CERES
Centre for Research on Embedded Systems

KKS Dnr 2003/0119

Research Profile
Annual Report 2008

Halmstad University
In cooperation with

Combitech AB
Emwitech AB
Ericsson AB
Free2move AB
Innovation Team AB
Saab Microwave Systems
SP Technical Research Institute of Sweden
Volvo Technology AB
XCube Communication AB
Cover photos: Upper: Per-Arne Wiberg and Ulf Paulsson

Lower left: Katrin Bilstrup
Lower right: E-lab equipment

Photos by: Roland Thörner, Katrin Bilstrup Mohamed Ezzat El-Hadedy Bertil Svensson, Johan Malm, Emil Nilsson,
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Preface
The spring of 2008 marked the half-time of the six-year CERES research profile funding. The efforts we have made in building up a productive, high-qualitative research environment in co-operation with industry are now expected to show concrete results. When summarizing 2008, I am happy to say that this is the case.

The scientific output in terms of full-paper reviewed publications in international conference proceedings and journals has more than doubled compared to the previous year. The ambitious publishing goals for 2008 were thus met with good margin. In addition, we saw three new research theses: two for licentiate and one for the PhD degree. The fresh PhD has followed the tradition of continuing the career at one of our partner companies, while the licentiates continue towards the PhD degree.

We also reached out even better than before to partners, colleagues and other contacts through our new CERES Newsletter, which has been very much appreciated.

The profiling process of Halmstad University has continued, clearly pointing out a further concentration to particular areas of strength. Embedded and Intelligent Systems is one of three selected research areas in which the University intends to seek full rights to educate and examine PhDs. To support this, CERES has further developed the collaboration with the other labs within the School of Information Science, Computer and Electrical Engineering. As a result, the joint research environment Halmstad Embedded and Intelligent Systems Research (EIS) is effective since July 1st, 2008. Initiatives are taken to build bridges between EIS and other research groups at the University. This will even further sharpen the profile of the University.

As part of the quality development and the process to get PhD examination rights, the University’s Research Board for Technology and Science decided to perform an external evaluation of EIS (including CERES) with the help of national and international expertise. The assessment was indeed very positive, clearly stating that the research is of very high quality according to international standards, with certain subgroups judged to be excellent. The “excellent and extensive collaboration with local and national industry” was highlighted, and the overall assessment of the PhD education environment was “excellent”.

The quality and timeliness of our research was manifested also in two international awards given to PhD students of CERES and in specific interest in our research results in
wireless networking from the European standardization organization. We have also witnessed how our expertise and advanced equipment and tools has enabled two new companies to be formed and start growing.

Towards the end of 2008 we decided about strategic recruitment of more researchers in our key areas – both senior and junior ones, some in close collaboration with industrial partners. We anticipate that these recruitments will be of great importance for our continued development.
Introduction and general information

Background
The Knowledge Foundation (Sw. KK-stiftelsen – KKS) supports the build-up of profiled research programs at the new universities in Sweden. The prime instrument for this is a six-year “profile funding” which is given to a university after extensive, international review of quality, relevance and plans. In the case of CERES at Halmstad University, the level of funding is 36 million SEK over a six-year period starting April 1, 2005. Before the start of the profile, CERES received so called platform funding during a build-up phase (2003-2004: 5 million SEK).

CERES is a research centre within the School of Information Science, Computer and Electrical Engineering at Halmstad University (IDE). The central research competences on which the research programme is built are: computer architecture, computer communication, and software technology, i.e., the competence areas of the Laboratory for Computing and Communication (CC-lab), one of the four laboratories that form the School of IDE. CERES also, in its research projects, relies on competence from the other labs of IDE: The Intelligent Systems Laboratory (IS-lab), the Laboratory for Mathematics, Physics and Electronics (MPE-lab), and the Laboratory for Man and Information Technology (MI-lab).

Focus, mission and goal
The focus of the research profile is on Cooperating Embedded Systems, more specifically on enabling solutions for cooperating and high-performance embedded systems and their applications.

The mission of CERES is to serve and promote the development of industry and society. It is a centre for industrially motivated, but mainly long-term research on the future technologies for and application opportunities with cooperating embedded systems. CERES serves as a partner for industry’s own research and development, as a recruitment base for those who seek staff with state-of-the-art knowledge, and as a competence resource for industry and society. CERES is an arena for research education and profiled master and bachelor studies.

Objective and Goal. The objective of CERES is to provide knowledge (solutions, theories, methods, tools) to bridge the gap from basic enabling technologies to application domains where cooperating embedded systems play a role. By this, CERES is intended to increase the competitiveness of Swedish industry. The goal is to make CERES an internationally recognized environment for research and graduate education, characterised by a well-developed research cooperation with industry. It shall be considered a leading centre of excellence on cooperating embedded systems.
CERES Organization

CERES Management

CERES Director: Bertil Svensson
CERES Vice Director: Magnus Jonsson
CERES Leading Group: Veronica Gaspes, Magnus Jonsson, Tony Larsson, Bertil Svensson (chair), Roland Thörner (secr.), Elisabeth Uhlemann, Per-Arne Wiberg, Nicholas Wickström
CERES Coordinator: Roland Thörner

CERES Reference Group

Appointed by the vice chancellor of Halmstad University after having consulted the CERES partners and the Knowledge Foundation.

Christer Fernström (chair) Xerox Research Centre, France
Lucia Lo Bello University of Catania, Italy
Hans Hansson Mälardalen University, Sweden
Åsa Lindholm-Dahlstrand Halmstad University, Sweden
Misha Pavel Oregon Health & Science University, USA
Thorsteinn Rögnvaldsson Halmstad University, Sweden
Tommy Skoog Independent consultant, Sweden
Rolf Rising Invest in Sweden Agency, Sweden

CERES Industrial Advisory Board (CERES IAB)

One representative (with substitute) from each industrial partner, plus CERES Director and Vice Director.

CERES IAB Chairman: Peter Olanders, Ericsson AB (until end of 2008)
CERES IAB Vice Chairman: Johan Sedelius Hörberg, Emwitech AB

Industrial partners

Combitech AB
Emwitech AB
Ericsson AB
Free2move AB
Innovation Team AB
Saab Microwave Systems
SP Technical Research Institute of Sweden
Volvo Technology AB
XCube Communication AB

Representatives

Anders Åström, Anders Åhlander
Johan Sedelius Hörberg
Thomas Lewin, Peter Olanders (until end of 2008)
Per-Arne Wiberg
Christian Kaestner, Martin Lindvall
Per Ericsson, Lars-Göran Karlsson
Jan Jacobson, Lars Strandén
Mats Rosenquist, Niclas Nygren
Mikael Taveniku, Christian Wigren
PART 1 – PROGRESS REPORT

This report is organized according to the detailed guidelines provided in the contract between The Knowledge Foundation and Halmstad University.

I. Scientific quality and connection to a clearly stated profiling of the University

The University’s Research Profile

CERES is an important part of the profile and strategy of Halmstad University. The University Board has decided to concentrate the research of the University to focused areas of international strengths, in such a way that it supports basic and advanced education as broadly as possible. Each of the University’s three, so called, areas of strength (AOS) will thus develop profiled research through interdisciplinary cooperation between several subject areas. Thus, the AOS “development and studies of organisation, region and society” has a Centre for Innovation, Entrepreneurship and Learning (CIEL); the AOS “quality of life, welfare and culture” has a Centre for Care, Health and Sports (CVHI); and the AOS “development of products, processes and services” has a centre called Halmstad Embedded and Intelligent Systems Research (EIS).

These centres are expected to be the primary research environments for the subject areas that carry the rights to train and give degrees at the Master and PhD level. It is stated that Information Technology (or Computer Science and Engineering) is such an area, supported by the research in Embedded and Intelligent Systems. The Master examination rights are already earned, and the University intends to apply for the PhD examination rights as soon as it is formally possible to do so, which is expected to be the case towards the end of 2009. These rights are crucial for the development not only of the subject area itself but for the development of the whole university.

CERES has contributed substantially to the formation of EIS during 2008 and forms a major part of its research programme. Later in this chapter, the forming and organisation of EIS will be described. In Chapter 7 and 8, the integrated role of CERES and EIS in the strategies for the future will be described.

Thus, the profile has a central and well-supported place within the University’s organization. CERES is also, with its strong record of spin-off companies from the embedded systems area, considered vitally important for the University’s profiling as an innovation-oriented university. It is interesting to see how an entirely new group of companies, in the areas of embedded, communicating and intelligent systems, has grown as a result of the University. This group of about twenty companies, three of which are on the public stock market, now has close to 400 employees, of which a large group are computer and electrical engineers graduated from Halmstad University.

A recently performed follow-up on all graduates on the Master’s level from Halmstad University in Computer and Electrical Engineering showed:
- that the engineers become innovation oriented and entrepreneurial and are capable of establishing new industry in embedded and communicating systems in the area,
- that the education meets industrial needs and that the engineers are highly employable (no unemployment found), and
- that the University has managed to combine industrial relevance with research orientation within this area (continuation towards PhD lies above the national level).

CERES Research Focus

Cooperating Embedded Systems is the “three-word focus” of CERES. The cooperation opportunities among and within embedded systems are enabled by new, emerging technologies; however, it is not these technologies per se that is in focus for CERES. Rather, it is the solutions for cooperation on a higher level (such as architectures, protocols, programming tools and methods, networking, etc.) that CERES researchers are working on – typically in cooperation with others – to bridge the gap between the new opportunities and the new applications. This can be illustrated by “the CERES goggles” shown in Figure 1.

Figure 1. Bridging the gap between technologies and applications (also known as the CERES goggles)

Main scientific areas

In terms of scientific areas, CERES has its strength in the following:

Computer architecture and systems design. Here the focus is on the new opportunities and challenges related to parallel and reconfigurable systems. Much of this relates to appropriate models of computation, to best serve the programming of high-performance embedded applications as well as the production of efficient code for parallel and reconfigurable target architectures.

Real-time and wireless communication. Here the focus is on guaranteed real-time services and dependable information transfer in wired as well as wireless networks standardized networks. Hardware and software technologies to enable low-power wireless applications, is another focused area.

Software technologies. Here the focus is on the application of component-oriented software technologies and technologies for coordination of distributed systems, as well as on the development and use of domain specific languages in order to achieve efficient and correct implementations.
Enabling technologies

Some of the enabling technologies that give new cooperation opportunities are the following:

**Parallel and reconfigurable hardware.** The advancement of VLSI technology (very large scale integration) makes it possible to design an embedded system as a system of cooperating systems, typically tailoring it to the demands of the application area.

**Short-range, low-energy wireless communication, together with embedded sensors, low-power processing, and energy scavenging.** These are all technologies that enable sensor networks and other systems based on cooperation over wireless communication links.

**Optical communication technologies and flexible, high-performance network switches.** Emerging techniques and standards for high-performance networks make it more cost-efficient to build high-performance distributed embedded computer systems.

**Component-oriented software technologies, and technologies for coordination of distributed systems.** Developing software for loosely coupled distributed systems requires new approaches, often in terms of components and coordination-supporting middleware.

Thus, the above technologies allow new forms of cooperation among or within the embedded systems (we refer to this as "macro" and "micro" cooperation, respectively).

Application areas

Although many of the solutions for cooperation among and within embedded systems can give benefit to almost any technical application area, CERES has chosen to put particular effort into a few, carefully selected application areas, in order to learn the application demands and become a recognized player also from an application point of view. The selected application areas are (see Figure 2):

**Health and elderly care.** The ageing population in Europe is a great challenge for elderly care. The development of technologies to support elderly people to continue to live an independent life is seen as one of the keys to meeting this challenge. The term “Ambient Assisted Living” (AAL) is sometimes used for description of how some of these supporting technologies may be used. It is believed that technology development in this area may create new economic and business opportunities.

**Intelligent traffic and transport systems.** A lot of new cooperative traffic applications ranging from collision avoidance to intelligent cruise control are enabled by cooperating systems relying on wireless communication vehicle-to-vehicle and vehicle-to-infrastructure. Similar technology can be used for making public transportation systems more efficient. Also transport of goods can be made safer, more secure and efficient by help of telemetry and tracking on-line in real time.

**Advanced sensing and communication systems.** Signal processing in future, array-antenna based radar systems represents a significant challenge in terms of sheer performance (TeraFLOPS), but also in terms of power dissipation and volume. The same is true for the baseband processing in base stations for future radio communication systems, such as WCDMA-LTE (long-term evolution), and in HDTV signal processing.

In Figure 2 it is additionally highlighted that many of (in fact, most of) the research results have a much wider relevance, thus being independent of particular application areas.
Figure 2. Main subject areas and applications of CERES. In following graphs, the application area “advanced sensing and communication systems” is sometimes referred to as “high performance signal processing”.

**Project formation strategies**

Based on the subject areas of strengths and the selected application areas, CERES projects in cooperation with the partner companies are formed as illustrated (with a fictive project) in Figure 3. A project is typically motivated by needs or opportunities in one or more application areas, as identified by the partner companies or the companies and the CERES researchers in dialogue, and where cooperating embedded systems is a critical key to the solution. Research questions are identified and the project is built on combining competence from several subject areas, as depicted in the figure. The goal is then to provide solutions for the application needs, but also develop new knowledge, methods and tools of general applicability.
CERES Research Focus in a Broader Context

Looking at the entire School of IDE, of which CERES is a part, we find that the industrial application of much of the research is concentrated to a few areas – the three mentioned for CERES (health, traffic/transport, high-performance embedded signal processing) and two more (process industry and experience industry). The vast majority of the ongoing projects are run in close cooperation with industries that are active in these areas. It has turned out that, in order to meet the demands from applications and industries, the ability to offer a combination of several areas of expertise in the same project is a true competitive advantage. Many recently started projects initiated by CERES have achieved funding in strong national competition based on this ability to combine strengths from two or more of the labs at the School of IDE.

To be able to attract long-term research funding, the university sees great advantages in organizing a strong, coordinated research arena within Information Technology, on which large, focused research programs can be built. Such an organization builds an even stronger competence base for the success of CERES as a continued program focusing on cooperating embedded systems. Thus CERES was initially relying primarily on the expertise within the Laboratory for Computing and Communication (CC-lab), but will increasingly be building on several labs. It is important for the school to be able to win more such, focused research programs.

With the “Goggles” metaphor, the coverage of this broader research environment can be illustrated as in Figure 4. Here, the core expertise of CERES is mainly used in the two circles meeting in systems solutions. The MPE-lab research provides some of the enabling
technologies, the IS-lab the intelligent applications and MI-lab the end usage and business models.

![Diagram of research cycle](image)

**Figure 4.** Embedded and intelligent systems research, ranging from enabling technologies, via systems solutions and applications, to business models

The School of IDE has a long list of industrial partners in its research. Many of them have long-term relations with one or more of the four labs. A coordinated planning of the research and its industrial contacts increases our ability to live up to the expectations of our partners, enables wider use of personal contacts, and makes collaboration more efficient.

Thus, with CERES as a central – and in fact the largest – actor, the School of IDE in June 2008 took the decision to form a unified research environment, starting its operation July 1st 2008. The name of the research environment is *Halmstad Embedded and Intelligent Systems Research (EIS)*, illustrated in Figure 5. In the new, larger research environment, CERES’ focus on cooperating embedded systems is combined with IS-lab’s, also very successful, research on intelligent systems, to form an EIS focus on *cooperating embedded systems for intelligent applications*. In support of the focus, EIS also encompasses research in informatics, semiconductor physics, nanoelectronics, and applied mathematics.

![Diagram of research environment](image)

**Figure 5.** The research environment EIS (Halmstad Embedded and Intelligent Systems Research) is supported by four competence areas (labs). Within EIS, CERES is a focused research programme developed and run in tight collaboration with industrial partners.

Within the larger environment, CERES will, of course, continue as a profile – a long-term focused research programme in collaboration with industry. We expect CERES to increase
its strength and competitiveness by the strategy to, in projects with industrial partners, consciously make use of the competence base of the entire EIS.

The forming of a unified research environment in embedded and intelligent systems enables strengthening not only of our own research, but also – through collaboration – strengthening of other research areas at the university. Examples include mechanical product design, innovation and entrepreneurship, healthcare and biotechnology, as well as environment and energy related research. In support of this, EIS is planning to extend its competence base via the formation of interdisciplinary groups: “EIS innovation group”, “EIS healthcare group” and “EIS energy and environment group”, all with the assigned task of building bridges to other research areas at the university, see Figure 6.

**Figure 6.** At Halmstad University, EIS relies not only on the competences in the four interacting labs of the School of IDE, but also on cooperation with other strong research environments.

**Evidence of Scientific Quality**

Scientific quality and industrial relevance are central to the development of CERES. Below we describe a few indicators of scientific quality, while industrial relevance will be covered in Chapters 5 and 6. Also, in Chapter 2 (The national and international competitiveness of the profile), the outcome of an external evaluation performed in 2008 will be described. The evaluation, which was concentrated on the two most central areas of EIS, i.e., CERES and IS-lab, clearly showed that the research in general has very high quality (as related to international standards), is considered excellent in some sub-areas, and demonstrates excellence in both industry cooperation and research education. (More in Chapter 2).

**Ph.D. and Licentiate examinations**

The scientific quality of the research has also been assessed through the external examinations and faculty oppositions taking place in connection with graduation as Ph.D. and Licentiate. Seventeen such examinations have taken place during 2003 – 2008; fourteen
of these have happened after the profile evaluation in April 2004. These fourteen are in the following areas:

- Wireless technologies in industrial communication systems (PhD, 2008)
- High-level programming of coarse-grain reconfigurable architectures (licentiate, 2008)
- Real-time communication in high-performance optical networks (licentiate, 2008)
- Energy efficient active RFID systems (licentiate, 2007)
- Real-time communication in high-performance networks (PhD, 2007)
- High-performance architectures for embedded signal processing (PhD, 2007)
- Real-time communication in distributed real-time systems (PhD, 2007)
- Computer architectures and languages (licentiate, 2006)
- Wireless networks (licentiate 2005)
- High performance communication networks (licentiate 2005)
- Real-time communication networks (licentiate 2004)
- Dependable wireless communication (PhD 2004)
- New models of computing (PhD 2004)
- Real-time systems design (licentiate 2004)

Zain-Ul-Abdin defending his Licentiate thesis (December 2008)

**Scientific publications**

The scientific productivity of CERES, in terms of published, full-paper reviewed scientific papers, is showing a very positive trend. 28 such publications appeared during 2008; this is a doubling compared to the average productivity over the previous five years. During the platform and profile periods of CERES, i.e., 2003 – 2008, the research group has published 93 full-paper reviewed scientific papers in international conference proceedings or journals. In addition, 8 invited chapters in scientific books have been produced.

In the research area of CERES, publications at well-renowned international conferences are often preferred, instead of journal publications. Some important conferences that CERES researchers have published at are:

- The IEEE International Parallel & Distributed Processing Symposium (IPDPS) and its workshops (HIPS, RAW, WPDRTS)
- The IEEE International Conference on Emerging Technologies and Factory Automation (ETFA)
• The IEEE International Conference on Industrial Informatics (INDIN)
• The IEEE International Symposium on Industrial Embedded Systems (SIES)
• The International Conference on Parallel Processing (ICPP)
• The International Symposium on Turbo Codes & Related Topics
• The IEEE International Conference on Embedded and Real-Time Computing Systems and Applications (RTCSA)
• The International IEEE Conference on Intelligent Transportation Systems (ITSC)
• The IEEE International Symposium on Wireless Vehicular Communication
• The International Conference on Engineering of Reconfigurable Systems and Algorithms (ERSA)
• The IEEE International Conference on Engineering of Complex Computer Systems (ICECCS)
• The IEEE International Symposium on Information Theory
• The IEEE Wireless Communications and Networking Conference (WCNC)
• The International Conference on Real-Time and Network Systems (RTNS)
• The World Congress on Intelligent Transport Systems (ITS)
• IEEE Vehicular Technology Conference (VTC)
• IFAC World Congress

Poster presentations: Edison Pignaton at ARM’08 and Zain-Ul-Abdin at ReConFig’08

Scientific Reviewing and Committee work

The researchers at CERES are frequently engaged as reviewers for scientific journals and conferences. During 2008 this includes: IEEE Transactions on Parallel and Distributed Systems, IEEE Transactions on Industrial Informatics, 16th Mediterranean Conference on Control and Automation (MED 2008), IEEE International Conference on Communications (ICC 2008), IEEE Transactions on Automation Science and Engineering, IEEE Transactions on Communications, IEEE Transactions on Wireless Communications, International Conference on Embedded Software (EMSOFT 2008), IEEE Vehicular Technology Conference (VTC Fall 2008), IEEE Vehicular Technology Conference (VTC Spring 2008), IEEE/ACM Symposium on Nanoscale Architectures (NanoArch 2008). (Several reviews each, in many of the cases, in total more than 30 papers). Magnus Jonsson and Elisabeth Uhlemann have been particularly active in serving the scientific community with review work during 2008.

CERES researchers have also participated in conference organization as program committee members, session organizers, or session chairs, for example at the following:


Magnus Jonsson, Tony Larsson, Bertil Svensson and Elisabeth Uhlemann have served as members of examination committees for PhD degrees at Blekinge Institute of Technology, Chalmers University of Technology, Linköping University, Lund University, Mälardalen University, and University of Western Australia. Magnus Jonsson and Bertil Svensson were expert evaluators for professorships at Örebro University and Linköping University, respectively. Tony Larsson was invited speaker at Sveriges Energiting 2008.

**International interest and awards**

The research by Elisabeth Uhlemann and Katrin Bilstrup about future technologies for communication between vehicles, as well as between vehicles and infrastructure, has attracted great interest not only in the research community but also with the European Telecommunications Standards Institute (ETSI). ETSI is an independent, non-profit, standardization organization in the telecommunications industry, and they have invited the CERES researchers for presentations and discussions.

Kristoffer Lidström won a Gold Medal in Young European Arena of Research, 2008. The competition, which attracted some 600 young researchers from all over Europe, was organized by the European FP7 Safety and Security programme. Kristoffer’s research, part of the CERES VAS project, deals with prediction of drivers’ behaviour in traffic situations. Preparation is now underway for demonstration of his results at the big ITS Symposium to be held in Stockholm in 2009.

Björn Nilsson, industrial PhD student at CERES and the CERES partner Free2move AB, won the RFID Nordic Award 2008 for his work on power-efficient protocols for active RFID systems. The competition was open for researchers from all the Nordic countries.

**Patents and Spin-off Companies**

Patent applications have been filed and patents have been approved based on research in the EGON project:

One approved Swedish patent: En anordning för trådlös manövrering och en metod för att manövrera anordningen. Inventors: Per-Arne Wiberg och Urban Bilstrup.

One approved PCT application: A device for wireless operation and method for operating the device. Inventors: Per-Arne Wiberg, Urban Bilstrup.

Also based on results and opportunities found in the EGON research project, a new company has been spun off: LeptonRadio AB, [www.leptonradio.com](http://www.leptonradio.com). CERES e-lab facilities and expert competence in microwave technology have been one of the keys to the successful development of another new company: Sondero Technologies, [www.sondero.com](http://www.sondero.com).

**International contacts**

During 2008, contacts with the following well known institutions have been further strengthened:

- **University of California at Berkeley, CA, USA:** Research collaboration.
  CERES PhD student Jerker Bengtsson made a two months visit to Professor Edward A. Lee at the EECS department and the Center for Hybrid Embedded Software and Systems (CHESS). Joint research related to the Ptolemy II project was developed, and the availability of the Berkeley tools and the associated knowledge has been of great importance for the final phase of Jerker’s PhD work. The contacts are continuing.

