, with European partners, will put consumers in control of their energy consumption by networking all their physical devices, without compromising their privacy.

The overall goal is to provide designers of future ICT with a greater understanding of ethical issues that emerge or are altered by new technology.
Oscar Mines Opinions at Google

Oscar Täckström spent the summer of 2010 as an intern with Google’s research division in New York City, where he worked on research and development of methods for opinion mining.

The web is largely a huge collection of fairly unstructured information. Most of the valuable things people know are found in freely expressed language. To make use of all that information, all we need to do is come up with ways of refining it.

Consumer opinions are an example: hidden in the text of blogs and forums they are useless, but extracted and aggregated they are highly useful. This is a difficult task considering all the various ways in which opinions can be expressed. Together with researchers at Google, Oscar developed a method that greatly reduces the need for human assistance when creating systems for mining opinions. Earlier you had to show such systems examples of all the possible ways of expressing opinions. With this new method you only need to show the system a set of reviews with ratings, and it figures out how opinions are being expressed all by itself.

Oscar will be returning to Google for the summer of 2011.
Swedish ICT Center for Systems Availability and Resource Efficiency

As part of SICS and Swedish ICT’s focus on Systems Availability and Resource Efficiency, a new center was created during the fall of 2010.

Currently there is a strong development in IT for better availability, reliability and resource efficiency in industrial and transportation systems. Inexpensive sensors connected to the Internet, precise yet robust data analysis and optimization algorithms, and a rapid development of computational power, have together paved the way for optimization and business operations on an unprecedented scale. This leap in technology provides truly remarkable opportunities in industry.

The center will act as a contact platform between academia and industry, arrange workshops and courses in the area, and initiate applied research projects and pilot studies.

SICS has more than ten years of experience of applied research within advanced IT support and tools for industrial operation and maintenance.
By providing knowledge and services in areas such as system architecting, process development, and quality assurance for software-intensive products, SICS can help Swedish industry to find ways of tackling the complexity of their products. A newly established research group under direction of Professor Jakob Axelsson concentrates the available competence in this area, and aims at the forefront of research in Software and Systems Engineering in collaboration with leading universities and companies.

In many traditional industries, that used to rely on mechanical solutions, software is now at the center of innovation. These companies combine mechanics, electronics and software to yield world-class products that achieve previously unforeseen levels of performance and functionality. However, these advances come at a cost: increased complexity. This complexity leads to rapidly increasing efforts for development, and also sometimes to quality problems for the users, simply because a large number of people need to be involved in the development and communicate with each other. The research discipline of Software and Systems Engineering tries to reduce these problems by improving the structure of the systems through better interfaces, more efficient processes, and more robust solutions.

When tackling complexity, a special focus is on the early phases of development where the cornerstones of the overall solution are put in place. However, this phase is a good example of what is sometimes called a “wicked problem” that has no clear definition or no right or wrong answer. This is because in the early phases so much is uncertain about the product, and so many different aspects need to be involved. Therefore, traditional research methods, such as experiments, are difficult to apply, and instead case studies and action research is used where the researchers work hand in hand with industry on real-world problems.

The group is already involved in projects ranging from the development of the complete IT infrastructure of a new eco-friendly city district in Stockholm, called Norra Djurgårdsstaden, to the design of propulsion control systems for trains in cooperation with Bombardier. As diverse as these tasks may seem, they can be solved through a common knowledge base now being offered by SICS.
Swedish Industry has a **Software Soul**

Swedsoft continued to promote the research agenda, which was unveiled late 2009. The key findings are:

- Software development needs to be recognized as a discipline in its own right.
- Incentives need to be created for cross-fertilization between companies, between universities, and between academia and industry.
- Grants need to be dedicated to a major national software initiative.

One of Swedsoft’s key efforts was to anchor this message among the key decision makers and influencer within politics, including all Swedish members of parliament. One of the main tasks of the Swedish Minister for Information Technology, Anna-Karin Hatt, is to formulate a digital agenda for Sweden, and Swedsoft has contributed towards this. Together with its partners, IT- och Telekomföretagen and Teknikföretagen, Swedsoft is working on proposals for the research and innovation bill, which the Swedish parliament is to enact in 2012. Swedsoft participated in the Almedalen Week, a political summit.

Swedsoft continued its “Swedish Industry has a software soul” campaign, to raise awareness of the importance of software even in products and services that are traditionally not seen as software.

During 2010, Volvo AB joined Swedsoft as a member and active participant.

In April 2011, Niklas Rudemo took over as director for Swedsoft. Prior to Swedsoft, Niklas Rudemo helped build the SICS spin-off Virtutech and its product Simics into the leader in the field of full-system simulation, culminating in its successful acquisition by Intel in 2010.

www.swedsoft.se

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**Swedsoft:**
Swedsoft is an industry initiative to strengthen Swedish competitiveness with regards to research and development of software intensive systems, services, and products.

**Members:**
ABB AB, Ericsson AB, Saab AB, AB Volvo, and Arcticus Systems AB from industry, SICS, Blekinge Institute of Technology, Chalmers, the IT University of Gothenburg, Linköping University, Lund University, Mälardalen University, and Uppsala University.
Innovations and New Businesses

Over the years, many new companies have been started based on SICS research. This is a very efficient way to make use of new findings and contribute to the competitive strength of Swedish industry. Here is a selection of currently very active spin-off companies.

**Peerialism**

Peerialism develops global file storage and video streaming technologies that scale with the explosive data growth on the Internet and in corporate networks. Peerialism helps TV networks and broadband operators to distribute TV and video more efficiently.

The solutions are built on peer-to-peer technology where users’ computers contribute with broadcasting and storage capacity. Key benefits are lower distribution costs and significantly increased capacity compared to existing solutions. Peerialism’s solutions build on advanced research in overlay networks. The company was spun off from SICS in 2007, including several researchers from SICS and KTH from the team lead by Professor Seif Haridi. Peerialism has offices in Stockholm and Cairo.

www.peerialism.se

**Axiomatics**

Axiomatics is the leading supplier of entitlement management solutions. As a research spin-off from SICS with many years of research and development, the Axiomatics team has developed cutting-edge software products to help enterprises gain secure access to their digital assets.

Axiomatics provides tools with various functionalities for managing, enforcing, analyzing, and auditing access policies to support and implement life cycle management for XACML policies in healthcare, finance, and defense industries.

CEO Babak Sadighi and CTO Erik Rissanen spun off the company from SICS in 2006. In December 2010, Axiomatics won a prestigious order from one of the world’s largest banks for its XACML based authorization product suite.

www.axiomatics.com

**Tacton**

Tacton’s Product Configurator simplifies and expedites the configuration, pricing and quotation of complex products and services. Tacton Configurator is in production use by a wide spectrum of leading manufacturing companies around the world.

Tacton is based on two decades of cutting-edge R&D starting at SICS. Klas Orsvärn, now Executive Vice President, spun off the company in 1998 together with Tomas Axling, Stefan Andersson, and other co-workers. With 60 employees, Tacton is today one of the major vendors on the sales configuration market, and on the market for Knowledge Based Engineering in SolidWorks 3D CAD.

www.tacton.com

**Gavagai**

Gavagai develops and employs automated and scalable methods for retrieving actionable intelligence from dynamic data, such as textual information sources from the Internet.

The Gavagai technology automatically learns the meaning of, and association between, concepts in large dynamic data streams. Gavagai uses this information to monitor, detect, extract and predict information for the financial, security, and consumer products markets.

Gavagai was spun off from SICS in 2008 by CEO Jussi Karlgren and Chief Scientist Magnus Sahlgren. Most of the technical staff at Gavagai have previously worked at SICS.

www.gavagai.se

**Telcred**

The latest spin-off from SICS is called Telcred. Telcred develops systems for physical access control, which are based on NFC (Near Field Communication) and allows the user to gain access with an NFC-enabled mobile phone. Furthermore, Telcred’s solution has been designed to work offline, which radically reduces the cost of installation and maintenance.

Carlo Pompili, CEO, spun off the company in 2009. In 2010, Telcred received funding from VINNOVA, the Swedish agency for innovations systems, through the program “Research for growth.”

www.telcred.com
Virtutech Aquired by Intel

In 2010 one of SICS’ first spinoff companies, Virtutech, was acquired by Intel Corporation.

Virtutech was founded in 1998 by Peter Magnusson and four other SICS researchers. In February 2010, Wind River, a wholly owned subsidiary of Intel Corporation, added the Virtutech product line to its embedded software product portfolio.

Virtutech produces tools for developing and designing high-end embedded systems, including avionics and telecom equipment. Virtutech develops and markets Virtutech® Simics™, a tool that simulates a workstation, multiprocessor servers, clusters, or networks on the level of individual machine code instructions. Virtutech has offices in Sweden and in the U.S.A.

www.virtutech.com

Carlo Pompili, CEO Telcred
Research on Computers and Emotions in Line to Spin Off

Your pulse, sweat and how you move are honest reflections of your emotions. Catching these data, and reflecting the patterns back to the user, may lead to a new business.

The human body often knows what is good for you, but it is not always easy to read its signals. The recent development of more wearable bio-sensor technology has made it possible to track your body’s response to what is going on in your life, in a convenient way. This is the basic idea of Affective Health, a new service which may help you understand yourself better.

Your pulse, sweat and how you move are honest reflections of your emotions. When these data are registered for a long period of time and presented as easily read graphics you may get a new and partly different view of your life. Relations, work situation and recovery are a few of the things that people using Affective Health have started to reflect upon.

Affective Health is a system which measures your pulse, movement and arousal level through bio sensors attached to your body. The bio-sensor data is displayed in real time on your mobile phone. It is visualized with shapes and colors of matching energy level that are intuitively understood.

To give deeper insights in your life and to see patterns of behavior, the system has to be used over a long period of time. The intention of this system is not to give you warnings of when your life is too stressful. Instead it reflects your life in a way that gives you the tools to interpret if a situation is stressful or engaging – or both – and if that is something you want to change.

In the beginning of 2011, Professor Kristina Höök’s team is verifying the business proposal of Affective Health, possibly leading to a new spin-off company.

www.sics.se/ah
On the following pages a selection of projects are described to give you a general idea of the activities at SICS. Many other projects are carried out during 2010–2011, but are not mentioned here. For more information, please visit www.sics.se.
A Tool for **Crisis Management** Planners

In case of a crisis or an emergency, the Swedish crisis management system triggers a joint effort from several agencies that, by law, are required to collaborate in response to the crisis. Together with the Swedish Civil Contingencies Agency (MSB) we have produced a prototype tool for detecting possible conflicts in resource activation which can arise due to incompatibilities among the engaging agencies’ contingency plans.

Emergency management is moving towards service-orientation and net-centric operations. An effect is that resources required for engaging a crisis often are shared or contracted from third-party owners. In the event of a crisis, resources are activated according to the specific needs posed by the crisis and in accordance with contractual agreements between the agencies and actual resource owners. For example, clearing municipal roads after snowstorms may be managed by contracted private companies. Such agreements may for example specify allocations, sharing principles, or conditions for resource request. A complication is that the agencies are autonomous, and thus may enter into resource activation contracts independently of one another. During crisis, the independently entered contracts all of a sudden become dependent when they need to collaborate. This may cause unforeseen clashes of resource needs, with devastating effects on the joint crisis management capability. For example, the same resource may have been allocated to two crisis actors.

The prototype tool is intended to help crisis management planners to improve existing activation plans and resource sharing agreements, by providing the ability to detect possible resource conflicts in advance. Given a set of resource activation contracts, a scenario, and a model for available resources, the tool indicates subsets of activation contracts where conflicts may occur.
One of the research groups at SICS investigates how to design successful robotic products with a starting point in the technology available today and technology that is feasible in the future.

**A user centered perspective**

Robots have started to enter the market, our homes, and everyday settings. They are not necessarily the technically and socially competent humanoids we find in science fiction, but come as a variety of robotic products such as robotic vacuum cleaners for the home, robotic toys for children and courier robots for transports at hospitals.

To understand how these robots should be designed, we strive for a user and experience centered perspective. We have the objective to understand how to design for long-term use, to investigate how methods and techniques from interaction design can inform robotic technology, and to explore the ethics that is related to robotic products and robotic research. For example, our work discusses the difference between ethics concerns based on empirical data and speculative ethics, and research ethics concerning how to evaluate robotic prototypes. We are also working on ethics that concerns specific robotic artifacts, such as when designing for users with disabilities.

User testing and user studies are important tools for discovering strengths and problematic issues with any product. To reveal issues that are connected with specific use situations or use contexts, and to investigate how well a product supports the intended use, we are conducting studies in naturalistic settings to learn about the product and how users may assimilate it into their daily routines and practices.

**Eating with a robot?**

Bestic is a robotic product that supports people who cannot feed themselves due to disabilities in hands and arms. It is designed to look like a kitchen aid, is equipped with a robotic arm that has a spoon attached, and it is programmed to simplify the action of picking up food from the plate. The user can steer the product with different operating devices adapted to their disability.