- **Technical University of Berlin, Germany:** Research collaboration.
  The research contacts between Dr. Elisabeth Uhlemann of CERES and Dr. Andreas Willig at TU Berlin, which started in 2006, have been further strengthened. Three joint publications and an application to EU FP7 are among the results. The EU FP7 application has also led to further developed contacts with, among others, the Institute Polytechnic Porto (IPP) in Portugal. Dr. Willig was also engaged as external reviewer of the initial parts of the PhD thesis of Urban Bilstrup.
• Scuola Superiore Santa Anna, Pisa, Italy: Research collaboration.

SSSA is a research contact of Halmstad University since 1993, which has included joint EU projects and conference organization. During 2008, Dr. Hoai Hoang Bengtsson has continued research jointly with Prof. Giorgio Buttazzo at SSSA. Contacts have also been established with an ongoing EU-project in embedded parallel processing.

• Universidad do Rio Grande do Sol (UFRGS), Brazil: Research collaboration.

Since February 2008 we have engaged a new PhD student, Edison Pignaton de Freitas, who has a Master’s Degree from Universidad do Rio Grande do Sol (UFRGS). Edison has during 2008 been involved in the S3 project. To establish a new academic contact and support Edison we have decided to cooperate with UFRGS and Professor Dr Carlos Eduardo Periera who will act as co-supervisor for Edison. Carlos does his research at UFRGS in the area of real-time distributed object computing and industrial automation and has also been visiting Halmstad to present his work. Likewise, CERES professor Tony Larsson has visited UFRGS.

Cooperation with Brazil. Professor Dr. Carlos Eduardo Periera, UFRGS/Brazil, (left) and Prof. Tony Larsson, CERES, (right) with joint PhD student, Edison Pignaton de Freitas

• University of Newcastle, UK: Strategic development of research and innovation contacts.

The contact with the University of Newcastle was initiated by the Health Technology Alliance. University of Newcastle has a “Campus for Ageing and Vitality”, and the city of Newcastle is putting specific efforts into the development of new innovations and business opportunities related to health and ageing. The A group from CAV, led by its Programme Director, Graham Armitage, has visited Halmstad. CERES personnel Roland Thörner (twice), Nicholas Wickström, Bertil Svensson, Anita Sant’Anna, and Wagner de Morais have visited Newcastle. There are many interesting opportunities for cooperation, both in research projects and in activities related to innovation support processes. A joint application in EU’s “Europe INNOVA European Innovation Platforms for Trans-national Cluster Cooperation” is one of the results (now awaiting evaluation by the Commission). The partners are: Newcastle University, Halmstad University, TU Munich (Germany) – as well as the associated innovation support organizations around the respective universities.
Visitors from Newcastle. From left to right, Ann-Mari Bartholdsson (Health Technology Alliance), Anne-Christine Hertz (Halmstad municipality), Nicholas Wickström (CERES), Gun-Marie Östedt-Axelsson (Representative for One NorthEast) and Bertil Svensson (CERES), hosted visitors from Newcastle: Reader Glenda Cook (Northumbria University), Director Graham Armitage (Newcastle University, Campus for Ageing and Vitality), and Professor Peter Gore (Newcastle University, Business School and ADL Smartcare Ltd)

In addition to the above, contacts with and visits at other leading research universities and other institutions have confirmed that CERES is working on highly important and relevant problems. In earlier years’ reports we have mentioned our contacts with Stanford University, University of California at Berkeley, Massachusetts Institute of Technology, IMEC, and Xerox, all confirming that we are approaching scientifically important and industrially relevant problems. These contacts are still active, although on a less intensive level.

- COST (an intergovernmental framework for European Co-operation in the field of Scientific and Technical Research): Contacts and interactions with COST Action 2100

Pervasive Mobile & Ambient Wireless Communications have been further strengthened. CERES researchers have participated in two Management Committee Meetings, one with a technical document presentation. The contacts with Prof. Christoph Mecklenbräuker, Institute of Communications and Radio-Frequency Engineering, Vienna University of Technology, Austria have been developed and led to a joint STREP application currently under evaluation.
2. The national and international competitiveness of the profile

In Sweden, CERES is generally recognized as one of the leading research environments within the real-time and embedded systems area – an area of considerable strength in Sweden. Some other groups are the Mälardalen Real-Time Research Centre (MRTC) in Västerås, the Embedded Systems Lab (ES-lab) at Linköping University, the Computer Engineering division at Chalmers, the Mechatronics group at KTH, and the Lund University Center for Applied Software Research (LUCAS). The other groups have other focuses, and CERES is unique in its specialisation towards cooperating embedded systems.

The publications and the research contacts make CERES well recognized internationally. Both have developed very positively during 2008. The number of publications has doubled compared to the previous year; thus during 2008 25 full-paper reviewed publications in international conferences were presented, and 6 journal papers were accepted (some of which appear in 2009). This increases the visibility of the centre even further. Strategically important research contacts, both within Europe and in the Americas, have been strengthened (as described in Chapter 1 and Chapter 3).

The strong position also comes from the strength of CERES’ industrial partners, all actively working in joint projects with CERES’ researchers and with each other. Examples:

Volvo is among the world leaders in technology for traffic safety and telematics. Researchers of CERES are working tightly together with not only Volvo engineers but also in European projects in which Volvo has a leading role. Ericsson is the world leader in mobile communication systems. During 2008, researchers at CERES have cooperated directly with the developers of future generation systems such as the WCDMA LTE (Long Term Evolution). Saab Microwave Systems is one of only a handful of companies in the world that is capable of developing future array-antenna based radar systems; in the cooperation with CERES the most demanding challenges for embedded signal processing are being addressed. Young, innovation based companies, such as Emwitech and Free2move, develop new supervision, communication and RFID systems for the world market.

Positioning of CERES

Our systematic effort to position ourselves in relation to important research centres or groups throughout the world – both centres with similar research programmes and specialized groups within our core areas – has continued, based on the model developed earlier year. The purpose is to learn from others as well as to set up interaction with selected groups, in particular with internationally leading groups in each of the key technologies of CERES.

In order to understand how each of the projects builds on the subject areas of CERES and contributes to the field of Cooperating Embedded Systems and to the advancement of applications, every project is positioned using the model that was shown in Figure 3 in Chapter 1. In Chapter 10, where all projects are described, such a positioning graph will be given for each of the projects. Summarizing all the graphs into one picture has also proved to be useful, since it reveals interesting patterns. One example is shown in Figure 7 (where most, but not all projects are included). This overall view reveals, among other things, that communication as a subject area is present in all projects, that almost all projects rely on
more than one subject area, and that several projects, from an application point of view, are motivated by their production of results that can be used in a variety of applications.

The approach of building projects that are based on several areas of expertise, as illustrated in Figure 3 and Figure 7, is a particular strength of CERES, distinguishing it from many other research environments and making it especially well-suited to cooperate with industry. In positioning CERES, this approach is therefore important.

In the positioning work, the researchers in each of the projects have identified relevant other projects that we can relate to, build up contacts with, and learn from. By way of example, related to the VAS project there is an EU project "CVIS - Cooperating Vehicles and InfraStructure", with which CERES researchers have written a memorandum of understanding to facilitate collaboration. Further, through Volvo Technology we have relations to the EU projects SAFESPOT and Pre-Drive C2X. Related to the EPC project, UC Berkeley, MIT and Stanford have projects on stream processing that take a unified language- and architecture view in the same way as we are doing; these are also projects that we have contacts with.
Figure 7. Positioning of CERES research projects in relation to subject areas (left) and application areas (right). The project names are in the centre, and indications of specific sub-areas are in the crossings.

- IPS: Implementation of Protocol Stacks
- S3: Situation Specific Surveillance
- VAS: Vehicle Alert System
- EPC: Embedded Parallel Computing
- ARFID: Active RFID Systems
- EGON: Ultra Low Power Active RFID
- REMOTE: Real-time Mobile Telecommunication
- WIREALMATICS: Wireless RT Communication for Telematics Applications
External Evaluation of Embedded and Intelligent Systems Research

As part of the quality control and development, the Research Board for Technology and Science at Halmstad University has decided to perform external evaluations of all research environments within its area of responsibility. The joint environment “Embedded and Intelligent Systems”, comprising CERES and IS-lab (Intelligent Systems Laboratory), was the first to be evaluated. The evaluation was performed during the autumn of 2008.

The appointed evaluation group represents significant experience in own research, research leadership, research financing and research evaluation. The group was led by Professor Per Eriksson, Director General of VINNOVA (The Swedish Governmental Agency for Innovation Systems) – now Vice Chancellor of Lund University. The other three members were: Professor Kim Guldstrand Larsen, University of Aalborg, Denmark, Professor Nahid Shahmehri, Linköping University, and Professor Robert Forchheimer, also Linköping University. Documents describing the research activities and results were first sent to the group. The group then visited Halmstad University for further presentations and, most importantly, interviews with almost all research staff and PhD students.

The group was asked to assess: the quality of the research, the direction and profile of the research, and the quality of the doctoral education. In its final report (available in its full length at http://www.hh.se/english/ide/researcheis), the group pointed out:

“Overall we find that the research conducted by the groups in EIS is very good. The research has such high quality that it attracts national attention and performs at an international level.

Certain subgroups perform at an excellent level. The research is of excellent quality, with publications normally having great impact, also internationally. Without doubt, the research has a leading position in its field in Sweden. Also, certain other subgroups have the potential to become excellent.

Furthermore, the long-standing collaboration with industry demonstrated by most of the research within EIS should serve as an excellent platform for future, high-quality research and publications.”

Strong areas mentioned in particular are real-time systems and wireless communications, as well as the fruitful combination of several existing competences to form a strong research environment. It was further pointed out that the group of post-docs is strong and has high potential.

The group found that the research competences cover nearly all essential aspects of intelligent embedded systems, and that they have significant impact on a number of applications in important areas, such as health, radar- and telecommunication systems, intelligent vehicles and transport systems. The excellent and extensive collaboration with local and national industry is recognized as a particular strength.

The choice made by the research environment to concentrate on prioritized application areas is appreciated. The areas, such as traffic and transport, health technology, and radar-and telecommunications, make the research strategically important and with high national and international impact.

The doctoral education, finally, is found to be excellent, both in its implementation and in its creative environment. The supervision is highly appreciated, and there is a good research culture.
Finally, the evaluators comment on the overall research area, intelligent embedded systems, in the following way:

“The topic of intelligent embedded systems provides an internationally established research area with high potential for research education, several open and challenging problems, as well as obvious industrial applications.”

One important conclusion that can be drawn from the evaluation is that the ongoing integration of several research groups, to form the EIS environment, bears promise to even further strengthen the research.

3. Cooperation and possibilities of cooperation with other universities

CERES has a wide-spread and active academic network, encompassing institutions in Sweden as well as abroad. Here we mention the most important ones.

National Cooperation

*Chalmers University of Technology* in Göteborg, 140 kilometers from Halmstad, is an important partner of Halmstad University in the research education. Until 2006, all Ph.D. students in CERES were registered at Chalmers (but with main supervisor and examiner at CERES). Bertil Svensson is a professor also at Chalmers (since 1991) and is the examiner of many of these students. Also Magnus Jonsson and Tony Larsson can act as main supervisors at Chalmers. In 2008, seven of CERES' fifteen Ph.D. students were registered at Chalmers, five of them at the Department of Computer Science and Engineering, one at the Department of Signals and Systems, and one at the Department of Microtechnology and Nanoscience.

In 2008, five associate professors and professors at the Department of Computer Science and Engineering at Chalmers were engaged as assistant supervisors of six of our Ph.D. students. One of them, Lars Bengtsson, has a part-time employment at CERES, with responsibilities also beyond Ph.D. student supervision. In addition, one professor at the Department of Signals and Systems at Chalmers, Erik Ström, has a part-time guest professorship at Halmstad University, including the supervision of one of CERES' Ph.D. students. MC2 (Department of Microtechnology and Nanoscience) and CERES are collaborating in a project aiming at new radio architectures. Here Halmstad University has one PhD student registered at MC2, with supervision both from Chalmers and Halmstad.

*University of Skövde* and *University of Örebro*. Effective January 1, 2006, Halmstad University has signed an agreement with the universities in Skövde and Örebro about joint PhD education. The three universities have very interesting complementary focuses within the information technology area, and they all have KK-supported research profiles. The agreement has given us the opportunity to form our own PhD education and benefit maximally from the interdisciplinary research environment that we have. A joint graduate school in Information Technology has been formed. In March 2008, the second joint workshop was hosted by Halmstad University, with faculty and PhD students from all three universities, altogether some 80 participants. The PhD students presented their current work which was discussed in seminar sessions with senior advisors from all the universities. At the end of 2008, CERES had eight PhD students enrolled in this joint PhD education. All, of course, have their main supervisors within CERES. In December, Zain-ul-Abdin became the first CERES PhD student to graduate in this cooperation. It is important to
point out that this new arrangement does not hinder us to continue our close collaboration with Chalmers.

*Other Swedish Universities and Research Institutes.* In the various research areas of CERES, we also have frequent contacts with groups at other universities (Linköping University, Lund University, Mälardalen University, Jönköping University) and research institutes (SICS, Imego, SP, The Viktoria Institute). In particular, the relations with Imego continue to be very tight through our cooperation with them in the KKS-funded expert competence programme minST – Micro and Nano Systems. SP Technical Research Institute of Sweden, being a partner of CERES, is involved in direct research project cooperation. During 2008, the two Vinnova funded projects ILISIS (together with SP and Jönköping University) and TripleN (together with Imego) were finished. As a result, each of the projects has led to the signing of long-term cooperation agreements between the partners. Thus, ILISIS and TripleN activities continue.

*SAFER.* Chalmers, SP and Volvo Technology take part in SAFER, a Vehicle and Traffic Safety Center at Chalmers, [www.chalmers.se/safer/EN](http://www.chalmers.se/safer/EN), together with Autoliv, The Swedish Road Administration and Lindholmen Science Park, among others. Katrin Bilstrup and Elisabeth Uhlemann of CERES therefore have a clear connection to SAFER through Erik Ström and participate in pre-studies and other SAFER activities. This collaboration has also led to Erik Ström accepting an SSF sponsored exchange position at Volvo Technology, to be able to spend half of his working time on industrial research and development in vehicular communications.

*SAVE-IT* is an industrial graduate school with a research focus on real-time and safety-critical systems. SAVE-IT is sponsored by the Knowledge Foundation and is managed by Mälardalen University. CERES has during 2008 had one PhD student in SAVE-IT.

**International Cooperation**

CERES and its researchers have a rich international contact network. Some of the contacts have developed into true collaboration resulting in joint work and publications. The most important are the following:

*Portland State University* and *Oregon Health and Science University*, Portland, OR, USA. Dan Hammerstrom, who is an adjunct professor at CERES, is professor and Associate Dean of Research at Portland State University. Reconfigurable architectures and nano-architectures are areas in which our collaboration has been further developed. Leveraging on these academic contacts in Portland, CERES also has developed connections to the largest Intel site in the world, the architecture development and manufacturing site in Hillsboro, OR. This also includes contacts with Intel's Health Research and Innovation Group.
Discussions about health care technology. Misha Pavel, Holly Jimison, Ann-Mari Bartholdsson and Nicholas Wickström

There are also contacts with OHSU in the area of intelligent signal processing, particularly in health monitoring and health care applications. Professor Misha Pavel, leading the Point of Care Lab at OHSU, has been in the reference group of CERES since 2007. In connection with the CERES reference group meeting in February 2008, professor Pavel and his colleague, Dr. Holly Jimison, made a longer visit to CERES and discussed cooperation possibilities. Project cooperation has evolved, including a two-month visit at OHSU by Anita Sant’Anna, who is a PhD student in the CERES research project SELIES.

University of California at Berkeley, CA, USA. UC Berkeley has some of the most influential research groups in some of the key technology areas of CERES, such as parallel computer architecture and wireless communication technologies, and has therefore been identified as a strategically important contact point for CERES. Earlier we have had contacts with the Berkeley Wireless Research Center. The contacts with UCB were significantly strengthened by the two-month visit made by CERES PhD student Jerker Bengtsson in the beginning of 2008. Jerker visited Professor Edward A. Lee at the EECS department and the Center for Hybrid Embedded Software and Systems (CHESS), and he developed joint research related to the Ptolemy II project at UCB. The contacts are continuing.

Technical University of Berlin, Germany. During 2008, the research contacts with TU Berlin, which started in 2006, have been further strengthened. Dr. Andreas Willig at TU Berlin was engaged as external reviewer of the initial parts of the PhD thesis of Urban Bilstrup. Joint publications and a joint EU application are also among the results. The work with the EU application has also led to further developed contacts with the Institute Polytechnic Porto (IPP) in Portugal.

COST action 2100, in which CERES assistant professor Elisabeth Uhlemann has been involved, has led to a joint STREP application with e.g., Vienna University of Technology, Austria, that currently is under evaluation.

Scuola Superiore Santa Anna, Pisa, Italy. SSSA is a research contact of Halmstad University since 1993, and earlier joint work has included EU projects and joint conference organization. During 2008, Dr. Hoai Hoang has continued research jointly with Prof. Giorgio Buttazzo at SSSA. Contacts have also been established with an ongoing EU-project in embedded parallel processing.
Universidad do Rio Grande do Sol (UFRGS), Brazil. UFRGS is one of the leading research universities in Latin America. The recruitment of a new PhD student with a Master’s degree from UFRGS led to the setting up of cooperation in research and research education between CERES and UFRGS. Professor Tony Larsson at CERES and Professor Dr Carlos Eduardo Periera from UFRGS will thus co-supervise the PhD student, Edison Pignaton de Freitas, working in the area of real-time distributed object computing. The cooperation has already resulted in several joint publications.

Newcastle University, UK. Newcastle University with its associated innovation system related to health technology has been identified as an interesting partner for CERES and EIS. The contact was in fact initiated by the Halmstad-based Health Technology Alliance. The Newcastle “Campus for Ageing and Vitality”, and the city of Newcastle’s specific efforts into the development of new innovations and business opportunities related to health and ageing constitute a perfect match to similar initiatives in and around Halmstad University. During 2008, visits of several people, in both directions, have taken place. There are many interesting opportunities for cooperation, both in research projects and in activities related to innovation support processes. A joint application in EUs “Europe INNOVA European Innovation Platforms for Trans-national Cluster Cooperation” is one of the results (now awaiting evaluation by the Commission). The partners are: Newcastle University, Halmstad University, TU Munich (Germany) – as well as the associated innovation support organizations around the respective universities.


PhD students in discussion. Wagner de Morais and a colleague at Living Lab in Newcastle.
4. Effects on education: undergraduate, master and PhD

Two-year Master Programme “Embedded Intelligent Systems”

Halmstad University addresses profiling in education by offering two 2-years Master programmes: “Embedded Intelligent Systems” and “Management of Innovations and Business Development”. Both programmes passed an evaluation by the National Agency for Higher Education in the spring of 2007. Two criteria were central for the agency: research and research education. In this, CERES played a very important role, together with the Intelligent Systems lab, for Halmstad University’s right to offer 2-year Master programmes in Computer Science and Engineering. CERES together with the intelligent systems lab, have become the flagship of Halmstad University in its profiling strategy. For the academic year 2008/2009 the programme “Embedded Intelligent Systems” was redesigned to include high profile courses very much influenced by CERES. These new courses are Embedded Systems Programming, Cooperating Intelligent Systems, Embedded Parallel Computing and Design of Embedded Intelligent Systems. All of these courses are taught by CERES staff in cooperation with the intelligent systems lab.

We also offer an International Master programme in Information Technology together with technical universities in Germany, Denmark and Poland.

All senior researchers of CERES are responsible for one or more courses in the Master’s programmes and also share the responsibility for supervising thesis projects. CERES PhD students are active as tutors in the laboratory, as seminar leaders and as assistant supervisors of projects. Researchers and industrial contacts are invited to act as opponents for Master theses.

Undergraduate and Master Education

CERES researchers and PhD students are actively involved in the process of developing new courses, in teaching them and in supervising Bachelor and Master theses. The great majority of Master theses in computer science and engineering are initiated from CERES projects. We strive for international publication of results wherever suitable. During 2008 results from Master theses were published at the The Fourth International Conference on Wireless and Mobile Communications (ICWMC 2008), World Congress on ITS, New York, NY, 2008 and at the Swedish National Computer Networking Workshop (SNCNW 2008).

CERES partners are a natural source for cooperation in education. Our partner companies are active in committees that follow our education programmes, and collaborate in thesis project formulation and supervision. We are currently working together with the board for education to more actively include our partners also in courses.

All programmes in computer science and engineering at Halmstad University make use of CERES for marketing purposes targeting new students. As a motor in reaching a wider variety of good candidates to computer science and engineering programmes, CERES has initiated a project to better understand gender and diversity issues. The project, which is sponsored by VINNOVA and runs from December 2008 to December 2011, builds on applied gender research performed by the ARGUS research group at Halmstad University. Aimed at influencing not only research and education, but also a wider “innovation
system”, the project is specifically targeting the research and development activities related to applications in health care. The project, entitled “Gender Perspectives on Embedded and Intelligent Systems – Applications in Healthcare”, is further described in an extended abstract in the Appendix.

**PhD Education**

During 2008 the research at CERES resulted in one PhD thesis and two licentiate theses.

Urban Bilstrup defended his PhD thesis “Blu etooth and Wireless Multihop Networks in Industrial Communication Systems” on December 19, 2008. The defence took place at Halmstad University and the opponent was prof. Orazio Mirabella from Catania University, Italy.

Kristina Kunert defended her licentiate thesis “Fiber-Optic AWG Networks Supporting Real-Time Communication in High-Performance Embedded Systems” on December 11, 2008. The presentation took place at Halmstad University and the discussion leader was Dr. Thomas Nolte from Mälardalen University, Sweden.

Zain-ul-Abdin defended his licentiate thesis “High-Level Programming of Coarse-Grained Reconfigurable Architectures” on December 18 2008. The presentation took place at Halmstad University and the discussion leader was prof. Mats Brorsson from the Royal University of Technology, Sweden. Zain’s thesis is the first degree earned at Halmstad University as a result of the collaboration with Örebro University and Skövde University in the field of Information Technology.

After their graduation CERES PhDs have found their way to industry. Of the graduates in 2007, Anders Åhlander is now with SAAB in Gothenburg; Xing Fan is with Ericsson Research in Lund; and Hoai Hoang is employed by Combitech in Gothenburg – but also part-time in the CERES research environment as a KK-financed post-doctoral researcher (“gränsgångare”). Urban Bilstrup, who graduated in December 2008, has joined SAAB in Linköping, where he works in a big European R&D project on future standards for radio communication.

**New PhD students**


A new PhD study course on Scientific Communication was taught for the first time during the spring of 2008.

All CERES PhD students have a follow up group of three senior researchers that meet regularly (once or twice a year) to update study plans and publication strategy.
Abstracts of Doctoral and Licentiate Theses, 2008

Bluetooth and Wireless Multihop Networks in Industrial Communication Systems

URBAN BILSTRUP

PhD Thesis, School of Information Science, Computer and Electrical Engineering, Halmstad University, and Department of Computer Science and Engineering, Chalmers University of Technology

Opponent: Professor Orazio Mirabella, University of Catania, Italy
Examination Committee: Mats Björkman, Mälardalen University, Bengt Lennartson, Chalmers University of Technology, and Dag Stranneby, Örebro University, all in Sweden.