SICS is currently collaborating with Bestic AB to conduct long-term studies of the product in order to understand experience related issues and potential design improvements. Designing for robotic eating aids raise specific design concerns, including ethics and aesthetics that relates to the users experience.

**Does it talk?**

How is a robot experienced when used for transportations at a hospital? Is it similar to the cleaners cleaning machine or is it a new colleague? Together with Robcab Systems AB, we have conducted a study of a transportation robot in order to learn how it can be experienced at the hospital. We studied a robot that carried blood samples between departments and investigated how staff and visitors experienced the presence of the robot. For some, the robot started out as an alien but gradually began to feel more like a colleague.

This work is part of a large European funded research collaboration including six universities, two research institutes and two companies spread across Europe.
Φ² – Sharing your Whereabouts by Scanning a Barcode

Using location-sharing services can be fun, but the search for venues in current services is sometimes tedious. So why not interact with real-world venues instead of entering a place manually within the application?

In 2010, location-sharing became very popular. Now people use services like Facebook Places, foursquare or Gowalla to share their whereabouts with their mobile phones. By doing a “Check-In” users report their location to the service. In the current services, users check-in by choosing their location manually from a list.

As part of the Mobile 2.0 project we created and evaluated different physical check-in methods for location-sharing. Instead of scrolling through a list, users can now interact with physical artifacts in the real world to select and share a place.

In May 2010, we published the Φ² Scanner (‘phi-square’ = ‘physical check-ins for foursquare’), an application that is using visual tags for the check-in. This application is available in the Android market allowing a large user base to test the new check-in method and to give us feedback about it. A tag generator at our project website enables users to simply print stickers and place them at a venue to create a user-generated infrastructure for the system.

Our published application showed a huge interest in physical check-ins by users of location-sharing services. The software was downloaded approximately 10,000 times and more than 3,000 tags have been generated within 8 months. In our field study users were excited about the new and easy way of checking-in. The visual tag functions as a reminder and makes the invisible service visible.

www.sics.se/projects/phi2
Mobile Life Excellence Centre

The Mobile Life VINN Excellence Centre is a research centre with SICS and Interactive Institute as strong and important research partners in collaboration with Stockholm University. After three years, the Mobile Life Centre has grown to be about 50 researchers. The research is interdisciplinary, involving researchers from computer science, interaction design, sociology and psychology, but also game designers, artists, dancers, and fashion experts.

The Centre’s competitive edge lies in making serious research on what we might normally portray as “unserious” activities in collaboration with our industry partners Ericsson, Nokia, Microsoft Research, TeliaSonera, Company P and Bambuser. We get inspired by doing studies on people’s mundane leisure and creative activities, such as horseback riding, hunting, parkour, dancing, or role-playing. We use those insights to spur innovative design processes, resulting in mobile applications, sensor-based applications, pervasive games, mobile mash-up services, new mobile media, technical platforms and materials to support amateurs’ creativity.

The centre started in 2007, and has financing from VINNOVA until 2017.

Innovation with Inspiration from Silicon Valley

In November, the Mobile Life Centre organized a trip with selected partners to explore the innovation system of Silicon Valley. Participants included SICS, Interactive Institute, Ericsson, Telia, Nokia and the Stockholm Municipality. We visited a number of corporate research labs and universities, including Stanford, Intel, Nokia, Ericsson, Yahoo!, Bump, Willow Garage, and PARC. The experiences will be used to develop Mobile Life’s approach to mobile services innovation.
In November 2010, Petra Sundström defended her PhD thesis “Designing Affective Loop Experiences”. The title comes from how she describes communication as a process in which people engage with body and soul, rather than just getting a message across.

In her thesis, Petra describes how, up to now, there has been a lack of attention to the emotional and the physical aspects of communication in the field of Human Computer Interaction (HCI).

“As designers of digital communication tools we need to consider altering the underlying model for communication that has been prevailing in HCI: the information transfer model. Communication is about so much more than transferring information. It’s about getting to know yourself, who you are and what part you play in the communication as it unfolds. It’s also about the experience of a communication process, what it feels like, how that feeling changes, when it changes, why and perhaps by whom the process is initiated, altered, or disrupted,” Petra says.

Communication is not only about getting the message across, but also about living the experience of communication – feeling it. The idea of Petra’s invention, the Affective Loop Experience, in design is to create new expressive and experiential media for the users, embodied with the social and physical world we live in.

An Affective Loop Experience is an in the moment emerging experience where the inner emotional experience, the situation at hand, and the social and physical context act together, to create one complete embodied experience. The loop perspective comes from how this experience takes place in communication, and how there is a rhythmic pattern in communication where those involved in the communication take turns in both expressing themselves and standing back interpreting the moment.

To allow for Affective Loop experiences with or through a computer system, the user needs to be allowed to express herself in rich personal ways involving our many ways of expressing and sensing emotions – muscles tension, facial expression and more. For the user, to become further engaged in interaction, the computer system needs the capability to return relevant feedback on those emotions, so that she gets encouraged to continue expressing herself.

In her thesis, Petra describes how she and her colleagues used the idea of Affective Loop Experiences as a conceptual tool to navigate a design space of gestural input combined with rich instant feedback. In their design journey, they created two systems, eMoto and FriendSense, see links below.

The opponent at this thesis defense was Professor John Zimmerman from The Human-Computer Interaction Institute and The School of Design at Carnegie Mellon University. It all went well and Petra Sundström is now one of the PhDs at the Mobile Life Centre at SICS.

The user can communicate emotions in the background of her text message. The stylus is sensitive to pressure and movement. This screen, for instance, which communicates rather intense and positive feelings, is created by soft and rapid gestures.
Electric vehicles can be considered as an open design space waiting to be explored. There are so many aspects to attend to, before the electric vehicle can compete with conventional cars when we look at it from the user’s point of view.

Electric vehicles are a major concern today, for the auto industry and for society at large. There are important issues with electric vehicles, some related to people’s understanding of the technology. One example is “range anxiety”: Even before the battery is discharged, the short range makes electric vehicles feel like conventional cars running low on gas and the users fear they will not make it to the destination before the battery is exhausted.

To estimate an accurate range of an electric vehicle a lot of planning is required. The on-the-spot planning that conventional cars can offer is not possible with electric vehicles. Factors besides current charge apply: the terrain elevation, the weather, traffic etc.

To address this problem SICS and KTH has developed different apps that help the user to conveniently calculate the range of the vehicle.

The “Favorite Places” app shows favorite destinations and if they can be reached with the current charge. For those that cannot be reached, the charge time needed will be shown. The “Planning and Reflection app” shows destination and charging events. For trips made in the past the historical charge times are shown. For trips planned in the future, the user gets help with planning the charging stops so that the destinations can be reached.

To estimate the range of an electrical vehicle, with all its dimensions, is a non-trivial algorithm problem, and it is not the only aspect that needs attention. There is a lot to do regarding all aspects of design of electric vehicles to make them not only environment friendly but also attractive, convenient and useful.

This work is funded by the STandUP for Energy initiative in Sweden and the Smart Energy activity of the European Institute of Technology (EIT).
In The Trend Inspector project we apply "crowdsourcing" methods on the clean energy-field.

To enable essential decision making today in prioritized areas like sustainability and energy, more detailed and accurate background knowledge is needed than earlier. This circumstance combined with the fact that stakeholders and policymakers more often have a background in economics or politics than science, creates a need for unambiguous and easily understood decision basis.

We are now entering an era when we to a higher extent will interpret the world through rapid data flows from the web, or through impenetrable sensor networks. This means that we can get both fast and detailed information about our world – if we are able to interpret them right, and convert the information into knowledge.

In The Trend Inspector project we apply “crowdsourcing” methods in the clean energy field. It is a way of tracing how trends and tendencies are succeeding each other through analyzing huge amounts of data from e.g. queries from different search engines, and how they vary over time.

We have targeted specific queries on relevant subjects like energy saving and solar power. The Trend Inspector does not answer the questions itself, it only delivers statistics from queries people from all over the world have already formulated.

The Trend Inspector has borrowed its appearance from a coffee table. The idea is that stakeholders and policy makers from the energy field should gather around the table, drink coffee and discuss environment or energy-related issues, and use the table’s predicting abilities as a decision basis.

Following the coffee table metaphor is the user interface based on coffee cups, which can be configured and rotated in different ways to interact with the application during the discussion. The participants can try out their theories, and present their suggestions in a persuasive and playful way.

The next step in the Trend Inspector project is a collaboration project with the company Recorded Future (co-founded by former CEO of SICS, Staffan Truvé), where we will try to utilize their advanced analyzing tools under the hood of our coffee table.

www.sics.se/projects/trendinspector
In the summer of 2010, a demonstration house with functioning systems for smart energy savings was presented in Almedalen Week, Gotland. This project focuses on the future of energy regulation at the end consumer level; that is to say, to the benefit of everybody.

Smart Grids is a popular concept, and lots of people are talking about the revolution that will be needed to cope with the construction of these smart electrical grids. SICS has developed a comprehensive picture of what is required at the end of the line, that is with the private end user. In a three-year project called “System-wide IT network for increased energy efficiency in housing”, and financed by the Swedish Energy Agency, SICS is investigating the possibilities of smart houses from an energy-saving perspective.

The name “system-wide” involves opening up different subsystems, so they can actually share and use information with each other. Today, it is not possible for an alarm to affect the temperature control system, nor is it possible to read the indoor temperature on your TV screen as they all use different protocols to communicate. This has now been solved in an elegant way:

To avoid managing all these protocols, we have chosen to use IP throughout. This means that in certain cases, we have to adapt some devices that still do not handle IP, but most of the time, we try to find alternatives that already support IP. The advantage with IP is that there is support for IP in all programming environments, there are good support tools and all users and developers already use it, for example for the Internet, IP-TV or IP-telephony.

Today, IPv4 is mainly used for data traffic over the Internet, even though this standard is under-dimensioned and the addresses are simply running out. The new alternative, IPv6, was developed over ten years ago, but it has not really made a breakthrough. Calculations show that as little as 1% of all Internet traffic uses IPv6. The system being developed by SICS communicates directly via IPv4 as well as IPv6. Since the Western world has already commandeered nearly all the IPv4 addresses, it is mainly the developing countries that
have a greater share of IPv6 traffic today. With IPv6, there are in practice an infinite number of addresses available, which means that our system is well prepared for broad utilization and expansion in many different ways.

SICS forecasts a future where all electronic equipment in the home, such as TV, stereo, cooker, fridge, and freezer will have their own IP address. In the demonstration house, small sensor nodes were used that measured parameters such as energy consumption, temperature and light, and thereby a regulation system for the whole house’s functions could be demonstrated.

The basic concept behind the SICS system is that it will include a certain level of automation. Today, there are plenty of solutions that only consist of a display showing the energy consumption. It is up to the user to change his or her behavior. Such systems, according to some studies, can reduce energy consumption by as much as 25%. However, this assumes the user is active and continues to steer his or her consumption, something that is not at all certain. As a rule, it is difficult to show how much is really saved and the commitment often diminishes after a while. Moreover, if you do not have direct resistive electric heating, then the heating is not included in such a system.

The heating is crucial for the energy consumption; heating and hot water consume the most energy, and it has to be controlled irrespective of type. To optimize the consumption and create permanent improvements more than visualization is required. In the model with which SICS is working, all information is collected – even that related to the heating – and thereafter the equipment is controlled automatically.

The next step for the work group at SICS, together with the project partner SUST (Sustainable Innovation), is to carry out a number of pilot installations of fully functioning systems in normal homes. The technology is developed and functions, now remains the extensive work with testing and evaluation.

We are out early with test runs of this type of system. The IP standard creates the preconditions for more accessible and less expensive equipment. In time, our aim is for totally automatic, intelligent systems that do not just help us reduce energy consumption but also improve the dwelling environment.

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**Smart Energy Apps for Homeowners**

Providing an infrastructure for the development and execution of smart energy apps is one of the goals of a European project, where SICS participates together with sixteen other partners from six countries. Smart energy apps could play an important role in achieving energy efficiency in the future, thus helping to reduce the overall energy consumption.

As consumers are paying for the energy they use, they are usually willing to save, if it can be done in a convenient way. The trick is to put consumers in control of the use of energy in their homes and workplaces. At SICS, we are developing a software infrastructure that can connect various electrical appliances, monitor and analyze their energy consumption, and provide an environment for the development and execution of smart energy apps. Such apps are light-weight programs that will typically save energy by controlling various aspects of the indoor environment, e.g. lighting or heating, without losing comfort. The infrastructure will contain a tool set that makes the development of such apps relatively easy. Developers, e.g. the home owners themselves or third-parties, will be able to express high level rules and policies, concerning for instance temperature levels in different rooms, and the infrastructure will then decide how they can be implemented in the most energy efficient way. As part of this process, the infrastructure will make use of a context framework that knows about floor plans, keeps track of the location of people as well as appliances, weather conditions, etc.

Privacy, trust and safety issues are also very important since apps may be downloaded and installed from the web, and may also be used to share energy consumption patterns between households in order to increase energy efficiency.
As the available data in the Internet become more abundant, finding the relevant information is like looking for a needle in a haystack. The Vitis publish/subscribe system is designed to help Internet users receive only the information of their interest easily and quickly.