Abstract. The objective of this thesis is to investigate the use of short-range wireless communication technology in industrial communication systems where there is a need for guaranteed timely delivery of correct information. Methods for achieving such capability are developed in the context of the physical layer, the data link layer and the application layer. Based on the insight that it is impossible to achieve strict determinism in a wireless communication system, a probabilistic definition of hard real-time systems is suggested, and thus a guarantee is given in the form of the probability of fulfilling a certain goal. Since a wireless channel is time variant, it is also necessary to continuously keep track of available resources. Allocation and link management methods for wireless communication systems therefore need to be dynamic and of an online character. An exhaustive resource allocation method with redundancy is first proposed for single message delivery and then extended for the operation of a single Bluetooth piconet. However, many devices in an industrial automation system have limited computational resources, especially if wireless sensors/actuators powered by battery or wireless power are considered. This implies that methods used for resource allocation must be of low computational complexity.

The complexity issue becomes evident when large systems are implemented, even if each individual sensor generates small amounts of data. The upstream and downstream flows of data grow rapidly in a hierarchical system with many sub-systems, sensors and actuators. It is empirically shown that the aggregated data flow in a monitoring system requires powerful communication nodes already at low levels in the industrial communication hierarchy. A predictable system requires that representative entities for the available resources are defined. In a communication system with a single broadcast domain, such as a single Bluetooth piconet, the resource space is often limited to the time domain. When a multihop wireless network with multiple broadcast domains is considered, the spatial domain is added as an available resource and, if a multi-channel radio transceiver is used, the frequency is also added as an available resource domain. These three domains represent the physical resource space that is available for a wireless multihop network. These are subject to trade-off in all of the three lowest protocol layers, and one of the most challenging problems in the design of a wireless multihop network is how to achieve efficient sharing...
of these resources. This problem is addressed by proposing a clustered architecture based on a dual-radio node that enables dynamic use of these resource domains.

**Keywords:** Bluetooth, industrial communication systems, short range devices, wireless multihop networks, wireless sensor networks, real-time communication, resource allocation

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**Fibre-Optic AWG Networks Supporting Real-Time Communication in High-Performance Embedded Systems**

**KRISTINA KUNERT**

Licentiate Thesis, School of Information Science, Computer and Electrical Engineering, Halmstad University, and Department of Computer Science and Engineering, Chalmers University of Technology.

**Opponent:** Dr. Thomas Nolte, Mälardalen University, Sweden

**Examiner:** Professor Bertil Svensson, Halmstad University and Chalmers University of Technology; Sweden

**Abstract.** High-performance embedded systems communicating heterogeneous traffic with high bandwidth and strict timing requirements are in need of more efficient communication solutions. This thesis proposes two multi-wavelength passive optical networks able to meet these demands. The networks are based upon a single-hop star topology with an Arrayed Waveguide Grating (AWG) placed in the centre. The intended application areas for the two networks are short range embedded communication systems like System Area Networks (SANs) and router architectures with electronic queuing. The AWG’s attractive property of spatial wavelength reuse, as well as the combination of fixed-tuned and tuneable transceivers in the end nodes, enables simultaneous control and data traffic transmission. This, in turn, makes it possible to support heterogeneous traffic with both hard and soft real-time constraints.

Additionally, two Medium Access Control (MAC) protocols, one for each network solution, are developed. Traffic scheduling is centrally controlled by a node, the protocol processor, residing together with the AWG in a hub. All nodes use Earliest Deadline First (EDF) scheduling and communicate with the protocol processor through physical control channels. A case study, including simulations, in the field of Radar Signal Processing (RSP) and simulations using periodic real-time traffic are conducted for the two application areas respectively, showing very good results. Further, a deterministic real-time analysis is
conducted to provide throughput and delay guarantees for hard real-time traffic and an increase in guaranteed traffic is achieved through an analysis of existing traffic dependencies in a multichannel network. Simulation results incorporating the traffic dependency analysis indicate a considerable increase in the possible guaranteed throughput of hard real-time traffic.

**Keywords:** Arrayed Waveguide Grating (AWG), real-time communication, optical communication, network architecture, optical network, medium access control (MAC) protocol, real-time analysis, traffic dependency analysis.
Networks (KPN) are gaining wider acceptance. Our hypothesis is that the use of languages based on appropriate model of computation enhances the productivity and allows better use of resources without compromising performance. As a proof of concept, experimental studies are performed based on CSP as a selected model of computation. The first study involves a concurrent language, which is used to generate descriptions for FPGAs. In the second, an approach of compiling a CSP based language, occam-pi, to a reconfigurable processor array is evaluated. The method is based on developing a compiler backend for generating native code for the target architecture.

5. Business relevance

The shift, in the embedded systems area, from stand-alone to communicating systems is a strong driving force in CERES focus on Coordinating Embedded Systems. The strong industrial cooperation serves as a compass for guidance to the most important application areas.

For the cooperating companies the research has several aims: producing PhDs with a strong edge in the specific area, getting useful results from the joint projects, as well as increasing the company’s knowledge about future trends and the R&D frontier.
Some of the companies that CERES has collaboration with are situated in the very vicinity of the University, locally in Halmstad. These companies are spin-offs from the University education or research and have grown to well-established companies. It is important for these local companies to be able to recruit skilled people on both Master and PhD level. With an increasing globalization and competition the demands on recruitment of skilled personnel, including PhDs, have high priority.

In total, at least twenty (20), today active, companies can be identified as spin-offs from the subject areas of the University that CERES represents. These companies together employ close to 400 persons, a majority of them BSc or MSc graduates from Halmstad University within computer, electrical and mechatronics engineering. Three of these companies are long-term research partners of CERES (Emwitech/Lansen, Free2move, Innovation Team), others are involved in other project cooperation (Lepton Radio, Phoniro, Sondero Technologies).

The research group has developed cooperation with companies also in other parts of the country, with an emphasis on the Göteborg area (Ericsson, Imego, Saab Microwave Systems, Volvo, XCube Communication).

As mentioned above, all research projects of CERES involve collaboration with one or more companies in one form or the other. Details of this will be given in Chapter 10: “New, ongoing and finished projects during the year; earlier finished conducted projects”.

In terms of industrial application areas, CERES is focusing on three in particular, namely: high-performance signal processing applications (advanced sensing and communication systems), intelligent traffic and transportsystems, and health and elderly care.
Advanced Sensing and Communication Systems

Among the CERES partners, Ericsson and Saab Microwave Systems base many of their products on advanced knowledge of computer architectures for signal processing, thus giving them a lead in time over more state-of-the-art based solutions. Within Ericsson, some of the grand challenges appear in base stations for future radio communication systems, such as WCDMA-LTE (long-term evolution). For SMW, the signal processing in future, array-antenna based radar systems represents a significant challenge in terms of sheer performance (TeraFLOPS), but also in power dissipation and volume. The parallel and reconfigurable architectures – and their programming models and tools – studied at CERES, are key technologies for high-performance signal processing applications.

Traffic and Transport

Even though improvements in automotive safety have caused a significant decline in the number of traffic fatalities there is a strong need for further work. One important area is wireless communication from vehicle-to-vehicle and vehicle-to-infrastructure which enables a lot of new cooperative traffic applications ranging from collision avoidance to intelligent cruise control. Similar technology can be used for making public transportation systems more efficient. Also transport of goods can be made safer, more secure and efficient by help of telemetry and tracking online in real time. Companies involved in joint research in CERES projects with traffic and transport applications are Free2move, SP, Volvo and XCube Communication.

Health and Elderly Care

Europe is facing a demographic challenge with an ageing population. The development of technologies to support elderly people to continue to live an independent life may be a key to meeting this challenge. The term “Ambient Assisted Living” (AAL) is sometimes used for description of how some of these supporting technologies may be used. It is believed that technology development in this area may create new economic and business opportunities in Europe.

These technologies are typically based on embedded sensors, processors and actuators – embedded in the environment or worn by persons. Co-operation among them is the basis for the system’s functionality, and this is therefore a natural application arena for CERES, often in collaboration with the other labs within EIS. Much of the research draws additional strength from the regional network “The Healthcare Technology Alliance”, incorporating
about 50 companies and a handful of caregiver organisations (such as municipalities). Some of these have been involved in Living Lab based projects and furthermore in joint planning and application for EU-financed research and innovation projects.

**CERES e-Lab**

Through a donation from “Sparbanksstiftelsen Kronan” of 3.5 MSEK over 2005, 2006 and 2007, the new facility e-Lab was formed. The laboratory is a meeting point for researchers and companies active in the area of electronic design and testing. e-Lab has further increased its activity during 2008. It has attracted companies from near and far. Some of these companies are CERES members such as Free2move, who conducts tests of their RF-designs in the lab.

The start-up of new companies, such as Lepton Radio and Sondero Technologies, has been enabled by the e-Lab facilities. Lepton Radio AB has been formed for commercialization of the research in the Egon project, funded by the Crafoord Foundation. This research project aims at the development of a novel, extremely energy-efficient radio technology. The e-Lab is used for both design and verification of the chips that are being produced during the project. Sondero Technologies uses the e-Lab facilities to verify and further develop a new, radio-wave based sensor technology with vast application opportunities.

Emil Nilsson e-lab, working in the EGON project
Innovation Support for SMEs

The research competence of CERES is made available to many other companies than the CERES partners. To a great extent this is done through the various innovation support projects that CERES is or has been involved in: minST and teknIQInnovation, sponsored by The Knowledge Foundation, and IILISIS and TripleN, sponsored by VINNOVA. These are all described in the Appendix of Extended Abstracts.

The teknIQInnovation programme is of particular interest, since it has developed a new method for cooperation with small and medium sized enterprises (SMEs). This method, which is based on clearly defined steps and active involvement from the company, is now influencing other expert competence programmes at the Knowledge Foundation. A handbook has been authored by the project leader, Roland Thörner of CERES (see publication list). Also, the method of working is now (starting 2009) being applied in a bigger scale in a larger regional project.

Roland Thörner

6. Commercial motives for the participating commercial enterprises

In connection with the latest meeting with CERES Industrial Advisory Board, in which all partner companies are represented, we asked the representatives to formulate their commercial motives for partitioning in CERES. Here are these quotations:

**Ericsson AB** is a world-leading provider of telecommunications equipment and related services to mobile and fixed network operators globally. 40 percent of all mobile calls are made through Ericsson-made systems. Ericsson has more than 60 000 employees worldwide. Current research related to CERES areas of strength concerns technologies ‘beyond 3G’ and sensor networks for safety and security. In CERES, Ericsson engineers and researchers in Stockholm, Göteborg and Mölndal take an active role in projects on architectures for high-performance signal processing as well as in “Situation Specific Surveillance”.

“Products from Ericsson AB consist to a very large extent of embedded systems, and networking such. To be a member of CERES means not only being in contact with a research group, addressing the area, but also to have the potential to work with other industries interested in embedded systems, with perhaps other views on the subject. The multi-disciplinary aspect of CERES is both its strength and attraction, gathering both academic expertise and industrial experience. Further, the centre also has the potential to serve as an excellent common research platform for both academic and industrial interests, hosting creativity and an extended contact network. (Peter Olanders)
Combitech AB is a leading supplier of services within system development, system integration, information security and system safety. Combitech has about 800 employees in 20 locations in Sweden. The company is part of the Saab Group, which is one of the world’s leading high-tech companies with primary operations within the defense and aerospace industries. Customers are primarily from such industries as defense and telecommunications.

“We participate in CERES in order to maintain and improve our competence in the area of advanced embedded systems. Thanks to the CERES cooperation we also get insight in related research fields and valuable personal contacts with people from the academic world as well as from leading providers of state-of-the-art embedded applications.” (Peter Gelin)

Volvo Technology AB (VTEC) is an innovation company within the Volvo Group and develops new technology, new product and business concepts for "hard" as well as "soft" products for the transport and vehicle industry. VTEC is based in Göteborg with site offices in France and the US and have about 400 employees. VTEC plays an active role in the CERES research project “Vehicle Alert System” aiming at increased traffic safety:

“During 2008, the CERES team has once again proven their ability to provide practical research results that complement Volvo’s efforts in European Research and Standardisation. Through dissemination of important research results at events like the ITS World Congress and ETSI meetings, CERES researchers have earned respect and made valuable and innovative contributions to the current efforts of standardising vehicle-to-vehicle and vehicle-to-infrastructure communication in Europe and North America” (Niclas Nygren)

Saab Microwave Systems (formerly Ericsson Microwave Systems) is a world leader in the design of advanced radar systems. The Company has about 1 250 employees and is based in Göteborg and Mölndal about 150 km from Halmstad. The cooperation with the researchers at Halmstad University in different joint projects has been going on since 1993.

“CERES is a way for us to get new influences from the research community, but also to strengthen the competence of our engineering personnel by actual participation in the research projects. We appreciate the long term focus in the research. Yet we have already got results that can be used, and partly have influenced our roadmaps and designs.” (Per M Ericsson)
SP Technical Research Institute of Sweden is one of Sweden’s largest research institutes, with a staff of about 870. The headquarters of SP is located in Borås (about 160 km from Halmstad). Branch offices can be found at several places in Sweden. The department of electronics is specialized in dependable systems, and brings its expertise to CERES projects in traffic safety.

“Research cooperation with leading research centres at universities is an important strategy of SP Technical Research Institute of Sweden. The CERES initiative helps SP to develop knowledge of dependable, cooperating embedded systems. The research results are applied in the development services and validation services offered by SP to industry. (Jan Jacobson)

XCube Communication has developed the first and only service that creates real-time visibility and actionable data to the less-than-load cargo owner without cooperation from the transporter, regardless of mode. The system is multi-modal, carrier independent, and flows through the supply chain. Different supply chain players are provided with the location and environmental conditions of the goods within the chain. Based in Göteborg and in Westford, close to Boston, USA, it has nine employees. XCube participates in the CERES projects “Situation Specific Surveillance” and “Architectures for Logistics Telemetry Applications”

“A company with lean organization acting in a high-tech market such as ours needs to be agile in creation of products. One of the most important factors enabling agility is close cooperation and participation in research activities aiming for our niche. CERES is a great match between our R&D needs and their areas of expertise. This cooperation will help us enhance our uniqueness and serve our customers as they expect.” (Christian Wigren)

Innovation Team is a consultancy company within the medical device and advanced technology field. It was founded by fresh graduates from mechatronics and innovation engineering in 1991 at the University of Halmstad. Currently with about 40 employees, it is based in Halmstad with sales office in Copenhagen, Denmark.

“Our goal with participation in CERES is to find and develop new technology that can improve user friendliness. This specially applies when advanced technology is merging into the medical device field, since many of the end users are “low-tech” users.” (Christian Kaestner)

Free2move AB is start-up founded by two of the University’s researchers in 2001. Its stock is noted on the Stockholm market. Free2move develops and offers wireless communication products based on RFID and Bluetooth technologies. It is based in Halmstad, with a sales office in Kuala Lumpur, Malaysia, and has twenty employees. Free2move participates in projects involving radio technology and has an industrial PhD student in CERES.
“Free2move is still a small development company which mainly builds its business on innovative development of products for wireless communication. It is of utmost importance for us not only to stay updated about state-of-the-art in our area but also contribute to it. CERES gives us a unique opportunity to do this. Participating in the projects that are formulated within CERES conveys new knowledge and competence, which would otherwise have been very difficult to achieve for us.” (Per-Arne Wiberg)

Emwitech AB is a spin-off company from Halmstad University, focusing on the market for security and surveillance products. The company joined CERES one year after the start of the profile and is participating in projects in the sensor networks area.

“The benefit of participating in CERES for Emwitech AB is grounded in the fact that Emwitech, as a small company, doesn't itself have the necessary resources to explore and manage all aspects and technical opportunities in the embedded systems area. Our range of products includes small wireless surveillance units with limited CPU capacity. These products need a special type of modular software smart functions to become really operational. We believe the cooperation with Ceres can provide us with new knowledge.” (Johan Sedelius Hörberg).

7. Growth potential of the profile

University strategy
Halmstad University’s strategy for research and education, adopted by the University Board in December 2007, states the importance of profiling and concentration to areas of strength. Of particular importance are the subject areas that carry the rights to train and give degrees at the Master and PhD level. It is stated that Embedded and Intelligent Systems is such an area. The Master examination rights in Computer Science and Engineering are already earned, and the University intends to apply for the PhD examination rights as soon as it is formally possible to do so (which is expected to be the case in January 2010).

CERES strategy for growth
As part of profiling, one joint research environment has been formed (July 1st, 2008) at the School of IDE, focusing on Embedded and Intelligent Systems. The new organization is called Halmstad Embedded and Intelligent Systems Research – EIS. The new formation will give great opportunities for a growth of CERES, both because the CERES research programme is such an important player in one of Halmstad University’s prioritized areas and because we see benefits in increased cooperation within EIS. Such cooperation will, for example, give us improved attractiveness for projects where the whole chain from enabling technologies, via systems solutions and applications, to end usage and business models is important to address. The joint research environment will also give a stronger platform for industrial partnership, where CERES can increase the number of industrial partners.

Outside the University, the strategic collaboration with research institutes in West Sweden (Imego and SP) also adds to the strength and growth potential of the centre.

We have seen that there is great industrial interest in our competence in embedded systems in general, and cooperating such systems in particular. This is a generally applicable technology, and it definitely represents an area of industrial growth. The Seventh
Framework Programme of the European Union states that ‘information and communication technology (ICT) is at the very core of the knowledge-based society’. Embedded systems play a key role in several of the seven challenges that the ICT work programme of FP7 focuses on.

By building strengths in well-chosen, expanding application areas of cooperating embedded systems – such as healthcare, intelligent transportation systems and advanced sensing and communication systems – the potential both for new industrial cooperation and for external financing grows considerably (in a Swedish as well as a European perspective). This is one of the strategies for growth of the profile. We see potential in increasing the number of application areas in the future, without losing focus and strength in each area. Two reasons for this are that we plan for growth of CERES and that we see increasing collaboration with other labs within the EIS environment. Those other labs add competence in other application areas. Healthcare in particular is a growing area where we see great opportunities. CERES, the Intelligent Systems Laboratory (IS-lab) and the Laboratory for Man and Information Technology (MI-lab) have, for example, received funding from VINNOVA for a “living lab” related to product development and research in healthcare and elderly care technology.

The ongoing profiling process also brings new collaboration between the University’s existing areas of strength. In case of CERES, we see an interesting potential in enhancing the cooperation with the groups of: Care, health and sports; Design, innovation and entrepreneurship; and Energy and environment.

**Recruitment for growth**

In the PhD student recruitment during the first two years of the profile period, we noticed that the interest in the research programme from highly qualified candidates is great. Interviewing the candidates, we find that what is especially appealing in the centre is the close collaboration with high-tech companies. We expect that this attractiveness of CERES holds also when we now also plan to recruit young graduated researchers to conduct projects together with the industrial partners. During 2008 plans for joint recruitment was drawn up with CERES partners Volvo Technology and Saab Microwave Systems. Recruitment of assistant professors for this cooperation will take place during 2009, with financial support from The Knowledge Foundation. Joint post-doc planning with CERES partner Combitech was also made – also with KK support. Thus, Hoai Hoang, a CERES doctoral graduate of 2007, who is employed by Combitech, is part-time post-doc at CERES.

Recruitment of young researchers is important for expanding the potential of CERES and making it even more competitive. Recruitment of more senior researchers is also on the agenda – one associate professor in computer engineering (ongoing), and one professor in computer science (planned for 2009).
8. Possibilities of continuation after support from the Knowledge Foundation has ended

Generic technology combined with other competences

The long-term financing strategy for CERES is based on the fact that cooperating embedded systems is a generic technology, which means that it is broadly applicable and easy to combine with other special competences. Such competences can be found both within the University, at other universities (in Sweden and abroad), and in industry.

This opens up opportunities for financing in new programmes, including programmes oriented towards particular application areas. The industrial areas that CERES has decided to focus on in particular (i.e., intelligent traffic and transport, health- and elderly care, and advanced sensing and communication systems) are all expanding areas in which the need for research programmes can be foreseen.

CERES has already been involved in several initiatives where our research competence is combined with other specializations. Examples are:

(1) A proposal for a Centre for Applied Intelligent Systems, which was evaluated by VINNOVA during 2006. In this program, the new solutions for cooperation among embedded systems are seen as enabling technologies for intelligent industrial applications. The proposal received extremely positive evaluations by the reviewers but, in spite of this, was not funded.

(2) An application to the Swedish Research Council in 2007 for a so called Linné centre in the field of biometric communication (IS-lab, CERES and other groups). In the extremely tough competition, the proposal was not funded.

(3) An application to SSF’s programme Software Intensive Systems in 2008 for a large project entitled Cooperative Embedded Intelligent Systems. This joint proposal with IS-lab and MI-lab was intended to do experimental research on software component and system integration techniques supporting intelligent surveillance, monitoring and supervision systems. The results would be demonstrated in an elderly care application enabled by wireless sensor and actuator network techniques. Elderly care requires adaptive “around the clock” monitoring and if a specific pattern or an anomaly is detected, with strong personal integrity constraints, real-time decisions and actions shall follow. Systems of this kind work under embedded constraints, such as bandwidth and energy limitations and must give dependable behavior while based on partly unreliable radio transmission. Surveillance and monitoring of humans also requires that the system has an ability to learn individual behaviors in a modular fashion. Overall quality of service is important and influenced both by the intelligent signal processing methods and the system integration techniques used. The goal of the project was to develop and evaluate methods, based on both disciplinary and systems oriented research, for how to design embedded intelligent software components and systems. The proposal received positive review comments, but was not funded.

(4) An application in 2008 to VINNOVA’s programme Innovations for Future Health. This application for a five-year support to build up a research and innovation environment (SILVER - Smart innovations in elderly living for early recognition of age related impairments) was developed together with University of Skövde and Örebro University. It built upon strengths from three KK profiles, one at each university. The vision of the initiative was to establish a cross-disciplinary research and innovation centre that enables widespread use of user acceptable domestic monitoring technology for prolonging
independent elderly living and facilitating early diagnosis of age-related impairments. This would be achieve by a threefold effort: (i) Research & technology development with focus on smart-home solutions i.e., intelligent sensors, information fusion, intelligent decision making, planning etc; (ii) Developing methodologies for technology evaluation hand-in-hand with end-users and care/health providers; and (iii) Commercialization effort and business models addressed early in the development process. In the evaluation, received in December 2008, SILVER was ranked among the 19 (of 103) proposals that were invited for an extended proposal. (Unfortunately, then in the final round, it was not among the 5 funded ones – decision received in March 2009).

Clearly we see continued initiatives in this direction as a natural roadmap for CERES and associated research groups at Halmstad University. This has actually been a strong reason for building a coordinated, broader research environment, as described earlier in this report. The strategy of striving to get funding for large, long-term research programmes must be combined with a strategy to reach the necessary financing level also through a large number of smaller project funding. Important in that case is to stick to a long-term research idea and vision. These are issues constantly being discussed in the CERES leading group, with the industrial partners, with the CERES reference group, as well as in the steering group of EIS.

**Importance of industrial cooperation**

The great interest in CERES from leading Swedish industries forms a good basis for financing from funding agencies such as the Foundation for Strategic Research (SSF) and VINNOVA. Therefore, one strategy of CERES is to further strengthen the relation with the existing partner companies of this category, and also to extend the number of such partners. These are companies that are engaged in research collaboration with several Swedish universities. Our strategy is to become/stay the preferred research partner for selected technology areas within the companies. For example: parallel and reconfigurable architectures and programming methodology for future signal processing in radar systems and radio base stations; sensor network technologies for safety and security; vehicle-to-infrastructure communication for traffic safety.

To be able to attract long-term research funding, we see great advantages in our new organization of a strong, coordinated research arena focusing on Embedded and Intelligent systems, on which large, focused research programmes can be built. Our ambition is also to be a natural partner for EU projects and to be an attractive partner for European companies. An important aspect, particularly important when it comes to funding from the Framework Programmes of the European Union, is the tight relations with the small and medium sized enterprises (SME) within CERES. These represent innovative technology that is attractive in future EU-project consortia formations.

**A basis in basic and advanced education**

A strong research environment needs to be rooted in high-quality education at the Bachelor’s and Master’s levels. This is important both for being able to recruit teachers and researchers on long-term contracts and for ensuring a good flow of young candidates for PhD research. As described in Chapter 4 of this report, the Master’s programmes have excellent recruitment from all over the world, but at the moment very few Swedish students – a consequence of the currently extremely low number of engineering students in general and students within information and communication technology (ICT) in particular. Two initiatives are currently underway within the School of IDE: (1) to increase the quality of the international recruitment of Master’s students even more by increasing the number of exchange agreements with good foreign universities, and (2) to further develop the programme offerings at the basic level (Bachelor’s level) in order to increase the interest
from young people. Among the points in the new Strategy for Basic Education are: innovation orientation, industrial connections, interdisciplinary approaches, and close connections to research. The University is determined to stay competitive in education within the ICT area and be among the leading Swedish universities in this area.

9. Information management of the profile

Information Strategy
CERES has an Information Strategy that is updated every year. The information strategy identifies target groups and suggests information activities.

The primary target groups are: The participating companies (in the CERES programme), other companies developing embedded computer and communication systems or products with such systems embedded, other research groups, and finally, students.

The secondary target groups are: Local and regional politicians and business people, who get insight in the potential and applicability of our research to develop industry.

Information-related activities to address the primary target group include (but are not limited to):

- Publication of scientific results in journals, conferences and reports
- Workshops or larger coordinating project meetings
- Publicity in engineering newspapers or industry-branch publications
- Web pages with up-to-date information and contact information
- Seminars for other companies
- Information through technology transfer programmes such as the teknIQInnovation and minST projects
- Bilateral discussions and seminars with other research groups
- In connection with courses, showing research activities to students
- Identifying and marketing suitable thesis projects as part of the research work together with industry
- Offering further education courses within the specialisation for engineers from industry
- Spreading of information about dissertations to industry, mass media, etc.
- Publishing a digital newsletter on a monthly basis

Some activities performed during 2008 will be listed in Section 15 of this annual report.

CERES started in February 2008 the digital “CERES Newsletter”. During the year, 5 issues were distributed to around 350 subscribers every second month. The newsletter links to articles at CERES home page.
Web articles 2008:
• The aim with CERES newsletter
• CERES half time evaluation
• Gender equality strengthening research
• Project leads to closer cooperation between Halmstad University and Imego
• New CERES project about parallel computing
• Living Lab - an arena for innovation
• CERES PhD student visiting Berkeley
• Reliable embedded systems
• Research without borders – post doc in the industry
• The new intelligent kitchen
• Big interest in network education
• Gold medal to CERES PhD student
• From Pakistan to Halmstad
• The thesis work that might save your data
• Fascinating strings
• Room for creativity – lab
• Unique radio has woken up
• The Egon radio and backscatter technology
• Strings as sensors
• Take care of experience
• Honour to SME PhD student teknIQInnovation completed
• VINNOVA finances CERES-researcher for strategic cooperation
• Time for Urban to defend his doctor's thesis

Publication Strategy

CERES has worked out a detailed strategy for its scientific publications.

According to this, we shall:
- Increase the number of publications in scientific journals – primarily by combining and further developing results that have first been published in conference proceedings.
- Strategically select the conferences where we first publish our results: (1) we should aim at the most influential conferences within our core scientific areas and application areas, but also conferences that match our profile of “cooperating embedded systems”; (2) the conference proceedings should be reachable by large groups of users through full text databases, they should allow us to put the full-text versions of our publications online, or the papers should be made available freely by the publisher.

CERES also has routines for the internal and external dissemination of our research publications. Moreover, “author criteria” have been worked out, stating for example: All authors must have contributed to the idea or the analysis in the paper; All authors must have contributed to the writing of the paper or with critical examination of it; All authors must agree on the contents and thereby take responsibility for the paper. The supervisor is normally co-author of PhD student papers, because he or she should be involved in the whole process.

All research results obtained in CERES, in cooperation with our partners, are and will be published internationally, in conference proceedings and journals. In order to, in particular, spread results and knowledge to all partners of CERES, as well as to other interested local/regional/national parties, annual conferences as well as theme workshops are arranged. These occasions are excellent opportunities for the CERES partners to interact with CERES researchers in a wider context than in the individual projects.

During 2007, we set up a method to calculate the minimum targeted publication rate for each researcher, both in terms of conference and journal papers. The aim is, however, not to have the main focus on individuals but to be able to calculate the expected number of publications for CERES as a whole, to use it when planning strategic recruitments in certain personnel categories, and use it as a useful tool to check if we go for enough publications in our concrete plans (see below). The way of calculating takes a number of things into consideration, for example: senior researcher or PhD student; percentage of research; number of PhD students to supervise.

Moreover, the senior researchers of CERES developed concrete publication plans for 2008 (and later for 2009). The information has been merged into a big planning table for all researchers at CERES, telling which month different papers are planned for submission and, if at least preliminarily known, where to submit them. Information about expected number of submitted papers (journal and conference papers, respectively) possibly leading to publication during the year under planning is also gained from the planning table.

We have now been able to compare the number of publications during 2007 and 2008 by CERES researchers. The result we see is a substantial increase in number of publications. We believe our work on the publication strategy, and the fact that we have made ourselves more aware of the importance of publishing, have been important for this increase.

**Partner Influence and Agreements**

The *CERES Industrial Advisory Board* (IAB) is important for spreading and discussing the results as well as planning the activities of CERES. The board meets at least twice a year. At one of these occasions all ongoing or recently finished research is presented and discussed.

IAB has one member (with substitute) from each of the industrial partners, plus the Director and the Vice Director of CERES. The chairman and the vice chairman of IAB are selected among the industrial representatives. During 2007 the CERES IAB has met two
times (April 17th and August 30th). The first meeting discussed, among other things, status in ongoing projects, different ways of cooperating in research projects and the planned half-time evaluation. The second meeting was held in conjunction with the Reference Group meeting, thus giving the Reference Group members and the company representatives an opportunity to discuss with each other.

The general agreement signed by all partners of CERES (CERES ramavtal) states that research results can be freely published and disseminated by the part that has created the result. If two or more have collaborated in creating the result, they should come to an agreement about publication and dissemination. Publication can be delayed in order to apply for patents.

For each project within CERES, a more detailed agreement (CERES projektavtal) between the partners in the project is signed. Here the Intellectual Property Rights (IPR) are described in more detail, with necessary regard to the specific circumstances in that particular project.
10. New, ongoing and finished projects during the year; earlier conducted projects

In this section we give an overview of current or recently finished projects by positioning them in relation to subject areas and applications, in the way described in Section 1. More detailed presentations, in the form of extended abstracts, are given in Part III of this report.

New Research Projects Started 2008 – with Other Funding

Two new projects were started during 2008, one with funding from Vägverket (Swedish Road Administration) and one with funding from VINNOVA.

System to Avoid Surprise Effects on Roads with Sparse Traffic

<table>
<thead>
<tr>
<th>Partners</th>
<th>Vägverket (The Swedish Road Administration)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other collaboration</td>
<td>Volvo Technology AB</td>
</tr>
<tr>
<td>Duration</td>
<td>20080701-20081231</td>
</tr>
<tr>
<td>Budget</td>
<td>400 ksek</td>
</tr>
<tr>
<td>Project leader</td>
<td>Magnus Jonsson</td>
</tr>
<tr>
<td>PhD students</td>
<td>Annette Böhm</td>
</tr>
</tbody>
</table>

G-EIS Gender Perspective on Embedded Intelligent Systems – Application in Healthcare Technology

<table>
<thead>
<tr>
<th>Partners</th>
<th>Halmstad municipality, Halland Regional Development Council (Health Technology Alliance), Phoniro AB, Free2move AB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other collaboration</td>
<td>Centre for Gender Equality, Halmstad University</td>
</tr>
<tr>
<td>Duration</td>
<td>2008-2011</td>
</tr>
<tr>
<td>Budget</td>
<td>1330 KSEK/year during 3 years (VINNOVA)</td>
</tr>
</tbody>
</table>
Project leader | Bertil Svensson
---|---
Other Halmstad University researchers | Suzanne Almgren Mason, Agneta Hansson

The G-EIS project is part of VINNOVA's initiative to further strengthen some of Sweden’s most prominent research and innovation environments by applying knowledge from gender research in the development of the environment. The EIS environment, of which CERES is a part, will make the project results and new knowledge useful in its extensive development work, with emphasis on profiling and growth and the consequent recruiting of new staff that the research environment faces. A gender perspective will put research as well as undergraduate and postgraduate studies in a new light, and is likely to encourage innovation toward useful applications. In collaboration with partners in the Health Technology Alliance, knowledge about the relevance of a gender perspective in technology education, research and the health technology application area will increase.

Expected results of the project include both more gender relevant innovations and technology applications and closer collaboration within the area of health technology. In the long run the project result ought also to be reflected in a more even sex distribution among both staff and students within EIS.

**Ongoing Research Projects 2008 – with Profile Funding**

The EPC project, which was started in 2007, has continued for the entire year 2008. In addition, the four projects that were started during CERES’ first year of operation as a profile went on for the entire year 2008: VAS, S3, ERTCENS and IPS.

**EPC – Embedded Parallel Computing**

<table>
<thead>
<tr>
<th>Partners</th>
<th>Combitech AB, Ericsson AB, Saab Microwave Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other collaboration</td>
<td>UC Berkeley (E.A. Lee), Ambric, Inc. (M. Butts)</td>
</tr>
<tr>
<td>Duration</td>
<td>June 2007 – May 2010</td>
</tr>
<tr>
<td>Budget</td>
<td>Profile funding 5.4 MSEK (+5.4 MSEK in kind from partners)</td>
</tr>
<tr>
<td>Project leader</td>
<td>Bertil Svensson</td>
</tr>
<tr>
<td>Other CERES researchers</td>
<td>Verónica Gaspes, Tony Larsson</td>
</tr>
<tr>
<td>PhD students</td>
<td>Jerker Bengtsson, Andreas Persson, Zain-ul-Abdin</td>
</tr>
</tbody>
</table>

Understanding parallel architectures and their usage is an important part of the CERES research programme. The project addresses the efficient use of parallel and reconfigurable computing structures in embedded high-performance applications. The industrial challenges for the research are baseband processing in base stations for future mobile communication systems and real-time image forming in synthetic aperture radar systems. The project has established cooperation with University of California at Berkeley and with a leading developer of processor arrays on a chip, Ambric, Inc., both in USA.
EPC Workshop.
Peter Brauer, Ericsson, and Per M Ericsson, Saab Microwave Systems.

Subject Areas

- V. Gaspes
- T. Larsson
  - Software Technology
  - Parallel Programming Models
  - Component Oriented Software

- M. Jonsson
  - Communication
  - High Performance Embedded Networks

- B. Svensson
  - Computer Architecture
  - Array Processors

Applications

- Traffic and Transport
- Healthcare
- High Performance Signal Processing
- Application Independent

PhD Students
- Jerker Bengtsson
- Andreas Persson
- Zain-ul-Abdin

Ericsson
Saab
Combitech
**VAS – Vehicle Alert System**

<table>
<thead>
<tr>
<th>Partners</th>
<th>Volvo Technology AB, SP, Free2move AB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other collaboration</td>
<td>Chalmers University of Technology</td>
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<tr>
<td>Duration</td>
<td>December 2005 – December 2008</td>
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<tr>
<td>Budget</td>
<td>4.2 MSEK (+ 4.2 MSEK in kind from partners)</td>
</tr>
<tr>
<td>Project leader</td>
<td>Björn Åstrand</td>
</tr>
<tr>
<td>Other CERES researchers</td>
<td>Magnus Jonsson, Tony Larsson, Elisabeth Uhlemann</td>
</tr>
<tr>
<td>PhD students</td>
<td>Katrin Bilstrup, Annette Böhm, Kristoffer Lidström</td>
</tr>
</tbody>
</table>

The Vehicle Alert System (VAS) project focuses on cooperative alert services based on timely and reliable (real-time) communication under the challenging circumstances pertaining to a highly mobile vehicular network. Both vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, and systems based on such communication, are in focus in the project. A cross-layer approach is taken, which includes three different levels of abstraction: link, network and application perspective.

Among the results so far are: simulation studies of routing protocols for V2V communication, as well as a preliminary design for the scheduling of alert traffic with real-time constraints in a merge assistance scenario.

**S3 – Situation Specific Surveillance**

<table>
<thead>
<tr>
<th>Partners</th>
<th>Ericsson AB, Emwitech AB, Free2move AB, Innovation Team AB, XCube Communication AB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other collaboration</td>
<td>TU Berlin, Germany</td>
</tr>
<tr>
<td>Duration</td>
<td>December 2005 – December 2008</td>
</tr>
<tr>
<td>Budget</td>
<td>Profile funding 5.4 MSEK (+ 5.4 MSEK in kind from partners)</td>
</tr>
<tr>
<td>Project leader</td>
<td>Martin Gustavsson, Ericsson AB</td>
</tr>
<tr>
<td>CERES researchers</td>
<td>Hoai Hoang, Magnus Jonsson, Tony Larsson, Elisabeth Uhlemann</td>
</tr>
</tbody>
</table>
The S3 project (Situation Specific Surveillance) is a platform for research in the areas of wireless sensor networks, ad hoc networks and wireless digital communication. The S3 project poses challenging questions on several different aspects and topics such as: energy efficiency, dependability, self-configuration, and scalability in wireless networks. These topics need to be addressed both in individual protocol layers as well as in a cross-layer design involving several levels. The project is therefore divided into three concurrent tracks: the link, network and application perspectives.

Among the results so far is a simple and practically implementable protocol in which relaying and packet combining work together to improve the probability that packets are delivered within a prescribed deadline over fading channels. Further that these techniques can be successfully applied on top of commercially available transceivers.
ERTCENS – Embedded Real-Time Systems based on Emerging Network Standards

<table>
<thead>
<tr>
<th>Partners</th>
<th>Combitech AB, Ericsson AB, Saab Microwave Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>December 2005 – December 2008</td>
</tr>
<tr>
<td>Budget</td>
<td>Profile funding 3.45 MSEK (+1.575 MSEK in kind and 0.3 MSEK in cash from partners)</td>
</tr>
<tr>
<td>Project leader</td>
<td>Magnus Jonsson</td>
</tr>
<tr>
<td>Other CERES researchers</td>
<td></td>
</tr>
<tr>
<td>PhD students</td>
<td>Kristina Kunert, Mattias Weckstén</td>
</tr>
</tbody>
</table>

The ERTCENS project has its focus in high-performance embedded real-time networking. Examples of applications are radar signal processing systems and radio base stations. Especially, we investigate the use of switched networks in such systems, treating aspects like real-time analysis, topologies, and dependability.

Among other results, the project has developed an analysis framework to calculate on guaranteed real-time performance in switched networks with FCFC (First Come First Served) queuing. The framework is based on scheduling analysis and has shown better results than the well-known Network Calculus. Furthermore, a method to choose topology of a switched network carrying real-time traffic has been developed. The method can even be used to choose different topologies to reconfigure between during run-time when having several working modes to switch between.
IPS – Implementation of Protocol Stacks

<table>
<thead>
<tr>
<th>Partners</th>
<th>Free2move AB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>August 2006 – July 2009</td>
</tr>
<tr>
<td>Budget</td>
<td>Profile funding 2.4 MSEK (+2.4 MSEK in kind from partner)</td>
</tr>
<tr>
<td>Project leader</td>
<td>Verónica Gaspes</td>
</tr>
<tr>
<td>PhD student</td>
<td>Yan Wang</td>
</tr>
</tbody>
</table>

IPS is a project addressing programming protocol stacks for embedded systems. The goal of the project is to produce software tools that facilitate the implementation of protocol stacks.

Among the first results is a tool for generating packet transformers from packet specifications.

Yan Wang
Ongoing Research Projects 2008 – with other Funding

The Living Lab project and the SELIES project are new CERES projects that rely on a broader competence base than earlier projects. This is illustrated in the positioning figure by showing as competence resources, not subject areas, but entire research environments. Thus, these two projects, which both are motivated by needs in the health sector, rely on competence also from the Intelligent Systems Laboratory and the Centre for Innovative Use of IT (at MI-lab), both within the School of IDE at Halmstad University.

SELIES – Supporting Elderly Life through Intelligent Embedded Systems

<table>
<thead>
<tr>
<th>Duration</th>
<th>First project period is October 2007 – October 2009. The two PhD students are part of a university research school; Research school in entrepreneurship and health.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Budget</td>
<td>600 KSEK/year (Bank Foundation Kronan)</td>
</tr>
<tr>
<td>Project leader</td>
<td>Nicholas Wickström</td>
</tr>
<tr>
<td>Other HH researchers</td>
<td>Thorsteinn Rögnvaldsson, Bertil Svensson</td>
</tr>
<tr>
<td>PhD students</td>
<td>Anita Sant’Anna, Wagner deMorais</td>
</tr>
</tbody>
</table>

A rapidly growing elderly population in Sweden as well as in the rest of the world imposes a need for ambient assisted living technology. To better tailor the technology to the elderly’s needs, understanding about the users’ context as well as their intention is desired. Likely, future systems are worn ubiquitously embedded in everyday objects and interoperable with other devices in their surroundings. Two main aspects of this are explored further in this project, the analysis of human movements through accelerometer based “motion primitives” and the aspects of integration of hardware components, functions and services in a platform to support applications.

The project is part of the Research School in Entrepreneurship – Health at Halmstad University, with funding from the Bank Foundation Kronan.
Living Lab – Safe and Secure at Home

<table>
<thead>
<tr>
<th>Partners</th>
<th>Emwitech AB, Free2move AB, HFAB, Innovation Team AB, KomiKapp/Rehatek AB, LBS, Science Park, Unity by Light AB, Medicpen AB, Neat Electronics AB, Phoniro AB, ProEvolution AB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>Aug 2007 – Aug 2009</td>
</tr>
<tr>
<td>Budget</td>
<td>1.6 MSEK (VINNOVA) + equal in-kind contributions from partners</td>
</tr>
<tr>
<td>Project leader</td>
<td>Carina Ihlström Eriksson (MI-lab/CIIT)</td>
</tr>
<tr>
<td>Other HH researchers</td>
<td>Roland Thörner, Nicholas Wickström, Nicolina Månsson</td>
</tr>
<tr>
<td>PhD student</td>
<td>Jesper Svensson</td>
</tr>
</tbody>
</table>

Living lab – Safe and Secure at Home is a VINNOVA funded project exploring the possibilities with a living lab approach. The focus is on methods for user involvement in the innovation process. The context is ICT services and products aimed at supporting and empowering elderly people. The project has a long list of industrial partners as well as partners that represent end users.

Carina Ihlström Eriksson and Jesper Svensson
EGON – Ultra Low Power Active RFID

<table>
<thead>
<tr>
<th>Partners</th>
<th>LeptonRadio AB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other collaboration</td>
<td>MPE-lab at HH, Chalmers dept. MC2 and CSE, Cambridge Consultants</td>
</tr>
<tr>
<td>Duration</td>
<td>Jan 2007 – Jun 2009</td>
</tr>
<tr>
<td>Budget</td>
<td>2.7 MSEK (Crafoord Foundation)</td>
</tr>
<tr>
<td>Project leader</td>
<td>Bertil Svensson</td>
</tr>
<tr>
<td>Other HH researchers</td>
<td>Pelle Wiberg, Urban Bilstrup, Håkan Pettersson</td>
</tr>
<tr>
<td>PhD students</td>
<td>Emil Nilsson, Björn Nilsson</td>
</tr>
</tbody>
</table>

The EGON project has received funding from the Crafoord Foundation as a project with exceptional potential. The project, which builds on competence not only at the Laboratory for Computing and Communication but also at the Laboratory for Mathematics, Physics and Electronics, relies heavily on the design tools and instruments present in the e-Lab facilities. Chalmers departments of computer science and engineering as well as nano- and microtechnology (MC2) act as academic partners. A spin-off company, LeptonRadio AB, has been started to commercialize the research results.

A new low power radio architecture based on a bi-stable regenerative transceiver with dissonant backscatter is investigated. A characteristic feature of the new technology is its ability to support communication with thousands of units simultaneously; further that each of these units consumes very little energy. This opens up vast application opportunities in the field of cooperating embedded systems. The goal of the project is to develop a radio design that, after further product development, enables the fabrication of active radio units with a battery lifetime of up to eight years and a price level in the same range as passive RFID tags.

A typical application area is in logistics, where readers can communicate with electronic tags on the goods. Unlike passive tags, active are readable at longer distance and can, as a further advantage, for example sense and log the temperature of the goods.
**WIREALMATICS - Wireless Real-Time Communications for Telematics Applications**

<table>
<thead>
<tr>
<th>Partners</th>
<th>Volvo Technology Corporation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other collaboration</td>
<td>Chalmers</td>
</tr>
<tr>
<td>Duration</td>
<td>March 2005 – March 2009</td>
</tr>
<tr>
<td>Budget</td>
<td>3.0 MSEK (Knowledge Foundation, Volvo, HH)</td>
</tr>
<tr>
<td>Project leader</td>
<td>Elisabeth Uhlemann</td>
</tr>
<tr>
<td>PhD student</td>
<td>Katrin Bilstrup</td>
</tr>
</tbody>
</table>

The WIREALMATICS project provides an opportunity for a recent PhD graduate to do research in close collaboration with industry. The main research goal is to enable wireless communications that meet the requirements from applications involving cooperating vehicles, but the project should also enable the graduate to do research in the more general area of wireless real-time communications as well as increase the interaction between industry and academia. Research is being done on wireless real-time communications guided by QoS parameters from several different applications in both vehicular networks, ad hoc networks and wireless sensor networks. The PhD student is investigating medium access methods suitable for providing real-time communication in an ad hoc vehicular network.
More than a dozen papers have been published during the project so far. Close collaboration has been established not only with VTEC but also with the European FP6 projects CVIS and SAFESPOT, the FP7 project Pre-Drive C2X, the intergovernmental framework COST as well as with the Chalmers-based traffic safety centre SAFER.