Publish/subscribe systems are nowadays widely used over the Internet. News syndication (RSS feeds), multi-player games, social networks and media streaming applications are a few examples of such systems. Users of these systems express their interest in certain data, by subscribing to a number of topics. Should any new data be published on a topic, the subscribers are notified and provided with the content.

Currently, the majority of these systems rely on dedicated machines to provide subscribe services. However, with a rapidly growing number of users on the Internet, and a highly increasing number of topics, it is becoming necessary to use decentralized models for providing such a service at a reasonable cost. Scalability comes with a cost though: a message published on a certain topic often needs to traverse a large number of uninterested nodes before reaching all its subscribers. This might sharply increase resource consumption for such relay nodes (in terms of bandwidth transmission cost, CPU, etc.) and could ultimately lead to rapid deterioration of the system's performance once the relay nodes start dropping the messages or choose to permanently leave the system.

At SICS, we have developed Vitis, which is a topic-based publish/subscribe system that scales to an unbounded number of nodes and topics, while the number of relay messages are kept low. This is achieved by the novel approach of enabling rendezvous routing on unstructured overlays. Vitis constructs a hybrid system by injecting structure into an otherwise unstructured network. The resulting structure resembles a navigable small-world network, which spans along clusters of nodes that have similar subscriptions. The properties of such an overlay make it an ideal platform for efficient data dissemination in large-scale systems. Measurements with subscription traces from Twitter and churn traces from Skype show that Vitis outperforms the existing solutions by decreasing both relay overhead and delivery latency to less than 50%. This certainly makes Vitis a promising solution for real-world applications.
Gold Medal to SICS for European Research Project

The SICS-led European Sensor Network Architecture project received the ITEA Achievement Award gold medal in 2010. The award is given annually by the ITEA organization to “highly successful projects with outstanding contributions”.

The European Sensor Network Architecture (ESNA) project ran from 2006 to 2009, with the purpose of developing a technical foundation for wireless sensor networks and the Internet of Things. One of the major results was SICS’ open source Contiki operating system, today one of the leading operating systems for wireless sensor networks and the Internet of Things.

The project explored sensor networks in industrial contexts including energy monitoring and management, industrial process control, and precision agriculture. The technology is now included in commercial products from many project partners, including ABB and CRL Sweden.

“The ITEA Board recognizes the important role that ESNA is playing in the Internet of things, with business-oriented wireless-sensor network applications using a standard architecture and proof-of-concept implementations,” said Philippe Letellier, Vice-Chairman of the ITEA 2 Board. “ESNA offers an impressive balance between advanced technological innovation – including the world’s smallest implementation of IPV6 and optimization of radio communications between devices to reduce energy use – and a business-oriented approach to defining applications.”

“The technology developed and the knowledge gained in the ESNA project are now an important part of our mesh technology product line,” said Björn Karlsson, Senior advisor to CRL Sweden. “Participating in the project gave us access to research results that we could immediately apply to our commercial offering.”

For SICS the ESNA project funded a critical part of the development of the Contiki operating system. It gave us the opportunity to put our system into good use in industrial applications and to learn from the specific challenges in commercial deployments. A unique characteristic of this project was the strong emphasis on innovation for challenging application domains. Such application work has not only resulted in successful commercial exploitation, but has also uncovered critical requirements that underlying software platforms have to fulfill.

ESNA was a collaborative research project with 20 partners from six European countries: Sweden, Finland, Belgium, Spain, Slovenia, and Croatia. The partners were universities, research institutes, large and small industry. SICS led the project.

The following Swedish companies participated: ABB Corporate Research, Communication Research Labs Sweden (CRL), Vibrel, Lansen Technology, Electronic Guard Center (EGC), and Vendolocus Development. The Swedish part of the project was funded by VINNOVA and the participating Swedish industrial partners.
Experience from Information-centric Networking Prototypes

A master student project in collaboration between SICS and Ericsson Research has provided hands-on experience with information-centric networking (ICN). The Subversion version control system was adapted to the network service of two ICN prototypes. Experiments were conducted in a local collaboration scenario which showed a clear performance benefit already with two local clients.

Information-centric networking is an approach for future network infrastructure where communication is based on transfer of named data objects. This approach enables integration of in-network storage for application-independent caching of data as part of the basic network service. The result is an infrastructure that provides efficient and scalable information distribution, matching today’s prevailing use of communication networks, and that also is better at handling mobile and other scenarios with limited communication capacity or with intermittent connectivity.

In order to gain experience with the latter, i.e. limited communication capacity, we selected a collaboration scenario which is very common in many of our projects. A group of people at a project meeting is sharing documents through one or more server-based systems, for example a Subversion version control repository. The repository stores a shared file tree and additionally keeps track of all modifications, or versions, facilitating joint document writing and code development.

A Subversion server and client were modified to use the communication service of OpenNetInf and CCNx, two ICN research prototypes. The modifications were straightforward – one important experience in itself from the project.

By using the ICN communication services, Subversion clients automatically fetch updated files in the repository from other nearby clients when possible. The experiments show (see figure) that already with two clients, there is a performance benefit in common scenarios despite the fact that these research prototypes are far from optimized.

The results and experience from this master’s project are important contributions to our goal to create working prototypes of network technology based on the information-centric paradigm relevant for next generation mobile systems at Ericsson.

Performance of Subversion/OpenNetInf relative to Subversion/HTTP for different capacity and delay to the server; values above 1 are better than today.
Simplifying Internet Applications Using Name-based Sockets

Internet applications today are required to implement network-based functionality by themselves. This greatly increases the complexity of applications, affecting the development time and the debugging effort required. By simply delegating the name-resolution to the operating system instead, we may solve the problem once and for all.

Today, network-based functionality such as mobility, multi-homing, path diversity exploitation, NAT-penetration (end-to-end connectivity), IPv6/IPv4 transition and interoperability, encryption and authentication are all up to the application to solve. Every single application is required to reinvent the wheel, which is very impractical.

By simply delegating the name-resolution to the operating system instead, we may provide all the network based features to all applications in a simple fashion. When the application only needs to tell the operating system the name of the endpoint it wishes to communicate with, the operating system is free to manage the locators as needed to provide connectivity, without disrupting the association to the application.

SICS is, in collaboration with Tsinghua University in Beijing and Ericsson Research in San Jose, engaged in an effort to standardize a common name-based application interface within the Internet Engineering Task Force (IETF), a large open international community of network designers, operators, vendors, and researchers.