ARFID – Active RFID (VLSI arch. for small-area, low-power wireless devices)

<table>
<thead>
<tr>
<th>Partner</th>
<th>Free2move AB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other collaboration</td>
<td>Chalmers, Dept. CSE</td>
</tr>
<tr>
<td>Duration</td>
<td>March 2005 – February 2010</td>
</tr>
<tr>
<td>Budget</td>
<td>1.6 MSEK (from the Knowledge Foundation: “Småföretagsdoktorander”, matched in kind (employment) by the company</td>
</tr>
<tr>
<td>Project leader</td>
<td>Bertil Svensson</td>
</tr>
<tr>
<td>Other CERES researchers</td>
<td>Lars Bengtsson, Pelle Wiberg</td>
</tr>
<tr>
<td>PhD student</td>
<td>Björn Nilsson</td>
</tr>
</tbody>
</table>

The aim of this project is investigation, development and evaluation of cost efficient RF mixed-signal VLSI architectures for active RFID (Radio Frequency IDentification) tags. Very low power consumption is necessary for long life-time; average in μW region is the target. Radio protocols enabling minimal power requirements and data communication algorithms to reduce the need of data redundancy is another prerequisite and are therefore developed. Protocols that can be adapted to the application needs, and thereby considerably lower the energy consumption, have been designed.
REMOTE – Real-time Mobile Telecommunication

<table>
<thead>
<tr>
<th>Partners</th>
<th>Free2move AB, LeptonRadio AB. Previous partners: HMS AB, ECSAB, Innovation Team AB and Ericsson AB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other collaboration</td>
<td>Chalmers; ITR UniSA Australia</td>
</tr>
<tr>
<td>Duration</td>
<td>January 1999 – December 2008</td>
</tr>
<tr>
<td>Funding</td>
<td>Chalmers Foundation, SSF/ARTES, SSF/PCC++, KKS/CERES and HH</td>
</tr>
<tr>
<td>Project leader</td>
<td>Pelle Wiberg</td>
</tr>
<tr>
<td>Other CERES researchers</td>
<td>Elisabeth Uhlemann</td>
</tr>
<tr>
<td>PhD student</td>
<td>Urban Bilstrup (PhD December 2008)</td>
</tr>
</tbody>
</table>

We foresee an even wider use of wireless communication in industry settings, the transportation sector and as a tool for ambient intelligence. Especially, the possibility to provide guarantees for time-critical applications becomes an emergent issue when wireless communication is used to interact and control a physical process. The standards for wireless communication that are available lack a general strategy of striving to deliver information reliably before a deadline. This calls for research efforts leading to new wireless protocols for time critical traffic.

The research methodology is to apply a framework where the deadline and the probability to fulfil a communication task before this deadline are thought of as quality of service (QoS)
REMOTE is a long-term research effort which started in 1999 and is now in its final phase. So far it has resulted in two licentiate and two PhD thesis, as well as in two spin-off companies. More than twenty international publications have appeared, some of them already well cited.

**BERT – Budgeting for Embedded Real-Time Systems**

<table>
<thead>
<tr>
<th>Partners</th>
<th>The project is connected to other CERES projects, mainly to ERTCENS (with partners Combitech, Ericsson and Saab Microwave Systems)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other collaboration</td>
<td>Chalmers Dept. CSE</td>
</tr>
<tr>
<td>Duration</td>
<td>2002 - present</td>
</tr>
<tr>
<td>Funding</td>
<td>Internal HH</td>
</tr>
<tr>
<td>Project leader</td>
<td>Magnus Jonsson</td>
</tr>
<tr>
<td>PhD student</td>
<td>Mattias Weckstén</td>
</tr>
</tbody>
</table>

The BERT project is focusing on how to, primarily in early design, cope with the growing system complexity. To increase engineering efficiency, we develop scheduling, allocation and analysis methods that can be integrated into a tool to help in the design of distributed embedded computer systems.

A systematic method for derivation of non functional constraints available at design time has been developed, making it possible to verify the implementability of a certain design and facilitate the implementation. A method to simulate the implementation process, to evaluate design and implementation methods in a cheap and repeatable way, has been developed. To support...
switched interconnection networks in our targeted distributed systems, we have developed a method to choose topology. We have also developed a preliminary solution to analyze a switched network using the knowledge about the task graph properties, in order to increase the amount of possible guaranteed real-time traffic.

The ADAPT project investigates possible solutions to the distributed control of systems of mobile entities, e.g. public transportation networks, transport and logistics operations and the flow of private transportation vehicles through a road network. The central questions of this project are which systems services are possible to cost-effectively distribute onto the fleet agents, what technologies are applicable and how to use them. The project, which started as an industrial PhD student project, has gone through a re-definition phase, depending on partner changes.
Finished Research Projects

**MISPA 2 – Memory Intensive Signal Processing Architectures 2**

<table>
<thead>
<tr>
<th>Partners</th>
<th>Saab Microwave Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other collaboration</td>
<td>Chalmers, Dept. Signals and Systems</td>
</tr>
<tr>
<td>Duration</td>
<td>February 2006 – May 2007 (MISPA 1 + MISPA2)</td>
</tr>
<tr>
<td>Funding</td>
<td>CERES Profile funding: 800 KSEK, matched in kind by company</td>
</tr>
<tr>
<td>Project leader</td>
<td>Jonas Lindgren, SMW</td>
</tr>
<tr>
<td>CERES researchers</td>
<td>Anders Åhlander, Bertil Svensson</td>
</tr>
</tbody>
</table>

The real-time image forming in future, high-end synthetic aperture radar systems is an example of an application that puts new demands on computer architectures. Is it at all possible to meet the demands with state-of-the-art technology or foreseeable new technology? We need to understand the computational flow, with its associated memory, bandwidth and processing demands. In this project we analyzed the application in order to, primarily, understand the algorithms and identify the challenges they present on a basic architectural level. The processing in the radar system is characterized by working on huge data sets, having complex memory access patterns, and doing real-time compensations for flight path errors. We proposed algorithm solutions and execution schemes in interplay with a two-level (coarse-grain/fine-grain) system parallelization approach. The results of this “upstream” study will serve as a basis for further, more detailed architecture studies.

Innovation Support Projects Active During 2008

**TeknIQInnovation**

<table>
<thead>
<tr>
<th>Partner</th>
<th>Jönköping University</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>October 2006 – September 2008</td>
</tr>
<tr>
<td>Funding</td>
<td>3.0 MSEK in total. The Knowledge Foundation</td>
</tr>
<tr>
<td>Project leader</td>
<td>Roland Thörner</td>
</tr>
<tr>
<td>Other CERES researchers</td>
<td>Nicholas Wickström, Hans-Erik Eldemark. Several more on a sub-project basis</td>
</tr>
</tbody>
</table>

The aim of the project is to strengthen Swedish small and medium sized companies’ ability to use research as a strategic resource in their product development, by supporting them in creating new products out of interesting ideas. The application area of the project is health care and the technological areas are intelligent and embedded systems. The project is completed during 2008, thirteen pre studies and 6 company projects have been accomplished together with School of engineering at Jönköping University. A dozen researchers, PhD students and engineers from CERES and IS-lab have been involved in company visits, pre-studies or minor research projects.

Roland Thörner
minST – micro and nano System Technology

<table>
<thead>
<tr>
<th>Partners</th>
<th>Mälardalen University, ACREO, Imego</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>2006 – 2012</td>
</tr>
<tr>
<td>Funding</td>
<td>The Knowledge Foundation. Halmstad University is a subcontractor of Imego. HH-budget ca 1 MSEK/year</td>
</tr>
<tr>
<td>Project leader</td>
<td>Sven-Arne Paulsson, Mälardalen University</td>
</tr>
<tr>
<td>Local project leader</td>
<td>Stella Erlandsson, Magnus Hållander (April 2008 -)</td>
</tr>
<tr>
<td>Other HH researchers</td>
<td>Kenneth Nilsson, Hans-Erik Eldemark, Magnus Larsson. Several more on a sub-activity basis</td>
</tr>
</tbody>
</table>

minST is a project with focus on increasing competence and competitiveness of SMEs in the area of micro/nano system technology by supporting cooperation between universities, research institutes and SMEs. This is done by supporting SMEs through tailor-made courses and other education, supporting product development and creating seminars as meeting places for knowledge transfer.

Triple N – New technology, New products, New companies

<table>
<thead>
<tr>
<th>Partner</th>
<th>Imego</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>April 2007 – January 2008</td>
</tr>
<tr>
<td>Funding</td>
<td>VINNOVA: 1.1 MSEK in total, equally shared between the two partners</td>
</tr>
<tr>
<td>Project leader</td>
<td>Dan Larsson, Imego</td>
</tr>
<tr>
<td>Local project leader</td>
<td>Bertil Svensson</td>
</tr>
<tr>
<td>Other HH researchers</td>
<td>Hans-Erik Eldemark, Roland Thörmann. Several more in sub-activities</td>
</tr>
</tbody>
</table>

The research institute Imego in Göteborg and CERES and IS-lab at Halmstad University together run the Project Triple N – New technology, New products, New companies, sponsored by VINNOVA. The project has three coordinated activities:
- Collaboration with small and medium-sized enterprises (SME). Competences and research work that the company needs as a development resource are identified, in particular in the areas of sensor systems and embedded systems.
- Commercialization of research results – in new companies as well as in established ones.
- More efficient use of common resources for research: personnel, expert knowledge, and laboratory equipment

Imego and HH have signed a contract to be strategic partners and continue to cooperate in the forms developed in the pilot project.

**ILISIS – Institut och lärosäten i samverkan för inbyggda system** *(Institute and Universities in Cooperation for Embedded Systems)*

<table>
<thead>
<tr>
<th>Partners</th>
<th>Jönköping University, SP Technical Research Institute of Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>April 2007 – February 2008</td>
</tr>
<tr>
<td>Funding</td>
<td>VINNOVA: 1.1 MSEK in total, equally shared between the three partners</td>
</tr>
<tr>
<td>Project leader</td>
<td>Lars Strandén, SP</td>
</tr>
<tr>
<td>Local project leader</td>
<td>Tony Larsson</td>
</tr>
<tr>
<td>Other HH researchers</td>
<td>Kenneth Nilsson, Per-Åke Jovall, Urban Bilstrup. Several more in sub-activities</td>
</tr>
</tbody>
</table>

Embedded systems are often used in applications with high requirements on safety and reliability. The embedded system must be dependable and behave as expected in order not to cause any risks. A product can include an embedded system for increasing safety. The three partners in the project, SP, Halmstad University and Jönköping University cooperate in order to support SMEs with development of embedded systems with high requirements on dependability. This initiative is mainly directed towards enterprises in Västra Götaland, Halland, Småland and Skåne. The partners have signed an agreement to continue the cooperation after the pilot project period.

**Finished Innovation Support Projects**

"Trygg Hemma" *(Swedish, approx. “safe and secure home environments")*

<table>
<thead>
<tr>
<th>Partners</th>
<th>Health care alliance, Hemvårdsförvaltningen Halmstad, NEAT Electronics AB, KOM I KAPP REHATEK AB, Phoniro AB, Emwitech AB, Lansen AB, LIC Audio, Free2move AB, ProEvolution AB, Medicpen AB, HFAB (Halmstad Fastighets AB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>February 2007 – August 2007</td>
</tr>
<tr>
<td>Funding</td>
<td>800 KSEK (KKS through NIVO)</td>
</tr>
<tr>
<td>Project leader</td>
<td>Roland Thörner</td>
</tr>
<tr>
<td>Other HH researchers</td>
<td>Nicholas Wickström, Nicolina Månsson</td>
</tr>
</tbody>
</table>

"Trygg Hemma” is a collaborative project which provides technology to support older people to stay longer in their homes if they desire.
The project is formed by three parts. The first part is on involving the different stakeholders in the development process of health care technology. The stakeholders can be the older person, the older person’s relatives, nursing staff, medical staff, the housing company, organizations and health care companies. The goal is to develop a system to capture the user centric aspects of the requirements and to do an inventory of ideas.

The second part of the project is concerned with the everyday life of the older people. The home is obviously an important part, but the environment outside the home is equally important. The technology provided here is often an embedded system, not interfering with the resident. Examples of this technology are radio communication, body worn sensor systems, efficient energy efficient battery operated hardware, sensor networks, sensors, and intelligent decision support algorithms.

In the third part of the project the technology and standards that promote the integration of functions are studied. In many cases today there exist good functions, but often the integration of these functions in systems fail. There is a need to standardize and build systems of integrated functions. In this part of the project new business models are investigated.

A lock system developed in collaboration between SMEs and caregivers in Halmstad.
II. Companies or other participating partners during 2008 – for each sub-project

Table 1. Participating companies or other partners for all research projects during 2008. Profile funded projects are marked in boldface

<table>
<thead>
<tr>
<th>Project (Profile funded projects marked in boldface)</th>
<th>Participating Swedish companies</th>
<th>Other collaboration</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPC – Embedded Parallel Computing</td>
<td>Combitech AB, Ericsson AB, Saab Microwave Systems</td>
<td>University of California at Berkeley, USA; Ambri Inc., USA</td>
</tr>
<tr>
<td>EGON – Ultra Low Power Active RFID</td>
<td>LeptonRadio AB</td>
<td>Chalmers University of Technology, Cambridge Consultants, UK</td>
</tr>
<tr>
<td>Living Lab – Safe and Secure at Home</td>
<td>Emwitech AB, Free2move AB, HFAB, Innovation Team AB, KomiKapp/Rehatek AB, LBS, Science Park, Unity by Light AB, Mediepen AB, Neat Electronics AB, Phoniro AB, ProEvolution AB</td>
<td></td>
</tr>
<tr>
<td>SELIES – Supporting Elderly Life through Intelligent Emb. Systems</td>
<td></td>
<td>Oregon Health and Science University, Portland, OR, USA</td>
</tr>
<tr>
<td>VAS – Vehicle Alert System</td>
<td>Volvo Technology AB, SP, Free2move AB</td>
<td>Chalmers University of Technology</td>
</tr>
<tr>
<td>S3 – Situation Specific Surveillance</td>
<td>Ericsson AB, Emwitech AB, Free2move AB, Innovation Team AB, XCube Communication AB</td>
<td>Technische Universität Berlin, Germany</td>
</tr>
<tr>
<td>ERTCENS – Embedded Real-Time Communication using Emerging Network Standards</td>
<td>Saab Microwave Systems, Ericsson AB, Combitech AB</td>
<td>Scuola Superiore Sant’Anna, Pisa, Italy</td>
</tr>
<tr>
<td>IPS – Implementation of Protocol Stacks</td>
<td>Free2move AB</td>
<td></td>
</tr>
<tr>
<td>Cooperating Mobile Agents</td>
<td>Pilotfish AB</td>
<td></td>
</tr>
<tr>
<td>Wireless Real-time Communication for Telematic Applications</td>
<td>Volvo Technology AB</td>
<td>Institute of Telecomm. Research, University of South Australia, Chalmers University of Technology</td>
</tr>
<tr>
<td>Active RFID – VLSI Architectures for Small Area, Low Power Wireless Devices</td>
<td>Free2move AB</td>
<td>Chalmers University of Technology</td>
</tr>
<tr>
<td>REMOTE – Real-time Mobile Telecommunication</td>
<td>Free2move AB, LeptonRadio AB</td>
<td>Chalmers University of Technology, Institute of Telecomm. Research, University of South Australia,</td>
</tr>
<tr>
<td>BERT – Budgeting for Embedded Real-Time Systems</td>
<td></td>
<td>Chalmers University of Technology</td>
</tr>
<tr>
<td>System to Avoid Surprise Effects ...</td>
<td>Vägverket</td>
<td></td>
</tr>
<tr>
<td>G-EIS – Gender Aspects on Embedded Intelligent Systems</td>
<td>Free2move AB, Phoniro AB</td>
<td>Health Technology Alliance, Halmstad municipality</td>
</tr>
</tbody>
</table>
12. Publications so far (dated)

a. International journals with full-paper review; book chapters

Accepted during 2008 for publication during 2009

Journals:

2008

Journals:

Book chapters:

2007

Journals:

2006

**Journals:**


**Book chapters:**


2005

**Journals:**


2003


b. **Doctoral and Licentiate theses**

2008


2007


2006


2005


2004


2003


c. **International conferences with full-paper review**

Accepted during 2008 for publication during 2009


2008


Binotto, A. P. D., E. P. Freitas, M. Götz, C. E. Pereira, A. Stork, and T. Larsson, "Dynamic self-rescheduling of tasks over a heterogeneous platform,” *Proc. of 2008 International Conference on ReConFigurable Computing and FPGAs (ReConFig’08)*, Cancun, Mexico, Dec. 3-5, 2008.

Zain-ul-Abdin, and B. Svensson, “Using a CSP based programming model for reconfigurable processor arrays,” *Proc. of 2008 International Conference on ReConFigurable Computing and FPGAs (ReConFig’08)*, Cancun, Mexico, Dec. 3-5, 2008.


Zain-ul-Abdin, and B. Svensson, “Using a CSP based programming model for reconfigurable processor arrays,” *Proc. of 2008 International Conference on ReConFigurable Computing and FPGAs (ReConFig’08)*, Cancun, Mexico, Dec. 3-5, 2008.


Gao, C., M. S. Zaveri, and D. Hammerstrom, "CMOS/CMOL architectures for spiking cortical column," Proceedings of IEEE World Congress on Computational Intelligence (WCCI) - Int. Joint Conf. on Neural Networks (IJCNN), June 1-6, 2008, pp. 2442-2449.

2007


Zain Ul-Abdin and B. Svensson, "A study of design efficiency with a high-level language for FPGAs", Proc. 14th Reconfigurable Architectures Workshop RAW’2007, March 26-27, 2007, held in conjunction with the IEEE International Parallel and Distributed Processing Symposium (IPDPS 2007), Long Beach California, USA.

2006


2005


2004


Menéndez Bellón, J. M. and M. Jonsson, “EDF-based protocol for a fiber optic network with passive star and separate control channel,” accepted for publication in Proc. IASTED International Conference on Communication and Computer Networks (CCN 2004), Cambridge, MA, USA, Nov. 8-10, 2004. (6 pages)

Agelis, S. and M. Jonsson, “Visualizing the potential of reconfigurable shuffle-patterns in optoelectronic routers by the use of MOEMS,” Proc. LASTED International Conference on


2003


d. Internal reports

2008


2007


2006


2005

2004


2003


e. Other (incl. national conferences and international conferences without full-paper review)

2008

Morais, W., A. Sant’Anna, and N. Wickström, A wearable accelerometer based platform to encourage physical activity for the elderly, Proc. 6th International Conference of the International Society of Gerontechnology, Pisa, Italy, 2008.


Bengtsson J. and B. Svensson, "Methodologies and tools for development of signal processing software on multicore platforms", Workshop on Streaming Systems in conjunction with the 41st Annual IEEE/ACM International Symposium on Microarchitecture (MICRO), Lake Como, Italy, Nov. 8-9, 2008.


2007


2006


2004


2003


13. Patents sought and/or granted during the year

Urban Bilstrup, Per-Arne Wiberg and Emil Nilsson have filed one PCT patent application and two national Swedish applications on a new, ultra low-power radio receiver/transmitter technology: “A Device for Wireless Operation and Method for Operating the Device”. A response on the PCT application has been received with good prospect of a strong patent.
14. Personnel during the year

The personnel during 2008 are shown in Table 2. In addition to those listed in the table, a number of researchers at other labs at the School of IDE are involved in joint projects with CERES. These are listed in Table 3.

Here follows a short description of the research orientation of the senior researchers of CERES:

Prof. Magnus Jonsson, professor of Real-Time Computer Systems, has his main research background in computer communication in embedded systems, embedded real-time systems, distributed computing and optical network and interconnection architectures. Newer research focus includes real-time communication in wireless ad hoc and sensor networks. He is the head of the Computing and Communications Laboratory and vice-director of CERES. Magnus is a member of the reference group of ARTES++ national research school in real-time and embedded systems.

Prof. Tony Larsson, professor of Embedded Systems, has 28 years of industrial research and development experience in system design of distributed real-time systems and embedded applications. His main research interest is in component oriented software and system design methods and architecture solutions for cooperating embedded systems.

Prof. Bertil Svensson, professor of Computer Systems Engineering, has his main research background in application oriented parallel architectures, embedded and real-time computer systems and applications, as well as the use of new technologies (e.g., optics) in innovative architectures. He is also active in research on low-power technologies for wireless communication and has earlier worked on applications and implementations of self-learning systems. Bertil has a long experience of working in joint research with industry. He is a member of the Scientific Council for natural and engineering sciences in the Swedish Research Council. Bertil is the director of CERES.

Prof. Dan Hammerstrom, guest professor in Computer Architecture, has his primary research interest in biologically inspired computer architectures and their realization in VLSI technology. He is also interested in the implications of technology scaling on computer architecture implementations in silicon. He has an industrial background in the field of high-performance embedded processors. He is professor in the Electrical and Computer Engineering department and Associate Dean for Research of Maseeh College of Engineering and Computer Science, Portland State University, OR, USA.

Prof. Erik S. Ström, guest professor in Communication Systems, is interested in signal processing and communication theory in general and in wireless communications, multiuser systems, and code-division multiple access (CDMA) systems in particular. His research deals mainly with near-far resistant synchronization, channel estimation, and detection for direct sequence CDMA systems. He is professor of Communication Systems at Chalmers University of Technology.

Dr. Verónica Gaspes, associate professor in Computer Science, has a background in programming logics and machine assisted proofs of program correctness. Her current research interest is in application of theories from computer science to building application specific languages and tools.
Dr. Elisabeth Uhlemann, assistant professor in Wireless Real-Time Communications, directs her research towards efficient wireless real-time communication networks with strict deadline and error rate constraints, including their applications in vehicle and traffic applications. For four years she has held a research position partially sponsored by Volvo Technology AB and The Knowledge Foundation.

Dr. Nicholas Wickström, lecturer in Computer Systems, has a background in embedded sensing and control in automotive applications based on soft-sensing techniques. Within the CERES profile his main responsibility is to lead the experimental research on applications of distributed, cooperating embedded systems, with a particular focus on the healthcare technology area. He is active also in the Intelligent Systems laboratory.

Lic.Tech. Per-Arne Wiberg, lecturer in Real-time Systems, has pioneered the area of real-time wireless communication, especially applied to industrial applications, and is active in transferring research results into commercial enterprises.

Dr. Björn Åstrand, researcher in intelligent mechatronic systems, has his main research interests in mechatronics, intelligent vehicles, mobile robotics and computer vision. Within the CERES profile his main responsibility has been to lead research projects in the intelligent traffic and transports area. He is active also in the Intelligent Systems laboratory.

Dr. Lars Bengtsson, associate professor in Computer Engineering at Chalmers University of Technology, is part-time employed to build up a VLSI electronics design laboratory at CERES and serve as assistant supervisor for one industrial Ph.D. student.

Dr. Hoai Hoang, was hired as a post doc during 2007. She has done her PhD work in CERES and took her PhD degree in May 2007. Her research interest includes real-time process scheduling, real-time communication and wireless sensor networks. In January 2009 she took up a position at Combitech, combined with part-time post-doc research at CERES.
### Table 2. CERES personnel during 2008

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jonsson, Magnus</td>
<td>Prof., Ph.D.</td>
<td>Prof., Real-time Computer Systems, Vice Director of CERES, Projects: ERTCENS, VAS, S3, BERT, G-EIS,</td>
</tr>
<tr>
<td>Larsson, Tony</td>
<td>Prof., Ph.D.</td>
<td>Prof., Embedded Systems, Projects: VAS, S3, ADAPT, ILISIS</td>
</tr>
<tr>
<td>Svensson, Bertil</td>
<td>Prof., Ph.D.</td>
<td>Prof., Computer Systems Engineering, Director of CERES, Projects: EPC, EGON, ARFID, SELIES, Triple N, TeknIQInnovation, G-EIS</td>
</tr>
<tr>
<td>Hammerstrom, Dan</td>
<td>Prof., Ph.D.</td>
<td>Guest Prof., Computer Architecture, Project: EPC</td>
</tr>
<tr>
<td>Ström, Erik S.</td>
<td>Prof., Ph.D.</td>
<td>Guest Prof., Communication Systems, Projects: VAS, S3</td>
</tr>
<tr>
<td>Gaspes, Verónica</td>
<td>Ph.D. C.S.</td>
<td>Assoc. Prof., Computer Science, Projects: EPC, IPS</td>
</tr>
<tr>
<td>Name</td>
<td>Title</td>
<td>Projects</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------------</td>
<td>----------------------------------------------------</td>
</tr>
<tr>
<td>Uhlemann, Elisabeth</td>
<td>Ph.D. E.E.</td>
<td>Assistant Prof., Wireless Real-time Communication</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Projects: WIREALMATICS, VAS, S3, REMOTE</td>
</tr>
<tr>
<td>Hoang, Hoai</td>
<td>Ph.D. C.E.</td>
<td>Post-doctoral researcher</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Projects: S3, EPC</td>
</tr>
<tr>
<td>Wiberg, Per-Arne</td>
<td>Lic.Tech. C.E.</td>
<td>Lecturer &amp; Project Leader, Real-time Systems (part time)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Projects: EGON, ARFID, REMOTE</td>
</tr>
<tr>
<td>Wickström, Nicholas</td>
<td>Ph.D. C.E.</td>
<td>Lecturer, Computer Systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Projects: SELIES, S3, TeknIQInnovation, Living Lab</td>
</tr>
<tr>
<td>Åstrand, Björn</td>
<td>Ph.D. C.E.</td>
<td>Project Leader</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Project: VAS</td>
</tr>
<tr>
<td>Bengtsson, Lars</td>
<td>Ph.D. C.E.</td>
<td>Assoc. Prof., Computer Engineering (part time)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Project: ARFID</td>
</tr>
<tr>
<td>Name</td>
<td>Title</td>
<td>Projects/Projects</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------------------------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>Bilstrup, Urban</td>
<td>Ph.D. C.E.</td>
<td>EGON, REMOTE</td>
</tr>
<tr>
<td>Dellstrand, Börje</td>
<td>M.Sc. E.E.</td>
<td>EPC</td>
</tr>
<tr>
<td>Erlandsson, Stella</td>
<td>B.Sc. Innovation Eng.</td>
<td>minST</td>
</tr>
<tr>
<td>Månsson, Nicolina</td>
<td>M.Sc.</td>
<td>Trygg Hemma, Living Lab</td>
</tr>
<tr>
<td>Eldemarck, Hans-Erik</td>
<td>M.Sc. E.E.</td>
<td>teknIQInnovation, minST, TrippelN</td>
</tr>
<tr>
<td>Name</td>
<td>Degree/Title</td>
<td>Position/Projects</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>Thörner, Roland</td>
<td>M.Sc. Informatics</td>
<td>Coordinator of CERES Projects: TeknIQInnovation, Triple N, Living Lab, G-EIS</td>
</tr>
<tr>
<td>Torstensson, Olga</td>
<td>M.Sc. Telecom.</td>
<td>Assistant project manager Projects: G-EIS</td>
</tr>
<tr>
<td>Bilstrup, Katrin</td>
<td>M.Sc. C.E.</td>
<td>Ph.D. stud., Communication Systems Projects: VAS, WIREALMATICS, S3</td>
</tr>
<tr>
<td>Böhm, Annette</td>
<td>M.Sc. C.E.</td>
<td>Ph.D. stud., Information Technology Projects: VAS, S3, G-EIS</td>
</tr>
<tr>
<td>Börjesson, Emma</td>
<td>B.Sc Political Sc.</td>
<td>Project assistant Projects: G-EIS</td>
</tr>
<tr>
<td>Name</td>
<td>Degree</td>
<td>Projects</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------</td>
<td>------------------------</td>
</tr>
<tr>
<td>De Freitas, Edison</td>
<td>M.Sc. C.E.</td>
<td>S3, VAS</td>
</tr>
<tr>
<td>Kunert, Kristina</td>
<td>Lic.Tech. C.E.</td>
<td>ERTCENS, S3</td>
</tr>
<tr>
<td>Lidström, Kristoffer</td>
<td>M.Sc., CS&amp;E</td>
<td>VAS, S3</td>
</tr>
<tr>
<td>Nilsson, Björn</td>
<td>Lic.Tech. C.E.</td>
<td>ARFID, EGON</td>
</tr>
<tr>
<td>de Morais, Wagner</td>
<td>M.Sc., C.S.</td>
<td>SELIES</td>
</tr>
<tr>
<td>Persson, Andreas</td>
<td>M.Sc., CS&amp;E</td>
<td>EPC</td>
</tr>
</tbody>
</table>
Söderstam, Per  M.Sc., CS&E  Industrial PhD stud., Information Technology  Project: ADAPT

Ul-Abdin, Zain  Lich.Tech. C.E.  Ph.D. stud., Information Technology  Project: EPC

Wang, Yan  M.Sc. C.E.  Ph.D. stud., Information Technology  Project: IPS

Weckstén, Mattias  Lic.Tech. C.E.  Ph.D. stud., Computer Science  Projects: BERT, ERTCENS

Table 3. Researchers at other departments and labs involved in joint projects with CERES

<table>
<thead>
<tr>
<th>Name</th>
<th>Function</th>
<th>Lab/Dep</th>
<th>Participates in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Håkan Pettersson</td>
<td>Prof.</td>
<td>MPE-lab</td>
<td>EGON</td>
</tr>
<tr>
<td>Carina Ihlström-Eriksson</td>
<td>Assoc. Prof.</td>
<td>MI-lab</td>
<td>Living Lab</td>
</tr>
<tr>
<td>Jesper Svensson</td>
<td>PhD student</td>
<td>MI-lab</td>
<td>Living Lab</td>
</tr>
<tr>
<td>Thorsteinn Rögnvaldsson</td>
<td>Prof.</td>
<td>IS-lab</td>
<td>SELIES</td>
</tr>
<tr>
<td>Anita Sant’Anna</td>
<td>PhD student</td>
<td>IS-lab</td>
<td>SELIES</td>
</tr>
<tr>
<td>Kenneth Nilsson</td>
<td>Assoc. Prof.</td>
<td>IS-lab</td>
<td>minST, ILISIS</td>
</tr>
<tr>
<td>Agneta Hansson</td>
<td>Gender Res.</td>
<td>HOS</td>
<td>G-EIS</td>
</tr>
<tr>
<td>Suzanne Almgren Mason</td>
<td>Gender Res.</td>
<td>Dep ext rel</td>
<td>G-EIS</td>
</tr>
<tr>
<td>Magnus Larsson</td>
<td>Lecturer, Head of IDE</td>
<td>IDE</td>
<td>minST</td>
</tr>
</tbody>
</table>
Recruitments during 2008


15. Calendar of communicating activities during 2008

Below is a calendar of communication activities during 2008. Each activity is broadly categorized into one of seven types.

NOT INCLUDED are the conferences in which CERES researchers have presented papers (See under Section 12c).

NOT INCLUDED are project meetings or steering group meetings in running projects.

<table>
<thead>
<tr>
<th>Month</th>
<th>Date</th>
<th>Activity</th>
<th>Communication purpose or type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>8</td>
<td>Meeting to establish interdisciplinary research cooperation in health technology (PRODEA)</td>
<td>Academic research cooperation</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Final report trippel N project</td>
<td>Partner collaboration</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>Meeting with Ericsson for Ambric cooperation</td>
<td>Partner collaboration</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>Meeting with minST and KK foundation</td>
<td>Other</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>Meeting with Entomred</td>
<td>New contact, follow up</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>Final master thesis presentations with external opponents from industry</td>
<td>Partner collaboration</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>Startup Gender equality project application</td>
<td>Other</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>Round table discussion to initialize cooperation and formation of joint research environment (EIS)</td>
<td>University internal collaboration</td>
</tr>
<tr>
<td>Feb</td>
<td>4</td>
<td>First CERES newsletter</td>
<td>External information</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>ILISIS meeting (partners and Vinnova)</td>
<td>External collaboration</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>teknIQInnovation - steering group and industry visit</td>
<td>External collaboration</td>
</tr>
<tr>
<td></td>
<td>6-8</td>
<td>COST Management Committee Meeting</td>
<td>External information &amp; Academic collaboration</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>Meeting with Neat Electronics</td>
<td>New contact, follow up</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Meeting with Entomrd AB</td>
<td>New contact, follow up</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>Meeting with Region Skåne EU-coordinator</td>
<td>External information</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>Meeting with Acticut AB</td>
<td>New contact, follow up</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>CERES Reference Group meeting</td>
<td>Partner collaboration</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>Halmstad Innovation City steering group</td>
<td>External information, regional collaboration</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>CERES Industrial Advisory Board meeting</td>
<td>Partner collaboration</td>
</tr>
<tr>
<td>Mar</td>
<td>5-6</td>
<td>Visit to University of Twente, NL</td>
<td>International collaboration</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Brainstorming Gender application</td>
<td>Other</td>
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<tr>
<td></td>
<td>10-12</td>
<td>PhD Student Conference</td>
<td>Academic collaboration</td>
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<tr>
<td></td>
<td>14</td>
<td>Meeting with Skövde and Orebro university: Joint research on elderly living</td>
<td>Academic research cooperation</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>Workshop: Embedded Parallel Computing</td>
<td>Partner collaboration</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>Meeting with Västra Götalandsregionen</td>
<td>Regional collaboration</td>
</tr>
<tr>
<td>Apr</td>
<td>3-4</td>
<td>Standardization meeting, COMeSafety, Brusels</td>
<td>Other</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Visit at VTEC for students and PhD students</td>
<td>Partner collaboration</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>CERES Newsletter</td>
<td>External and internal information</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>G-EIS seminar</td>
<td>Internal information and strategic work</td>
</tr>
<tr>
<td>Date</td>
<td>Event Description</td>
<td>Collaboration Type</td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>-----------------------------------------------------------------------------------</td>
<td>----------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Research education meeting with Chalmers</td>
<td>Academic research cooperation</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Vinnova meeting - Develop strong research environments by applying gender aspects</td>
<td>Strategic work</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Meeting Emnitech AB</td>
<td>Partner collaboration</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Meeting Ericsson AB</td>
<td>Partner collaboration</td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>6 Meeting Vinnova (ARTEMIS, ENIAC)</td>
<td>Strategic work</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 Meeting with Free2move (project application)</td>
<td>Partner collaboration</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8 Meeting with Skövde and Orebro university: Joint research on elderly living</td>
<td>Academic research cooperation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9 Meeting with VTEC and Vägverket</td>
<td>Partner collaboration</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9 Meeting with Mentor Graphics</td>
<td>Partner collaboration</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15 Meeting with VINNOVA, cooperation with research institutes</td>
<td>Partner collaboration</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16 teknIQinnovation - steering group and industry visit</td>
<td>External collaboration</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19 MRTC, research presentation</td>
<td>External information</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22 Meeting with PRODEA</td>
<td>Academic collaboration</td>
<td></td>
</tr>
<tr>
<td></td>
<td>28 CERES Newsletter</td>
<td>External and internal information</td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>29-30 International Living Lab workshop</td>
<td>Partner and academic collaboration</td>
<td></td>
</tr>
<tr>
<td></td>
<td>29 Public research information &quot;Mingla med forskare&quot;</td>
<td>External information</td>
<td></td>
</tr>
<tr>
<td></td>
<td>29 Master thesis presentation day</td>
<td>Partner and academic collaboration</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10-11 Kick-off for the FP7-project Pre-drive C2X</td>
<td>Academic and industrial collaboration</td>
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<td>16 Visitors from Shanghai University</td>
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<td>16 VINNOVA giving information about calls for funding</td>
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<td>15 Meeting with COMeSafety</td>
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<td>29 Presentation for new Masters students</td>
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<td>4 Seminar held for VTEC about IEEE 802.11p</td>
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<td>11-12 Visit from Newcastle</td>
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<td>26 CERES Newsletter</td>
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<td>3 Seminar held for VTEC about Body Area Network</td>
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<td>3 Meeting with IMEGO</td>
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### 16. Other information which the University, with the assistance of the Reference Group chooses to put forward

None.

### 17. Updating the project information on the website of the Knowledge Foundation

Separately.
18. Personal Statements from Reference Group Members

 Christer Fernström (chairman) 
 Hans Hansson 
 Åsa Lindholm-Dahlstrand 
 Lucia Lo Bello 
 Misha Pavel 
 Thorsteinn Rögnvaldsson 
 Tommy Skoog 
 Rolf Rising

CERES continues to demonstrate very good progress in building a coherent research focus and setting up increasing collaborations with the Swedish and the international research communities as well as with Swedish industry. The centre has a well articulated research agenda with challenging research goals of both academic and industrial interest. From its long-standing strong position in high-speed signal processing CERES has developed additional focus on applications in the healthcare sector and research on sensor networks and software technology, has created a research school with PhD education jointly with Skövde and Örebro and attracted new PhD students. In 2008, CERES has played a key role in establishing a more ambitious research environment across several labs at Halmstad University. These are all very good signs of growth. Many of my comments included in last year’s annual report are still valid, but I will below point out the important questions I would like to highlight for 2008.

Research and publications
Researchers at CERES have good publication track records. Last year we pointed out that the number of publications had somewhat decreased, but that we had noted clear efforts to remedy the situation. This has already become to bear fruit in 2008, and we feel that the situation has rapidly become quite good, also with publications in journals. Nevertheless, we emphasize that it must be a key objective for the CERES leadership team to continuously focus on the publication strategy and plans for targeting top conferences and journals in an even more systematic manner. Last year we also proposed that CERES should look for recruiting more Post-docs to help sustain publication. However, little progress has been made on this specific point.

We are pleased to see that research collaborations on the national level are progressing very well and that CERES continuously seeks further opportunities for international collaborations and we eagerly await a first success in establishing a EU-supported research project. We recognize that it is very difficult to obtain the first funded projects, but CERES has established itself as a credible candidate to participate in proposals, and we are
confident that there will be some successful proposals in the near future. This will both
boost international research collaboration (and for example open the door for recruiting
Post-docs from other European research teams) as well as help support the future CERES
funding when the current profile funding is reduced or even disappears.

On the local level, CERES is acting as a catalyser to establish a new research focus across
different labs at Halmstad University by creating a research agenda on Intelligent
Embedded Systems - EIS. This is in itself a very interesting result of CERES.

Industrial relations
The situation here is mainly the same as last year. Industrial relations are good with an
interesting combination of top notch industry and local start-ups, and the value of working
with CERES has been confirmed by representatives of the industry partners at several
occasions. The potential issue we see is that the growth in the number of partners may be
too modest (no new partner has officially joined CERES over the last years). As proposed
last year, we believe that CERES should consider different opportunities for bringing in
new partners, maybe with different degrees of involvement. This is partly already taking
place, with non-CERES members participating in some of the new projects, but the
question here is how to make such ad hoc collaboration evolve and become sustainable. In
a longer-term perspective it should be of strong interest to also bring in non-Scandinavian
members into the CERES industry consortium.

Organization
The leadership team is competent and has been very successful in establishing CERES.
Recent efforts have successfully helped create a strong and sustainable organization of
CERES.

Christer Fernström, Xerox Research Centre, France

Hans Hansson
CERES is developing well. It is particularly satisfying to observe the improvement in
publications, that CERES is the core of the larger EIS prioritised research area at HH, and
that plans for strategic recruitment are now being implemented. Industrial collaboration
continues to develop very well. The CERES team is well on track and the achievements are
at or above expected levels.

Below I provide some specific comments:

The leading team has been successful in strategic planning and development of CERES.
The recruitment plans are promising. However, for the long term success of CERES and in
light of the expected upcoming evaluations for the rights to issue post graduate degrees, I
recommend a further increased emphasis on strategic recruitment of in particular
internationally established senior researchers.

The ambition to publish more journal articles and to target the most prestigious
conferences is important and should continue. The increase in publications from 2007 to
2008 is impressive and is the result of a conscious strategy. Based on the success, it is now
time to formulate even more ambitious goals for the final years of the funding period.
Despite the unfortunate outcome of larger funding applications in recent years, it is for the post-profile years imperative that CERES continues to put enthusiasm and dedicated efforts into preparing and participating in additional efforts of this type. The competitiveness of CERES is continuously improving, and I am confident that this in the coming years will lead to a positive funding decision. Stay focused, be consistent, focus on your unique selling points, and team up with more established partners when appropriate. CERES is a successful centre with a lot of potential!

_Hans Hansson, professor, Mälardalen University, Sweden_

**Åsa Lindholm Dahlstrand**

CERES has demonstrated very good progress over the years. It is very satisfying to follow the development of the centre. It is a well managed research centre, and the interaction between its management, members and reference group has continued to work well. The centre has a well articulated research agenda with challenging research goals of both academic and industrial relevance.

CERES’ projects appear to be of high quality and well balanced, but the amount of ongoing research and development is not fully reflected in the number of international journal publications. The ambition to publish more journal articles and to target the most prestigious conferences is important and should continue. In 2008 the publication strategy of CERES seems to have resulted in a substantial increase in the number of conference publications, but, unfortunately not in any increase of international journal publications. Hopefully this is changing now; the list of accepted and forthcoming papers is suggesting that this is the case for 2009.

CERES is highly important for Halmstad University and for the region. In 2008 CERES has contributed substantially to the creation of new research environment (Embedded and Intelligent Systems Research, EIS) at Halmstad University. The EIS centre is one of the university’s three ‘areas of strength’, upon which Halmstad University is building its profile and research strategy. EIS is expected to support the subject area Information Technology, where the university already has earned the right to award Master degrees, and intends to apply for doctoral examination rights relatively soon in the future.

The creation of EIS has also enabled collaboration and strengthening of other research areas at the university. One such example can be found in the development of Halmstad Research School Entrepreneurship – Health, where all three ‘areas of strength’ participate and contribute to the development of a doctoral school in entrepreneurship, innovation, digital health and lifestyle. With CERES as a very central actor in EIS, this puts CERES in the very core of the future strategy of the university.

As a member of Halmstad University, as well as the Reference group, I am very much looking forward to following the development of CERES in the future.

_Åsa Lindholm Dahlstrand, professor, Halmstad University, Sweden_
Lucia Lo Bello

The year 2008 has witnessed an impressive growth of the activities run under the CERES program and a significant increase of their impact. The number of publications on leading international conferences significantly increased and similarly the research contacts with foreign institutions, both within Europe and outside Europe (US, Brazil, etc.).

The convergence which led to the establishment of the joint research environment named Halmstad Embedded and Intelligent Systems Research (EIS), effective since July 1st, 2008, is very important and very promising not only for the current activities, but also for long-term results, even after the end of the CERES program funding.

The very positive outcome of the external evaluation of EIS performed with the help of national and international experts clearly confirmed the high quality of the research carried out and the effectiveness of the management. The interest of ETSI in the CERES research results in the area of wireless networking is another important indicator of the successful efforts spent investigating in this area. The increasing number of PhD and licentiate students as well as the establishment of new spin-off companies show the vitality of the research and the soundness of the results.

For the future, it is recommended to continue and further broaden the research initiatives in collaboration with foreign research institutions. The announced recruitment of new researchers, with both senior and junior profiles, is very welcome and is expected to pay back already in the short term.

Lucia Lo Bello, University of Catania, Italy

Misha Pavel

The CERES review conducted in November of 2008 was my second review as a member of the Reference Group. The most significant impression from this meeting was the responsiveness of the CERES group to the comments made previously by the members of the Reference Group. CERES obviously continued to select research and development areas that are likely to have significant impact on engineering, science and society, including innovative technology in healthcare, transportation, sensor networks, etc.

At Oregon Health & Science University we had an opportunity to collaborate with one student who visited our internationally recognized laboratory specializing in gait and balance. During the short time of the student’s visit she and her advisor were able to collect relevant data that were then analysed in an innovative manner. The results of this work have been submitted for publication. This was an example of an intense and productive international collaboration that will likely yield results that will have a significant impact on a variety of European initiatives, such as Ambient Assisted Living.

I would also like to note the collaborative efforts within the school of IDE, whereby CERES became a central unit in the new research environment, namely Embedded and Intelligent Systems Research. These activities are strengthening CERES as well as other areas within the university.

The number of peer-reviewed publications has increased in accordance with the advice from the Reference Group that resulted in CERES adapting an aggressive publication
strategy. It appears that this trend will continue and these and future publications will become a key component underlying the positioning of CERES within the international scientific and engineering community.

_Misha Pavel, professor, Oregon Health & Science University, USA_

**Rolf Rising**

CERES has now become an institutionalized part of Halmstad University which is a successful milestone by itself. CERES is also a well recognized player among regional companies. However, the regional customer base, and even the Swedish one, may be too small for bringing CERES to a front position in an area where research to some extent is market driven.

Having said this it is important for CERES to start developing collaboration with foreign industry leaders. A strategy including definition of focus area, CERES vision, industry targets and research offerings should be worked out, and resources should be set aside for operating this strategy towards measurable goals in terms of some first international projects.

_Rolf Rising, Invest in Sweden Agency, Sweden_

**Thorsteinn Rögnvaldsson**

I focus my comments on CERES’ development in relation to Halmstad University’s strategic plan.

During 2008, CERES joined with three other research labs at Halmstad University and formed the new Halmstad Embedded and Intelligent Systems Research (EIS) environment. This new research environment represents a focused effort in information technology with more than 40% of the gross research budget of Halmstad University (more than double that of CERES). CERES was the driving force in this development, which was perfectly in line with the University research strategy, to decrease the number of research labs and fuse them into a larger structure with a “critical mass” that can attract prestigious grants.

Halmstad University’s strategy for the future is to try to get the right to educate research students (formally, researchers within EIS have for many years supervised doctoral students registered at other universities but who have been employed and active at Halmstad University). The information technology field is a central part in this strategy, with CERES as the engine for the development. In preparation for this, Halmstad University arranged an external evaluation of EIS (the CERES and the Intelligent Systems parts, the two largest parts in EIS) in November in 2008. The result of this evaluation was that EIS (CERES and Intelligent Systems) have an overall very good international level, with excellent research in some fields, and that the environment is able to provide very good conditions for doctoral education. Furthermore, the external evaluators ranked the industrial collaboration and contacts as excellent, perhaps even outstanding. The University’s plan is to achieve the right to grant degrees on doctoral level during 2010 and CERES will be the fundament for this.

Another strong evidence of the development and high level of CERES is that Halmstad University, as the only Swedish University that does not have the right to grant doctoral
degrees (except for the Military Academy), was recommended (June 15, 2009) to receive strategic long term grants from the Swedish government to develop outstanding world leading research in ICT (in collaboration with Linköping University, Lund University, and Blekinge Institute of Technology). This is very prestigious and perhaps a first proof that CERES development into a larger environment with more “critical mass” was correct.

The publication strategy in CERES has begun to yield results. The number of Journal publications has increased and the awareness of the importance of publications in key databases is high. The number of publications per million research funding is increasing. The newly formed EIS environment is well visible in the databases; ten of the twenty most cited papers from Halmstad University in Thomson Scientific’s Web of Science are authored by researchers in EIS.