Name-based interfaces have historically proven to be a great success, the majority of programming languages and frameworks provide a name-based approach. However, these are usually application-protocol specific, non-dynamic and unilateral. A name-based interface standard should push the envelope, providing not only a place where to write the name of the counterpart, but also a standardized way for applications to check for bilateral support and negotiate network-functions to be used for the duration of the communication.

We are, together with our Chinese partners, actively developing a prototype for name-based sockets, including network features. To date the prototypes support the name exchange, multi-homing (shim6), multi-path exploitation (Multi Path TCP) and IPv4/IPv6 selection mechanisms. During 2011 we will continue the standardization effort.
SICS Center for Networked Systems forms a strategically strong research consortium together with SICS and the industrial partners, Ericsson, TeliaSonera, ABB, Saab, T2 Data, Peerialism and Vendolocus Development, as well as the academic partners, MdH, KTH and Uppsala University. The center is guided by the vision of The Reliable Internet, a secure and reliable infrastructure for industry and society. To achieve this we take a networked systems approach, comprising the complete system view all the way from user expectations to the underlying network technology, in order to address the needs of critical applications. Furthermore the center is multidisciplinary organized, combining methods and results from three research areas: networking, distributed systems, and intelligent systems. The center supports a creative meeting place. We define and carry out projects together. The center actively promotes personnel mobility between the center’s partners, and supports competence development of the center’s partners.

The center started in 2007 and receives funding from VINNOVA and KK-stiftelsen until 2012.

www.sics.se/cns
Change detection enables network management to proactively make important technical and business-related decisions when there are sudden changes in network traffic. It can for instance allow flexible pricing at very big news events or popular new services. We have successfully tested a probabilistic approach for autonomous change detection.

Self-adaptation and self-management are important elements for coping with increasingly complex systems, such as IP-networks. An important aspect for maintaining reliability and failure-resilience in such systems is the detection of significant variations in observed network behavior. Here, such variations could for example be caused by changes in user behavior, service performance, or network configurations. Being aware of such changes enables effective management of network resources, allows for flexible pricing of services, and most importantly, increases the control of the network.

Change detection constitutes a useful complement to management processes, such as distributed fault-detection and localization, as it increases situation awareness and enables network management to proactively make important technical and business-related decisions. In addition, such information can be used as input to other management mechanisms for autonomous adaptation of network resources and configurations to the observed current behavior. For example, detected changes do not necessarily imply network failures, but could rather be regarded as early symptoms of malfunction, malicious activity or any of the above localization of the exact root cause is usually done through event correlation using detected changes as input.

In 2010, we developed a probabilistic approach for autonomous change detection, which is part of our continuous work towards distributed probabilistic management in networked systems. The probabilistic approach is memory efficient, flexible, and can be used in both centralized and distributed applications. The approach has successfully been tested for monitoring variations in network performance, and for reliable movement detection in sensor networks. The approach is currently tested for detection of changes in mobility patterns.

www.sics.se/networkmanagement
A large and increasing part of today's Internet traffic is due to downloading of digital media. In order to cope with increasing traffic volumes and still provide good service quality towards end-users, content and service providers make use of dedicated Content Distribution Networks (CDNs). A CDN is a set of connected servers which stores and replicates data in order to maximize accessibility while minimizing bandwidth usage and latencies. When a piece of content is uploaded to the CDN, the network needs to decide how many replicas to make and on which servers to place them. Since both the storage capacity of each server as well as the life time of the physical storage device is limited, in terms of the number of times data can be written onto it, the allocation decision is not straightforward.

In this joint work with Ericsson research, we are investigating a new set of replication policies that let the servers mutually decide which content they should store. As the number of servers in a CDN can be arbitrarily large the policies have to be executed at individual servers, and should require only a small amount of communication overhead. By letting the servers gossip about the content they currently store, and the frequency of requests they receive, it is possible to make them collaborate and share the workload more efficiently. Not only does this decrease the global bandwidth usage but also the number of disk writes needed in the process.
Local caching of popular TV programs in IPTV distribution has the potential to reduce bandwidth requirements for time-shift TV services significantly. Within the CNS center we have, through large scale simulations, showed that caching strategy, program set size and type of programming all have large impact on total bandwidth consumption. The results are highly relevant for cache placement, dimensioning and management policies.

Today, many telecom and broadband companies distribute TV channels in their networks and also gradually introduce time-shifted viewing to allow consumers to watch the programs after its scheduled time. However, distributing time-shifted TV-streams to individual viewers requires a lot of bandwidth and is a big challenge for the operators.

In this project we have, together with main partners Telia and Ericsson, implemented an empirical workload model that we use to simulate weeks of TV distribution with time-shift. The simulation results show that local caching of the most popular programs limits bandwidth requirements significantly. We also see that the choice of caching strategy, program set size, the type of TV channel and other parameters have a large impact on the results.

Our experiments also show that demand profiles for different types of programs have a very clear and significant impact on cache hit ratio. This opens the field for more informed caching strategies e.g. scheduling cache deletions with a cost based on demand estimates.

Large, predictable, daily variations in user demand also give opportunities for pre-caching during low traffic periods. We show that transfer scheduling of the content can reduce peak bandwidth requirement to less than half for realistic scenarios. Combining this result with informed cache replacement and efficient demand prediction has huge potential for media distribution in general.
SICS has a strong and broad commitment to advance and promote cloud computing technology.

SICS conducts research in the following topics within cloud computing:
- Distributed storage systems where object metadata enables efficient access, search, management and manipulation of data.
- A programming model and runtime environment for data-intensive applications, providing for good data locality and moving beyond batch-jobs to computations triggered by data arrival and transformation in the cloud.
- Information-centric networks to cache data in the network and provide network-based publish/subscribe mechanisms.
- Resource allocation frameworks providing superior elasticity and fine-grained control over resources.
- Cloud management.
- Trusted execution environments to protect users from the cloud provider.

A number of new initiatives have been taken during 2010:
To test and evaluate new technologies in this field, both developed in house and elsewhere, SICS together with KTH has set up a common testbed connecting clusters at SICS and two different sites at the Royal Institute of Technology: KTH/Kista, and KTH/PDC. An open consortium, called the Cloud Innovation Centre (CIC), to promote cloud technologies, has also been founded.

SICS leads the work on programming frameworks in the European IP-project Vision-Cloud. There we work with leading industry to support the requirements from four different industrial cloud application areas. Deutsche Welle and Rai, for media, Siemens for healthcare, SAP for enterprise, and Telenor, FT, and Telefonica for telecom. Moreover SICS leads the EIT ICT Labs’ research action line “Computing in the Cloud”.

To promote new startup companies in Sweden, based on cloud technology, SICS Seed Accelerator has been started. See separate articles on this spread.