I find the CERES and the EIS development to be excellent and the prospects for the future are very good.

Thorsteinn Rögnvaldsson, professor, Halmstad University, Sweden

Tommy Skoog

CERES has as a centre of excellence developed well and steadily all since the beginning. The number of publications is closing up on expected levels and international co-operation with universities and new research partners is improving. CERES is advised to continue focussing on a strong management to maintain a firm future development especially since the internal co-operation with several other research resources within HH is forthcoming.

It is important for CERES to further strengthen the interaction with industry and partners especially in the healthcare sector. This area is supposed to grow during the foreseeable future and will attract industry and partners, existing as well as new ones. CERES should take measures to create a clear visibility on the international research arena in order to attract further students and researchers.

Tommy Skoog, Independent consultant, Sweden

Halmstad 2009-06-29

Bertil Svensson
Project leader

Grenoble, France 2009-06-29

Christer Fernström
Chairman of the Reference Group
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Anm: Kostnader i andra KK-finansierade projekt inom samma forskningsmiljö (såsom småföretagsdoktorander och företagsanknuten forskarassistent) redovisas inte här.

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Signatures – Financial Report

Halmstad, June 24th, 2009

Eva Nestius, Accountant
Bertil Svensson, Project leader
Part III – EXTENDED ABSTRACTS OF CERES PROJECTS

Research Projects
System to Avoid Surprise Effects on Roads with Sparse Traffic
G-EIS – Gender Perspectives on Embedded Intelligent Systems – application in healthcare technology
EPC – Embedded Parallel Computing
VAS – Vehicle Alert System
S3 – Situation Specific Surveillance
ERTCENS – Embedded Real-Time Communication using Emerging Network Standards
IPS – Implementation of Protocol Stacks
SELIES – Supporting Elderly Life through Intelligent Embedded Systems
Living Lab – Safe and Secure at Home
EGON – Ultra Low Power Active RFID
Wireless Real-time Communication for Telematic Applications
Active RFID – VLSI Architectures for Small Area, Low Power Wireless Devices
REMOTE – Real-time Mobile Telecommunication
BERT – Budgeting for Embedded Real-Time Systems
ADAPT – Autonomous Driver Assistance in Public Transport
Memory Intensive Signal Proc. Arch. (MISPA2)

Innovation Support Projects
TeknIQ Innovation
minST
Triple N
ILISIS
Trygg Hemma – Leva och Bo
The project is focusing on how to design a system, using wireless communication, that can alert drivers to avoid surprise effects when driving on roads with sparse traffic.

1. Background and Motivation

The introduction of communication technology provides new means to reduce the number of fatalities and financial loss of traffic accidents. Recently, active ITS safety applications based on vehicle-to-vehicle (V2V) or vehicle-to-infrastructure (V2I) communication have become the interest of research groups worldwide. Often, the focus lies on dense traffic as e.g. in urban or highway scenarios. Sparsely trafficked roads in rural areas did not get much attention so far, although a system warning for e.g. on-coming traffic has the potential of saving many lives on Swedish roads.

For cost and practical reasons, it cannot be expected that all (or even a majority of) vehicles will be equipped with the proper communication technology in the foreseeable future. Detecting a vehicle and sending out a warning to other traffic participants can therefore not be expected to only be done by the vehicles themselves. Sensors and access points (Road Side Units, RSU) along the roadside are a necessary complement. Installation costs can be motivated by setting up this infrastructure at accident-prone road sections where e.g. the sight is inhibited and by the fact that road side infrastructure can be used for a broader set of communication services and a possible integration of diverse communication solutions to reach global connectivity. For the initial safety system for rural environments, we suggest a vehicle-to-infrastructure based solution, compatible with upcoming ITS standards as 802.11p and working within the frequency spectrum suggested for European ITS applications. However, the solution must work with only vehicle-to-vehicle communication also. This is important since infrastructure, in terms of road side units, will only be installed at strategic places.

In this project, we define a system architecture for a vehicle-to-infrastructure and vehicle-to-vehicle communication based system to avoid surprise effects on roads with sparse traffic. Results from projects like CVIS and SAFESPOt are natural input for the project. The reliability and timing of the information exchange between vehicles and road side units is very important in order to be able to increase the traffic safety. We therefore consider real-time communication aspects in the design of the system, based on our ITS-related results from the VAS project (Vehicle Alert System) and by adapting non ITS-related research on real-time and reliability to the requirements of the proposed system. Moreover, we do experimental measurements of wireless communication to obtain knowledge about the performance one can expect.

The outcome from the project is expected to prepare for a continuation where a system demonstrator should be implemented and detailed protocol, performance and reliability studies should be done.

2. Results

A survey of related projects in the area of vehicle networking has been done. Moreover, we have defined a system architecture, with focus on the communication issues, to support applications that warns the driver about sudden events like an approaching vehicle. The system architecture supports both vehicle-to-vehicle and vehicle-to-infrastructure communication. We have also proposed methods to support fast connection setup and handover to a roadside unit nearby. Initial measurements with IEEE 802.11p have been done.

PARTNERS AND STATUS

The project is directly funded by the Swedish Road Administration (Vägverket).

Project leader: Magnus Jonsson.

PhD candidate: Annette Böhm.

The project has now been run as a pre-study project during fall 2008.

PUBLICATIONS

Annette Böhm, ”Vehicular communication system decreasing surprise effects on rural roads with low traffic density (Mötesvarningssystem)”, Technical Report IDE09XX, Halmstad University, Dec. 2008.

Maarten Frederix, ”Develop a system to avoid surprise effects on sparse traffic roads”, Master’s Thesis in Electrical Engineering, Technical Report IDE09XX, Halmstad University, Jan. 2009.

Gender Perspective on Embedded Intelligent Systems – Application in Healthcare Technology

S. Almgren Mason
Centre for Gender Equality, Halmstad University

By integrating a gender perspective in all activities, the G-EIS project (Gender Perspective on Embedded Intelligent Systems) has as its aim to make EIS (Halmstad Embedded and Intelligent Systems Research Environment) a national and international model of gender equality and a leading environment for research, innovation and education within computer technology and its applications in products and services. As EIS is particularly well organised and accomplished concerning applications of technology in the area of health technology, this is the main focus of the project. A gender perspective will be integrated in the research environment as well as in the whole process from idea to product and end user.

1. Background and Motivation

Embedded Intelligent Systems (EIS) is the joint research field of the four collaborating laboratories at the School of Information Science, Computer and Electrical Engineering (IDE) at Halmstad University. The four labs are the: Computing and Communication lab (CC-lab), Intelligent Systems lab (IS-lab), Man and Information Technology lab (MI-lab), and Mathematics, Physics and Electrical Engineering lab (MPE-lab).

The research of the four labs is integrated into a strong concerted research environment within embedded systems (EIS) – with a perspective reaching from the enabling technology via new system solutions and intelligent applications to end user aspects and business models. Embedded systems are systems of micro computers, sensors, communication etc. built into products, with the aim of offering new functions and properties in the product/service. It is an expanding research area with many applications, not least ones that exist in everyday life.

EIS has strong connections to both established and new, expanding firms hived off from the university. The research environment is active in the Healthcare Technology Alliance, a network of around sixty companies, counties and health care providers in south western Sweden with the aim of developing the region into a leading arena for the development of health technological products and services. Several projects together with these participants concern both research and technology transfer.

An integrated gender and gender equality perspective in innovations within the health technology area is necessary in order to be able to meet the needs of an ageing population with quality innovations. The relevancy of a gender perspective is clear in relation to the fact that about 70% of all those older than 75 years are women. Older women are on average cared for in hospital for twice as long as men, partly due to differing disease panoramas, but also because men are more often cared for in the home by a woman while the women who live longer more often live alone. With the expansion of home-help and home nursing new needs follow and it is likely that a gender perspective will become necessary for the development of products and services that can make daily life easier for the elderly.

The gender perspective also has relevance from the point of view of care staff. New technology is developed for application within the health and care sector where the larger professional groups consist mainly of women. The technology, most often designed by men, is used by women. With this in mind it is clear that an important aspect of good innovations is that the end users are involved in the innovation process.

2. Problem formulation

Technology is traditionally considered a male area of work and this is reflected in the sex distribution within IDE. Among the enrolled students, the discrepancy is even larger than among the staff (which in fact has a better sex distribution than most other equivalent environments). A pilot study shows that there is a need to problematise the science of technology and its application in relation to gender and gender equality, and to carry out development work for a more gender equal and gender aware work and research environment. In addition, health care is an area concerned with both technology development and gender aspects – many elderly women live alone toward the end of their life and many care givers are women. Technology can be used to facilitate both being able to stay in one’s own home and the often heavy and complex work of health care. The end users are regarded as possessing untapped knowledge that can help researchers produce more user-friendly products.

3. Approach

The gender and gender equality perspective is to be integrated not only in the research environment of
EIS and its research partners, but also in the whole chain from the recruitment of students to the consumers of the innovation system’s products and services. The project team is a combination of staff from EIS and gender researchers. Four Ph.D. students or younger researchers represent the four labs and function as “change agents” – they receive training in gender equality, research aspects of gender equality in their respective labs, and report back to the gender researchers as well as to IDE. Phases of the project have been named the “sowing phase”, the “growth phase” and the “harvest phase” with the intention of sowing the seeds of gender equality awareness and competency, expanding this over and throughout the whole health technology field and finally reaping the benefits of an integrated gender perspective. The four dimensions of Joan Acker’s theory of gendered organisations are first applied to and mapped in the research environment EIS, and will later in the project process be tested on the Health Technology Alliance and its operations.

4. Expectations
EIS will make the project results and new knowledge useful in its extensive development work, with emphasis on profiling and growth and the consequent recruiting of new staff that the research environment faces. A gender perspective will put research as well as undergraduate and postgraduate studies in a new light, and is likely to encourage innovation toward useful applications. In collaboration with partners in the Health Technology Alliance, knowledge about the relevance of a gender perspective in technology education, research and the health technology application area will increase.

Expected results of the project include both more gender relevant innovations and technology applications and closer collaboration within the area of health technology. In the long run the project result ought also to be reflected in a more even sex distribution among both staff and students within EIS.

5. Partners and status
Funding: VINNOVA
Duration: 2008-2011
Project leader: Professor Bertil Svensson
Change agents: Stefan Byttner, Annette Böhm, Mikael Hindgren, Jesper Hakeröd
Project participants: Olga Torstensson, Roland Thörner, Carina Ihlström Eriksson, Magnus Jonsson, Håkan Pettersson, Magnus Hållander, Magnus Larsson
Gender team: Suzanne Almgren Mason, Emma Börjesson, Agneta Hansson, Gunilla Fürst Hörte
External participants: Anne-Christine Hertz (Halmstad municipality), Ann-Mari Bartholdsson (Halland Regional Development Council), Joel Eliasson (Phoniro AB), Pelle Wiberg (Free2move AB)

Figure 1. Expected project results
The project addresses the efficient use of parallel and reconfigurable computing structures in embedded high-performance applications. The industrial challenges for the research are, e.g., baseband processing in base stations for future mobile communication systems based on the LTE (long-term evolution) standard, and real-time image forming in synthetic aperture radar systems.

**Keywords:** Stream processing, Coarse-grain reconfigurable computing, Processor arrays, Parallel computation models, High-performance signal processing, Radio base-stations, Radar signal processing.

**Purpose**
Understanding parallel architectures and their usage is an important part of the CERES research program on Cooperating Embedded Systems. The project addresses the efficient use of parallel and reconfigurable computing structures in embedded high-performance applications.

**Goals**
The overall goals of the project are: (1) to understand which overall (hardware and software) architectures are best suited for a given application domain, and (2) to find efficient ways of writing programs / mapping applications that execute efficiently on parallel/reconfigurable computing systems. The project does not address general purpose processing; rather it is oriented towards the needs of high-performance embedded signal processing applications.

The Project has four main “threads”, each with its own goal:

**Thread 1**
*Stream processing architectures and languages with applications in baseband processing.* Goal: To develop language based tools that enable efficient execution of baseband processing algorithms on programmable array architectures. (See Figure 1).

**Thread 2**
*Programming of reconfigurable chip architectures.* Goal: To explore well established computation models and devise new design methods based on these models to — for selected streaming application(s) — program the emerging class of reconfigurable chip architectures with varying granularity. (See Figure 2).

**Thread 3**
*Methods for coordination of signal processing components.* Goal: To develop methods for design of high performance signal processing software that is portable to several parallel platforms.

**Thread 4**
*Studies of realization of challenging signal processing applications.* Typical for the applications in question is that it is initially unknown whether it is at all possible to meet their demands with state-of-the-art technology or foreseeable new technology. Goal: For particular such application(s), acquire understanding of the demands on computer architectures, and possibly propose architecture solutions.
RESULTS
Among the results so far are:

Models for manycore performance evaluation. A machine model that captures essential performance measures of array structured, tightly coupled manycore processors has been developed. A timed intermediate representation has been constructed, and, by means of abstract interpretation, this can be executed in order to obtain feedback about the run-time behaviour of the application (see Figure 3).

CSP based programming of reconfigurable processor arrays. An approach of compiling a CSP based language, occam-pi, to a reconfigurable processor array has been evaluated. The method is based on developing a compiler backend for generating native code for the target architecture. The new parallel architecture from Ambric has been used as target.

PARTNERS AND STATUS
Associated partners: Ambric, Inc., Portland, OR, USA; UC Berkeley, CA, USA.

Project funding: CERES profile funding from the Knowledge Foundation, together with the industrial partners’ efforts in the project.

Project duration: June 2007 – May 2010.
Project leader is Bertil Svensson, CERES.

PUBLICATIONS
Zain-ul-Abdin and B. Svensson, “Using a CSP based programming model for reconfigurable processor arrays,” Proc. of 2008 International Conference on ReConFigurable Computing and FPGAs (ReConFig'08), Cancun, Mexico, Dec. 3-5, 2008.
The Vehicle Alert System (VAS) project focuses on cooperative alert services based on timely and reliable communication under the challenging circumstances in highly mobile vehicular network scenarios. Both vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, and applications based on such communication, are in focus in the project. We take a cross-layer approach including three different levels of abstraction: link, network and application perspective.

1. Background and Motivation

A reduction of fatalities and financial loss due to traffic accidents is a common goal of ITS (Intelligent Transport Systems) research. The introduction of communication technology plays a vital role in the development of proactive ITS safety applications. It enables vehicles to receive data that help both the vehicle itself and its driver to correctly assess the current traffic situation and its potential hazards. Information is shared between vehicles through inter-vehicle communication, either vehicle-to-vehicle (V2V) or vehicle-to-infrastructure (V2I), the latter involving an access point called road side unit (RSU).

The Vehicle Alert System (VAS) project is doing research in the areas of cooperating embedded systems, vehicular ad-hoc networks (VANETs), wireless sensor networks and wireless digital communication. VAS aims at using V2V and V2I cooperative communications to support ITS safety applications by providing different types of warning messages in a timely and reliable fashion.

2. Problems and Goals

The issues of cooperative ITS safety applications are tackled on several levels of the communication stack.

At the application layer, the system must be able to handle communicated kinematic data observations from vehicles in dependable and scalable ways. The information is used to make a vehicle aware about traffic situation and potential collision risks. Specific sub-goals include:

- Develop a system architecture that takes into account the roles of infrastructure versus vehicles as carriers, interpreters and goal driven controllers of information.
- Find methods for modeling, prioritizing and handling situational information and decision making in a scalable way, even in overload situations.
- Enable cooperation between autonomous nodes with multiple, possibly conflicting, control goals.

At the medium access control (MAC) and network level, we are faced with problems due to high vehicle mobility, instability in signal strength and the fact that ITS safety applications rely on the timely delivery of data. Scheduling of messages must be done according to their importance levels and timing requirements. Specific sub-goals include:

- Develop MAC methods for vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication supporting the real-time requirements of safety-critical ITS applications.
- Develop protocols and methods that are able to handle highly dynamic environments and that enable fast connection setup and handover in order to support the instant delivery of critical data.
- Investigate a joint approach to connection setup, medium access control and schemes to handle base station access (V2I) and/or routing in ad-hoc networks (V2V).

At the link level reliable connections must be formed using efficient coding and modulation methods for timely delivery of information. Specific sub-goals include:

- Design transmitters and receivers using error control coding and cooperative diversity to provide reliable information transfer within limited time frames.
- Use the application specific quality of service parameters to prioritize traffic even at the lowest protocol layers to achieve maximum utilization of the limited resources in a wireless network.

3. Application Scenarios

We identified several type scenarios, representing different application areas and typical issues and problems in ITS safety applications.

Emergency vehicles, e.g., ambulances, traditionally use sirens and light to inform other road-users that they are approaching. Using both V2V and V2I communication, the zone of awareness can be extended through proactive warning messages and a path for the emergency vehicle can be cleared in time. The emergency vehicle should be able to communicate with VAS infrastructure to query for suitable routes to its destination, as well as to request traffic signal pre-emption. Real-time and routing issues are important in this scenario.
Figure 1. Vehicles and infrastructure cooperate on the macro level to create a "green wave" for the ambulance.

The merge assistance scenario, Figure 2, illustrates how cooperating vehicles can increase safety and efficiency at highway on-ramps. A highway entrance might be a given spot for roadside infrastructure. Here, both safety-critical data and non safety-critical data (comfort and entertainment) should be supported, stressing the need for prioritization and scheduling of transmissions.

Figure 2. A truck merging onto the highway coordinates with other traffic for a safer and smoother maneuver.

The pedestrian crossing warning scenario, Figure 3, employs mainly V2I communication to warn the driver that pedestrians are located on, or near the crossing. Crosswalk signaling infrastructure can also benefit from interaction with vehicles. If a vehicle is unable to stop in time, for example due to road conditions or driver inattention, the crosswalk signaling system could delay giving the “walk” signal or alert pedestrians. At unguarded crossings detectors could alert drivers that there are pedestrians waiting to cross.

Figure 3. Vehicles and infrastructure cooperate to create a safer situation at a pedestrian crossing.

4. Results

We have made several state-of-the-art surveys and pre-studies, e.g. in the form of technical reports and master thesis works. Topics include: communication standards for wireless vehicle communication, medium access control (MAC) protocols, routing and forwarding techniques, and fast handover techniques.

The VAS project resulted in several scientific publications and technical reports that can be divided into the following categories:

4.1 Medium Access Control in V2V and V2I communication

Short and medium range communication for vehicular networks is subject to the WAVE (Wireless Access for Vehicular Environments) standardization process conducted by the IEEE 1609 working group. The physical and link layers in particular are currently being standardized as IEEE 802.11p, a variation of the IEEE 802.11 Wireless LAN standard. Simulation results of the MAC protocol in the standard IEEE 802.11p strongly indicate that additional efforts are needed to provide timely and reliable vehicular communications.

The only standard supporting direct V2V communication will be the upcoming 802.11p. This has a major drawback in its MAC procedure namely unbounded channel access delays when the network load increases (could be either an increase in the data traffic injected by nodes or an increase in the number of the participating nodes within transmission range). In a VANET there cannot be any restrictions on the number of participating nodes. Therefore, the MAC algorithm must be able to cope with a high number of nodes and degrade gracefully as the network becomes overloaded. Simulations show that the MAC procedure of 802.11p, i.e., carrier sense multiple access with collision avoidance (CSMA/CA), collapses very early. We suggest the employment of a self-organizing time multiple access scheme (STDMA) for the V2V. This is already in commercial use through a surveillance system for ships called Automatic Identification System (AIS). The first simulation results reveal that this algorithm performs remarkably well for the vehicular environment and further investigations have been initiated.

For V2I communication, we suggest an enhancement to 802.11p MAC by placing an additional real-time layer on top of the unaltered IEEE 802.11p protocol, such that a deterministic, polling-based MAC method is introduced. This real-time layer guarantees the timely delivery of safety-critical data. We apply real-time schedulability analysis to determine the minimum amount of bandwidth needed for safety-critical data transmission, while the remaining bandwidth is left for best effort services. Additionally, we further enhanced our solution by introducing geographical priority zones around an area of hazard (e.g. an intersection), defining different levels of priority and, thereby, determining a vehicle’s communication parameters based on its geographical position (see figure 4). The merge assistance scenario is used as a target application for both the system description and the simulation analysis.
The S3 project (Situation Specific Surveillance) is a platform for research in the areas of wireless sensor networks, ad hoc networks and wireless digital communication. The S3 project poses challenging questions on several different aspects and topics such as: energy efficiency, dependability, self-configuration, and scalability in wireless network applications. These topics need to be addressed in a cross-layer design involving several levels. The project is therefore divided into three concurrent tracks: the link, network and application perspectives.

### 1. Background and Motivation

The S3 project (Situation Specific Surveillance) is a platform for cross layer research in the areas of wireless sensor networks, ad hoc networks, wireless digital communication and their applications.

The purpose of the S3 project is to investigate the potential of using wireless sensor networks for surveillance purposes. An application scenario in a real-world setting is used as a starting point for research on topics related to ad hoc wireless sensor networks. Key issues are energy-efficiency, mobility, self-configurability, dependability, scalability, and real-time support.

### 2. Problem

The S3 project poses challenging questions and reveals interesting problems on several levels and is therefore divided into three concurrent tracks.

At the link level the dynamic network conditions together with the power constraints impose strict requirements on forming reliable connections requiring a minimal amount of energy in terms of transmitted energy, transmission and receiving times, as well as low complexity decoding. Specific sub-goals are:

- Provide reliable and energy efficient communications on the wireless links in the sensor network by efficiently coding the information.
- Enable scalability and manage hot spots in the link layer by efficient coding and cooperation.

At the network level, we are faced with similar requirements on the end-to-end connections. Specific sub-goals are:

- Take a joint approach to connection setup methods, medium access control and routing in ad hoc networks to combine energy efficient communication with quick response times.
- Develop methods to ensure both timely and reliable end-to-end delivery of messages.

Application level design must be able to handle data aggregation, control and cooperation in a distributed system in secure and scalable ways. Specific sub-goals are:

- Design system and software architecture including principles for sensor data collection, aggregation or replication, distributed control and redundancy enabling graceful/safe function degradation.
- Define and evaluate principles and solutions for autonomous, sensing mission driven, system and software configuration and network setup.
- Design methods for use of component based software in distributed sensor network applications and solutions for cooperation and system coordination in distributed system with low duty ratio.

### 3. Application Scenarios

There are many applications for wireless sensor network based surveillance systems ranging from locating mobile systems and tracking moving objects to monitoring of static objects and object relations. For the S3 project, a medium size harbor (Figure 1) was chosen as a suitable testing area since it offers a variety of applications for surveillance systems.

![Aerial photo of harbor area](https://via.placeholder.com/150)

**Figure 1. Aerial photo of harbor area with permission from Lantmäteriverket.**

Containers with valuable goods need around-the-clock monitoring. Using a network of cooperating sensors enables immediate reporting if goods are moved out of a certain area or if the seal of a container is broken. A static network of sensor nodes can be used to monitor certain local spots of interest in the harbor area.

By deploying a net of sensors in larger parts of the harbor, intruders can be recognized and their movement over the property can be traced. Harbor workers and ship crews can be authorized to move freely in restricted parts of the area and are thereby not recognized as intruders.
For normal monitoring, only a few sensor nodes need to be active, while an alert causes additional sensors in the concerned area to wake up and take part in the data collection and processing required for tracking and evaluating the event.