Research in the EIT ICT Labs

ICT Labs of the European Institute of Innovation and Technology (EIT ICT Labs) is a new initiative aiming at turning Europe into the global leader in ICT innovation. SICS is one of the three core partners of the Stockholm node.

Higher education will be transformed to promote creativity and entrepreneurial spirit. 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.

Research carried out within EIT ICT Labs currently focuses on three strategic research action lines:
- Computing in the Cloud
- Internet Technologies and Architectures
- ICT-mediated Human Activity

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
- lead the selection of proposals to be funded
- stimulate coordination of various activities to increase synergy and the creation of the cloud computing research community within EIT ICT Labs
- represent the “Computing in the Cloud” research of ICT Labs

http://eit.ictlabs.eu
Demo of Health Records for a Billion Indians

Distributed Information store for Global Healthcare Technology is a project for building a scalable and highly reliable information store for the electronic health records of all the 1.2 billion citizens of India. The project leverages SICS’ expertise in the area of cloud computing. Our project partner is the Swedish Indian Centre for Development of Advanced Computing (C-DAC), who contributes expertise in health care management systems software. SICS is responsible for developing a trusted and reliable distributed long-term cloud store for electronic health records based on open-source software and off-the-shelf hardware, while C-DAC is working on the standardization of electronic health records and front-end software.

In December 2010, the mid-term review of the project was held in Pune, India, organized by VINNOVA (Sweden) and the Ministry of Information Technology in India. The review was a great success. SICS demonstrated an early version of the distributed database technology running on 14 nodes, showing how the system scales to massive numbers of nodes. The review was preceded by a workshop involving the main players in both the private and public healthcare markets in India, and there was a very high level of interest in and demand for the solution in India. In Sweden, we introduced the system at an eHealth seminar held at SICS in February 2011, and, even here, the need and demand for a scalable secure store of electronic health records has never been greater.

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C!C and SICS Seed Accelerator

The Cloud Innovation Center (C!C), founded by SICS and KTH, is an open consortium promoting cloud technologies in academia and industry.

Within C!C, researchers collaborate on national and international cloud projects, coordinate education activities, interact with industry through agile business driven projects, and contribute to Swedish seed accelerator programs. C!C hosts the annual Cloud Computing Day, with its first event on September 14, 2011 in Kista.

C!C is the academic partner of SICS Seed Accelerator, a newly started seed accelerator. SICS Seed Accelerator will create startups from scratch and help existing startups and innovative companies on clouds. In later stages, 2012 and beyond, other technology areas will be covered by SICS Seed Accelerator. In addition to its close connection with C!C, SICS Seed Accelerator also works closely with Mobile Life and innovation support services, like KTH Innovation and STING.

SICS Seed Accelerator is organized under SICS with support from RISE (Research Institutes of Sweden) and is part of the EIT ICT Labs initiative. SICS Seed Accelerator is an early user of the EIT ICT Labs cloud based innovation platform proposed and developed by C!C. Together C!C and SICS Seed Accelerator creates an unique platform for cloud innovation and startups.

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www.sics.se/dight

www.sics.se/seedaccelerator
We simplify programming of large-scale multicore systems by providing efficient message-passing for component-based applications, and enabling custom execution scheduling.

A novel flexible and efficient programming framework for multi-core architectures, called ArchiDeS, has been developed at SICS. The name stands for Architecture specification, Deployment-time tuning and reconfiguration, and Scheduling of execution on multiprocessors – elements of parallel applications that are usually not decoupled from each other.

ArchiDeS applications are composed of hierarchical components, where components communicate and synchronize by message-passing. Different messages can be processed in parallel, supporting task, data and pipeline parallelism. Message processing on different cores is completely unsynchronized and therefore efficient. Different cores need to synchronize only for load balancing and managing consistency of the state of stateful components. ArchiDeS provides higher-order components and architectural abstractions, enabling in particular generic component “wrappers” for tuning the behavior of nested components and application reconfiguration.

Finally, ArchiDeS enables application-specific execution schedulers. An execution scheduler determines which messages are processed on which cores and in which order. A typical execution scheduler in ArchiDeS contains one fast local message queue per core. Scheduler code can also access remote message queues for load balancing. An execution scheduler can be programmed to “understand” messages it schedules – it knows the destination components and can read message contents. An application-specific scheduler can exploit the application domain knowledge in order to, e.g. prioritize messages on the critical path or containing important data.

ArchiDeS is currently implemented in C++ due to its low and predictable overhead. We are using ArchiDeS to develop and evaluate a detailed software model of 3GPP Long Term Evolution (LTE) uplink data processing in radio base stations. We can run the model on modern Intel x86 multicore chips and on a Tilera TilePRO 64 core system, and are currently designing and evaluating custom execution schedulers.

www.sics.se/projects/archides

The Architecture of the LTE model in ArchiDeS.
During 2010, SICS was involved in a collaboration project on the topic of optimized sheet metal cutting together with the startup company Tomologic AB.

Due to increasing global competition and a constant demand for lower prices, the manufacturing industry is always striving to minimize the costs of mass producing metal details. A large part of these costs are metal costs, of which the waste is significant and can be as much as 50% of the raw material. Minimizing this waste is therefore extremely important and a reduction of as little as 1% can save millions.

Tomologic AB was founded in 2009, and has a unique competence in minimizing the waste when mass producing metal details. This competence was acquired through many years of practical experience by its founder Magnus Norberg Ohlsson. Using Tomologic’s technology, the safety distance between metal details (which is ubiquitous in nesting, the technology traditionally used by the industry) can often be reduced or even completely removed. This can lead to reducing the waste with as much as 50%, without affecting the quality of the end result. Tomologic’s goal is to offer its technology as an online optimization subscription service.

The collaboration project was about adding advanced search algorithms to Tomologic’s optimization software. While simple to state, the problem of finding the best placements for a number of metal details in order to minimize the waste is in general very hard to solve to optimality. SICS worked closely with Tomologic’s development team to come up with a solution that integrated well with their technology and fulfilled their requirements on efficiency and quality. Extensibility and the possibility to adapt the search algorithms to a multicore computing environment were also important design goals.

www.tomologic.com
A New Approach to the Planning Process

The new planning process for train traffic, developed by SICS, separates the train plan into two parts: The service that Trafikverket (the Swedish Transport Administration) commits to deliver to its customers (the operators), and the production plans containing the details of how Trafikverket will deliver what has been promised. The separation of the two parts opens for the possibility to apply lean production and just-in-time principles on the latter part.

SICS has been conducting timetable related research for many years which has resulted in a prototype tool for efficient timetable generation. Just as important, research has also shown that there is huge potential to revise the entire planning process at Trafikverket to enable seamless and continuous plan updates, and to offer flexibility and better service to their customers. The current projects at SICS focus on developing algorithms for an optimizing tool, and how the process at large needs to evolve in order to get the greatest benefit out of technological improvements.

Since 2010, the railway market in Sweden is completely deregulated, meaning that many operators now compete for the same capacity. It is the task of Trafikverket to coordinate the applications for train paths from all operators and create one single train plan for the whole country, for one full year at a time. For instance, the 2012 train plan will take shape in spring 2011 and be valid until December 2012. Establishing a very detailed plan as long as 15 months in advance does not seem very efficient, particularly as changes to the plan are hard to make. After examining the process, the researchers at SICS were able to show how applying elements of lean production and just-in-time would improve the planning process significantly.

The key is to minimize waste, and to “pull” rather than “push”, throughout the process. Translated to our setting, lean production means that Trafikverket should avoid putting effort into details in a plan that is likely to become outdated before it will be used. The pull strategy involves producing only what the next step in the value chain really needs, when it is needed, and to perform only value-adding activities.

The new process is called Successive Allocation, in which the train plan is separated into two parts: the service that Trafikverket commits to deliver to its customers, and production plans with the details outlining how Trafikverket will deliver what has been promised. The first part is negotiated and clearly stated in contracts, and should typically include the arrivals and departures that are important to the operators. All other details belong in the production plans, and can change as often as necessary as long as the delivery commitments stay the same. To facilitate frequent changes and updates, new computerized tools that semi-automatically propagate the changes and optimize the plans are expected to play a prominent role.

With the high capacity utilization of the railway network that we see today in Sweden, the change suggested by SICS could potentially result in huge savings for the railway sector, and for society as a whole, since it will make railway traffic more efficient and flexible. Trafikverket has set up a development program to have the Successive Allocation incorporated by the year 2015, and SICS will continue to play an important role while this change is being implemented.
makes Huge Savings for the Railway Sector
# Financial Report

## Statement of Profit and Loss, KSEK

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<tr>
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<tbody>
<tr>
<td><strong>Income</strong></td>
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<tr>
<td>Net Sales</td>
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<td>90 178</td>
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<tr>
<td>Other operating income</td>
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<td>801</td>
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<tr>
<td><strong>TOTAL INCOME</strong></td>
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<td><strong>101 545</strong></td>
<td><strong>92 547</strong></td>
<td><strong>90 721</strong></td>
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<tr>
<td><strong>Operating expenses</strong></td>
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<tr>
<td>Other external costs</td>
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<td>Personnel</td>
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<td>Depreciation and write-downs of tangible assets</td>
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<td><strong>Operating profit/loss</strong></td>
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<tr>
<td>Result from financial investments</td>
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<td>323</td>
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<td>Profit after financial items</td>
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<td>308</td>
<td>1 240</td>
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<tr>
<td>Other taxes</td>
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<td>-183</td>
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<tr>
<td><strong>NET PROFIT FOR THE YEAR</strong></td>
<td><strong>775</strong></td>
<td><strong>125</strong></td>
<td><strong>923</strong></td>
<td><strong>546</strong></td>
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## Balance Sheet, KSEK

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<tr>
<td><strong>ASSETS</strong></td>
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<td>Fixed Assets</td>
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<tr>
<td>Tangible assets (machinery)</td>
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<tr>
<td>Financial Assets</td>
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<tr>
<td><strong>Total fixed assets</strong></td>
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<td><strong>1 614</strong></td>
<td><strong>1 627</strong></td>
<td><strong>1 537</strong></td>
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<tr>
<td>Current assets</td>
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<tr>
<td>Ongoing projects</td>
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<td>Current receivables</td>
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<td>Investments</td>
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<td>Short-term investments</td>
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<td>21 019</td>
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<td>Cash and bank deposits</td>
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<td><strong>Total current assets</strong></td>
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<td><strong>TOTAL ASSETS</strong></td>
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<td><strong>71 091</strong></td>
<td><strong>69 166</strong></td>
<td><strong>63 605</strong></td>
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<tbody>
<tr>
<td><strong>EQUITY AND LIABILITIES</strong></td>
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<tr>
<td>Equity</td>
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<tr>
<td>Share capital</td>
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<td>100</td>
<td>100</td>
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<tr>
<td>Statutory reserve</td>
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<td>21 908</td>
<td>21 908</td>
<td>21 908</td>
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<tr>
<td>Profit brought forward</td>
<td>2 321</td>
<td>2 197</td>
<td>1 274</td>
<td>728</td>
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<tr>
<td>Profit for the year</td>
<td>775</td>
<td>125</td>
<td>923</td>
<td>546</td>
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<tr>
<td><strong>Total Equity</strong></td>
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<td>24 205</td>
<td>23 282</td>
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<tr>
<td>Current liabilities</td>
<td>61 644</td>
<td>46 761</td>
<td>44 961</td>
<td>40 323</td>
</tr>
<tr>
<td><strong>TOTAL EQUITY AND LIABILITIES</strong></td>
<td><strong>86 748</strong></td>
<td><strong>71 091</strong></td>
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<tbody>
<tr>
<td>Employees, full-time equivalent heads</td>
<td>96</td>
<td>94</td>
<td>86</td>
<td>84</td>
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</table>
Basic Facts

In December 2010 SICS had 108 employees, (96 full-time equivalent heads) including 48 PhDs. The turnover was 109 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.

Industrial Partners

About 20% of SICS’ research is financed by the industry, including contributions from SICS’ industrial partner association, FDF. Members of FDF in 2011 are:

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

Other notable customers over the year were Trafikverket, Nokia, and a number of Swedish SMEs.

Organization

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

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 in April 2011

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

Contact:
Managing Director: Christer Norström
Chief Scientific Advisor: Seif Haridi
Business Manager: Janusz Launberg
Financial Manager: Charlotta Jörsäter
Communication Manager: Kersti Hedman
SICS is Sweden’s leading industrial research institute for applied information and communication technologies. SICS is a non-profit organization, with the sole purpose of developing other companies operating in Sweden. We have developed technical solutions for the Swedish industry for 25 years. Working on different types of commissions, from long-term projects in which knowledge develops during years of collaboration, to short-term assignments in which the institute can provide key solutions within a few months.

SICS’s ambition is to conduct research that is both leading and needs-driven and, therefore, useful to our partners. SICS’s strength is based on deep expertise in selected strategic areas, and close cooperations with national and international universities and institutions – combined with close collaborations with both small and large companies operating in Sweden.

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

COLLABORATIONS WITH SICS
• 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
Janusz Launberg, janusz@sics.se