4. Results

On the application level we have studied application scenarios, sensor types and composed measurement configurations involving multiple sensors. Techniques to find and allocate sufficiently good, although not always optimal, sensors to use and techniques for how to setup and configure measurement and surveillance missions have also been studied and compared. We have also made studies on mission driven and adaptive software configuration and setup of sensor networks based on agent based middleware.

We have made surveys and protocol comparisons, focusing on energy-efficiency and real-time. Both MAC and routing protocols have been compared. Further, we investigated how to support real-time communication using IEEE 802.15.4 for wireless sensor networks. Wireless industrial networks have many similarities with wireless sensor networks when used for surveillance. Short packets of control data should be transmitted reliably and in time this for the control process itself and for enabling short wakeup cycles to preserve energy.

For timely and reliable end-to-end delivery of messages, we have developed a framework which includes both a retransmission scheme and analysis methods necessary to calculate real-time performance guarantees. We are now working on improvements to better tackle the high bit error rates often present in wireless sensor networks.

Relaying and packet combining is a way to increase reliability while at the same time preserving energy by reducing the number of retransmissions. Initial results of a simple and practically implementable protocol in which relay and packet combining works together to improve the probability that packets are delivered within deadline over fading channels shows that these techniques can be applied on top of commercially available transceivers.

A simple demonstrator system for monitoring a group of children has been implemented using the Mica2 motes from Crossbow with TinyOS and TinyDB. Each node in the network used the received signal strength indicator (RSSI) to approximate the distance to its neighbors and a central analyzes the measurements and warns the teachers if a child is wandering off. Initial results indicate the RSSI is too imprecise for this type of distance measurements due to the fading properties of the radio environment.

PARTNERS AND STATUS

Industrial Partners: Ericsson AB, Emwitech AB, Free2move AB, XCube Communications inc, and InnovationTeam AB.

Funding: CERES profile funding (Knowledge Foundation) together with the industrial partners’ efforts in the project.


Project leader: Dr. Martin Gustavsson, Ericsson AB.

PUBLICATIONS


that are robust against communication failures. 

coordination rules, in the form of driver behavior models as one such strategy. Another strategy is the use of pre-shared secret keys for communication.

Continuous measurements made by vehicles in the network is useful for specific communication quality predictions based on continuous measurements.

Middleware services that provide site-specific context information for traffic safety applications over wireless channels have been proposed. A middleware service that provides site-specific communication quality predictions based on continuous measurements made by vehicles in the network is one such strategy. Another strategy is the use of pre-shared coordination rules, in the form of driver behavior models that are robust against communication failures.

4.2 Fast connection setup and handover in V2I communication

Also based on the merge assistance scenario, the connection setup method using 802.11p was studied and we suggested a proactive handover method between RSUs, setting an upper limit to the delay experienced from handover. This method is based on position information and speed estimations of the communicating vehicles.

4.4 Application and Middleware

The hardware and software technology platform developed in the European IP project CVIS has been used to implement a prototype warning system.

VAS will evaluate the platform and provide input on scalability and deployment to the CVIS consortium. Contacts have been initiated with the COST Action 2100 to evaluate suitable channel models for vehicular communications.

PARTNERS AND STATUS

Industrial Partners: Free2move AB, SP Technical Research Institute of Sweden, and Volvo Technology Corporation.

Project funding: CERES profile funding from the Knowledge Foundation and the industrial partners’ in kind efforts.


Project leader: Björn Åstrand

Application and middleware strategies for reliably providing traffic safety applications over wireless channels have been proposed. A middleware service that provides site-specific communication quality predictions based on continuous measurements made by vehicles in the network is one such strategy. Another strategy is the use of pre-shared coordination rules, in the form of driver behavior models that are robust against communication failures.

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Project leader: Björn Åstrand

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ERTCENS - EMBEDDED REAL-TIME COMMUNICATION USING EMERGING NETWORK STANDARDS

X. Fan1, M. Jonsson1, K. Kunert1, K. Lind3, P. Olanders3, M. Weckstén1, A. Åhlander2


The ERTCENS (Embedded Real-Time Communication using Emerging Network Standards) project has its focus in high-performance embedded real-time networking. Examples of applications are radar signal processing systems and radio base stations. Especially, we investigate the use of switched networks in such systems, treating aspects like real-time analysis, topologies, and dependability.

Keywords: Real-time communication, real-time systems, high-performance embedded networks, switched networks

1. Background and Motivation

The ERTCENS (Embedded Real-Time Communication using Emerging Network Standards) project focuses on high-performance (low latency and high bit-rate) embedded communication between different parts, boards, chips, or modules inside an embedded system. Some networks might be limited to cover a certain rack or box (e.g., a radar signal processing system or a radio base station unit), while other might cover a truck, an airplane, an automation industry, or a set of medical equipment, all networks being essential parts of embedded systems. Such embedded systems are getting more and more complex, distributed, performance demanding, heterogeneous and with rapidly changing conditions. New solutions and knowledge are therefore needed for real-time communication and resource handling in such systems to get them dependable, cost-effective, and predictable without increasing the engineering cost.

Moreover, novel emerging network standards, often incorporating switched interconnection technologies, give new features and performance possibilities. However, methods etc to bridge the gap from enabling networking technologies and standards to cooperating embedded systems with high real-time and reliability demands are needed. As an example, models to characterize the real-time performance must be developed.

2. Goals

The main goals of the project are:

- To develop analysis methods and understanding of standardized (COTS) networks to be able to use low-cost technology in embedded systems with high real-time and dependability demands.
- To evaluate limitations in current/emerging standards concerning real-time services and dependability.
- To develop methods etc that can be used in standardized networks, utilizing the existing hardware but adding software or analyzing methods to improve the support for real-time traffic.
- To develop a method or guidelines for the choice of topology, e.g., to avoid bottlenecks.
- Develop cost-effective support of timely and reliable end-to-end delivery of messages.
- To investigate how a holistic view of the communication in heterogeneous embedded networks can help the designer to avoid bottlenecks and to develop predictable system behavior.

3. Results

The real-time communication demands for three representative embedded systems applications have been characterized. Moreover, a survey of emerging COTS-based networks has been done. Also, an investigation of how to combine the best from vehicle networking and high-performance networking was done in the scope of a master thesis project. The result was a specific network protocol design.

We have developed an analysis framework to calculate on guaranteed real-time performance in switched networks with FCFC (First Come First Served) queuing. The framework is based on scheduling analysis and has shown better results than the well-known Network Calculus. In simulation studies, switched Ethernet has been assumed, but the framework should be rather easily adapted to other standards. Together with priority queuing (see Figure 1), we can even guarantee delay bounds for real-time traffic by having it going through the high-priority queue, not disturbed by other traffic through the low-priority queue.

[Figure 1. FCFS queuing combined with priority queuing.]

In the area of topologies, we have developed a method to choose topology of a switched network carrying real-time traffic. The method can even be used to choose different topologies to reconfigure between during run-time when having several working modes to switch between.
Regarding the support of timely and reliable end-to-end delivery of messages, we have developed a basic framework for that. The framework includes both a retransmission scheme and analysis methods necessary to calculate real-time performance guarantees.

One PhD has been graduated within the scope of the project (Xing Fan).

PARTNERS AND STATUS
Industrial Partners: Combitech AB, Ericsson AB, Saab Microwave Systems.

Project funding: CERES profile funding from the Knowledge Foundation, together with the industrial partners’ efforts in the project.


Project leader is Magnus Jonsson, CERES.

PUBLICATIONS


IMPLEMENTATION OF PROTOCOL STACKS

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2. Free2Move, SE-302 48 Halmstad, Sweden

IPS is a project addressing programming protocol stacks for embedded systems. It is a collaboration between Halmstad University and free2move in the context of CERES – center for research on embedded systems. The goal of the project is to produce software tools that facilitate the implementation of protocol stacks.

1. Background and Motivation

We find the need for tools that help automatize the implementation of protocol stacks in the fact that many companies are re-implementing well-known infrastructure protocols as well as implementing new application protocols. There are many well known techniques to do a good job in these implementations in order to avoid a number of bottlenecks. However, these techniques, that come from a number of disciplines, are not always easy to understand or to implement. Tools that automate the use of these techniques are a way of providing infrastructure that makes these techniques more available for new applications.

2. Problem

Implementing protocol stacks is tedious, error-prone and time-consuming. It is even more so when targeting small embedded systems, which usually have additional, non-functional constraints. Thus, implementations have to minimize energy consumption, memory usage as well as other computation resources. In order to improve on time-to-market, scalability, maintainability and product evolution, even development time and programming methodology are relevant.

3. Approach

We propose to design a domain specific language to facilitate protocol stack implementations targeting resource constrained embedded systems. Code will be compiled into C and have correctness, efficiency and maintainability in focus. We address the protocol stack as a whole to enable cross-layer optimizations and address resource utilization via a suitable runtime system.

4. Results

The main ideas of the project were presented in [1]. To the moment we have a language (PADDLE) for writing packet specifications in a modular way. Our compiler generates a C library with useful functions for packet processing. Some salient features of the library are that it can deal with both physical layout and semantic constraints, that it is bit oriented (as opposed to requiring byte alignment) and that it works directly on the buffer where the packet resides. Packet processing with PADDLE improves the correspondence between the specification and the implementation as the latter is generated from the former. Also, packet parsing and marshaling is kept in one place instead of finding fragments spread over packet processing code. This results in code that is much easier to maintain as changes can be done in only one place. We present these ideas in a paper submitted to ICDT 2009 [2].

As part of our work we have contributed a library for processing ad-hoc data in the programming language.
Haskell [3]. Our language for describing packets implements a special kind of ad-hoc data format.

PARTNERS AND STATUS
Industrial Partner: Free2Move
Project funding: CERES profile funding from the Knowledge Foundation, Free2Move, Halmstad University.
The project extends through August 2006 – August 2009.
Project leader is Veronica Gaspes.
Results from the project will form part of the PhD thesis of Yan Wang.

PUBLICATIONS


[3] Y. Wang, V. Gaspes, “A Library for Processing ad-hoc Data in Haskell: embedding a data description language.” Accepted for publication to the 20th symposium on the implementation and application of functional languages.
A rapidly growing elderly population in Sweden as well as in the rest of the world imposes a need for ambient assisted living technology. To better tailor the technology to the elderly needs, understanding about the user’s context as well as their intention is desired. Likely, future systems are worn ubiquitously embedded in everyday objects and interoperable with other devices in its surrounding. The operation is human centered and special concern to the user privacy needs is taken. Two main aspects of this is explored further in this project, the analysis of human movements thru accelerometer based “motion primitives” and the aspects of integration of hardware components, functions and services in a platform to support applications.

1. **Background**

The rapid aging of Europe’s population poses new problems to be addressed in the near future. According to the World Health Organization Statistics [1], about 1.6 million of Swedish people (17% of total population) are aged 65 or over. Projections show that in the next 40 years, the largest part of population growth will be among people aged 65 and older.

In future years, the increased number of people aged 65 and over will exert great pressure on the healthcare system to treat age-related problems. These problems comprehend different aspects of physical, social and cognitive wellness as well as assistance from professional or informal caretakers.

Most age-related problems demand long-term, expensive treatments which weigh upon society as a whole. To cope with economic limitations of the available resources, the traditional health care system has been shifting its attention from medical facilities to home-based medical assistance.

2. **Technical Motivation**

Great part of technological development aims at creating intelligent systems to aid humans in performing certain activities. The success and effectiveness of these systems are correlated with their ability to perceive, interpret and interact with the environment. The comprehension of movements can provide important information about what is happening in the surroundings (context awareness) and consequently, information about what actions need to be taken. Therefore an artificial conceptual system, capable of coding and decoding physical movements, is of primary importance.

To make solutions appealing, practical and useful outdoors, poses several challenges; light-weight and ubiquitous, robust and embedded in devices normally worn such as shoes, bracelets or jewelry and wrist watches. Thus utilizing modern MEMS sensors built can lead to products of low cost and less obtrusive operations. Currently, the accelerometer is the main candidate, due to its low cost and power consumption and general applicability [2].

When dealing with small and portable sensors, the volume of the power source represents a significant portion of the device’s total size. Thin-film batteries, for example, are small of customizable shapes and flexible form factor. However, reducing the size of the power supply should not compromise the energization of the embedded system. For instance, medical sensors and smart tags, powered by small batteries, should work from several months to many years.

3. **Aging Aspects**

Some of the more challenging aspects of ageing are the “geriatric giants”, see Figure 1.

![Figure 1: Five geriatrics challenges often referred to as “geriatric giants”](image)

In many cases it is difficult to directly assess e.g. cognitive decline (dementia) in the elderly community. Today, a battery of tests is performed by a clinician when suspicion has been established. The great challenge is to
establish this first suspicion due to the sparse contacts with the healthcare system. Future healthcare systems could be personalized and based on continuous assessments of functional status over time. Changes observed over time can be due to normal age progression, change of life patterns or decline due to illness.

4. Intelligent systems challenges

One important challenge of recognizing human behaviors is to understand the current activities as well as activities performed over time. Here, the main aspect is the use of human motion analysis as a tool for supporting elderly life and suggests a new “motion language” approach to such task.

5. Embedded systems challenges

Ambient computers in e.g. the home environment could be a better suited alternative to mobile monitoring systems as they are less intrusive and can work without the challenges associated with battery operated equipment. To better understand what types of measurements that can be done in the home and the requirements of them a study is underway to compare the most frequents metrics used to characterize decline. One examples of metrics are

Another track is to optimize the way the systems spend energy. Typically, modern hardware has different power saving states to allow conservation of energy. To best utilize them, special concern needs to be address to optimize the scheme. Simpler systems might be possible to optimize offline whereas more complex systems might benefit from runtime support. A current study examines the benefits of taking the transition time of different power states into account when modeling the energy use of mobile computing systems.

6. References


PARTNERS AND STATUS

Project funding: Sparbanksstiftelsen Kronan, Halmstad University.

The project period is October 2007 –

Project leader is Dr. Nicholas Wickström.

The two PhD students are part of a university research school; Research school in entrepreneurship and health.

PUBLICATIONS


LIVING LAB – SECURE AT HOME

Living lab – Secure at home is a VINNOVA funded research project exploring the possibilities with a living lab approach. The project primarily focuses on methods for user involvement in the innovation process. The context of the living lab is ICT services and products aimed at supporting and empowering elderly people.

1. Background and Motivation

A living lab approach aims at providing usable ICT products and services, which in some cases can be problematic. The living lab approach addresses this issue by incorporating three different stakeholders/perspectives that is essential for launching successful ICT innovations. First, there is a need to know who the users are and to identify their needs and preferences. Second, to be able to produce commercial successful innovations, business models needs to be addressed early in the process. Finally, there is a need to incorporate knowledge about technology.

According to Eriksson et al., (2005), society, market and enabling technology is essential stakeholders/perspectives needed in a co-design process to enable successful ICT innovations (Fig. 1).

![Figure 1. Society, Market and enabling Technology in a Co-design process.](image)

In a Living Lab, ICT innovations are created and validated in collaborative multi-contextual empirical real-world environments. The individual is in focus in the role of a citizen, user, consumer, or worker and is seen as a valuable source of innovation. In the living lab – secure at home project we focus on methods for user involvement to improve the innovation process for SMEs in the health care sector.

2. Problem

The overall research question is: In what way does user participation affect the innovation process in a Living Lab approach?

The aim is to:

- Identify which methods and techniques for user involvement that are most suitable for different parts of the innovation process,
- Apply and modify these methods and techniques in different parts of the innovation process,
- Testing and evaluating these methods and techniques in several processes of innovation,
- Examining in what way user involvement influence the innovation process from different stakeholder views (e.g. SMEs, Municipalities etc.)
- Examining the value of the Living Lab approach for generating business as well as user value in an ICT innovation,
- Discussing pros and cons with the Living Lab concept,
- Discussing the experience of building a Living Lab.

3. Approach

The project is divided into several cases based on our partners’ field of interest. The cases are categorized into three different areas:

1. Innovation (from start to finish)
2. Further development of existing products
3. New application areas of existing products

This approach allows us to experiment with different methods and techniques for user participation in different parts of the innovation process as well as investigating different stakeholder views.

4. Results

The results from the project will be divided into three categories:

1. Evaluation and development of methods for user participation in the innovation process.
2. Establish a long-lasting living lab at Halmstad University. To be able to do this, we need to:
   a) generate knowledge about suitable models and methods for a user centric innovation system,
   b) bring together relevant and needed partners,
   c) establish a user database.
3. Support our partners development processes of new products and services aimed at empowering the elderly.
5. Partners and status

**Industrial Partners:** Emwitech AB, Free2move AB, HFAB, Innovation Team AB, KomiKapp/Rehatek AB, LBS, Science Park, Unity by Light AB, Medicpen AB, Neat Electronics AB, Phoniro AB, ProEvolution AB

**Project funding:** VINNOVA funded

The project extends through August 2007 – August 2009.

Project leader is Carina Ihlström Eriksson.

Results from the project will provide a base for the PhD thesis of Jesper Svensson.

Other involved people are Roland Thörner, Nicholas Wikström and Nicolina Månsson.

6. Publications


Submitted:


In progress:


A new low power radio architecture based on a bi-stable regenerative transceiver with backscatter functionality is investigated. A characteristic feature of the new technology is its ability to support communication with thousands of units in very short time period; further that each of these units consumes very little energy. This opens up vast application opportunities in the field of cooperating embedded systems. The goal of the project is to develop a radio design that, after further product development, enables the fabrication of Radio Frequency Identification (RFID) units with a battery lifetime of up to eight years and a price level in the same range as passive RFID tags.

1. Background and Motivation

Today the radio technology has been miniaturized to a level where a transceiver can be realized in the size of a couple of square millimeters. This small form factor has led to new application areas such as: Road User Charging (RUC), Real-Time Location Services (RTLS), and Internet of things. Typical characteristics for these wireless applications are: short range (less than 100 m), short response time, low power consumption, and low data rate. If these requirements are paired with low price, current radio technology is inadequate. This challenge leads into a part of the design space of radio transceivers that traditionally has not been considered. Two radio technologies commonly mentioned for these application areas are passive and active radio frequency identification (RFID). A passive RFID system provides very low cost per tag, but such a system has an extremely limited operational range (a maximum range of a couple of meters). On the other hand active RFID systems are often based on common short range transceivers like IEEE 802.11 or ZigBee, where the tags are expensive and have rather high power consumption (10-100 mA when operating). The short operational range of passive RFID systems, and the high cost and high power consumption of active RFID systems more or less has disqualified both active and passive RFID technologies for these application areas. This has lead to an open field for new innovations in the area of radio technology.

2. Problem

The fact that the transmit output power is very limited for short-range radio transceivers, less than 100mW (typically in the range of 1mW to 10 mW), implies that it is not the emitted output power of the transmitter that dominates the power consumption. Instead the short range transceiver’s power consumption is dominated by the radio electronics like: local oscillator, mixer and IF amplifiers and baseband signal processing. These parts of the transceiver are often common or similar building blocks for the receiver chain and the transmitter chain. This implies that the power consumption is similar for the reception and the transmission operations of a short range transceiver.

All commonly available short range transceivers have relatively high power consumption during operation (independent of if it is in receive or transmit mode). This makes it very hard to build a system where devices need to be accessible in short time. As an example, consider a RUC system where a reader must be able to identify a passing vehicle within one second. This response time requirement implies that the device on the vehicle must be in active (receiving) mode for several milliseconds, at least once every second – all the time! One can clearly see that there exists a fundamental trade-off between the response time and the power consumption of such a device. In fact the only realistic way to achieve both short response time and low power consumption is to minimize the power consumption of the transceiver in receiving mode. For cost reasons, in addition it is necessary to consider much simpler radio architectures than those commonly used for wireless short range transceivers today.

3. Approach

A new low power radio architecture and operation method is proposed; it is based on a bi-stable oscillator which has been applied in a feedback amplifier circuit. The two states of the bi-stable oscillator have been defined as receiving and oscillating. In receiving mode the oscillator circuit is biased in such a way that it is just below the threshold to start oscillating, i.e., the circuit is stable. A small incoming RF signal, on the right frequency, brings the oscillator to oscillating mode, the biasing of the oscillator is moved in such a way that the circuit starts oscillating. The bi-stability is based on the non-linear characteristics of the transistor. The new radio
architecture is a reincarnation of Armstrong’s super regenerative receiver, with the major difference that this circuit is only brought to oscillation by the presence of an external RF signal via the antenna. Figure 1 displays the basic architecture of the radio. It is based on an LC-tank with controllable resonance frequency (here indicated by the presence of a varactor diode), and feedback amplifier represented as a negative resistance. The negative resistance compensates for the resistive losses that are present in the LC-tank. This enables a control of the Q value (the selectivity) of the circuit. Interesting to notice is that the Q value (selectivity) and sensitivity increase for the circuit, the closer to the tipping point for oscillation that the circuit is biased. The first is true since when, \(-R = R\), the Q value goes towards infinity. The latter is true, since the closer to the tipping point that the oscillator circuit is biased, the less RF energy (via the antenna) is necessary to bring the circuit into oscillation.

Figure 1: Principle of the new radio architecture.

The active backscatter provides a bidirectional information exchange channel between the reader and the entire set of tags. When the reader is emitting RF energy at certain frequencies, it brings all tags in range (tuned to these specific frequencies) to start oscillate. By defining an alphabet of symbols and assigning these symbols different frequencies the start of an oscillation is the symbol detection mechanism used at the tag, i.e., a form of course frequency shift keying. Further, by letting the tags oscillate for a longer time period than the time when the RF signal is emitted from the reader, it is possible to receive information from the set of tags – so called active backscatter. A tag will start emitting an RF signal at the tuned frequency as soon as it starts to oscillate, since the oscillator is non-shielded from the antenna.

By mapping each tag’s individual address to a sequence of symbols, each tag is represented by a unique sequence of symbols. By further expanding the number of necessary symbols by two it is possible to feedback information to the reader during the arbitration sequence.

4. Status

EGON is an applied research project, in which the approach is to go from idea, via verification, to implementation of a full demonstrator. The present project status is that fundamental verification of the behavior of the bi-stable circuit has been conducted by simulation and implementation. For example, a first chip has been manufactured, see Figure 2, to compare the simulation tools and simulation models’ result with a real implementation in a commonly used C-MOS process. A second chip, enabled for the 2.4GHz ISM band has been designed and sent for manufacturing. Furthermore, several discrete circuit designs are under evaluation. Research has also started on the design of energy-efficient protocols when the radio is applied in Active RFID systems.

Figure 2: First test chip, an amplifier for the oscillator circuit.

PARTNERS AND STATUS

Funding: The Crafoord Foundation; Halmstad University.
Partners: Chalmers University of Technology: MC2, CSE;
Lepton Radio AB, a start-up company based on the project.
Project leaders: Bertil Svensson and Per-Arne Wiberg.
The WIREALMATICS project (Wireless Real-Time Communications for Telematics Applications) provides an opportunity for a recent PhD graduate to do research in close collaboration with industry. The main research goal is to enable wireless communications that meet the requirements from applications involving cooperating vehicles, but the project should also enable the postgraduate to do research in the more general area of wireless real-time communications as well as increasing the interaction between industry and academia.

1. Background and Motivation
The increasing requirements on vehicles regarding quality, dependability, safety and functionality calls for an integrated approach where the different subsystems of the vehicle communicate. In order to reach the goal formulated by the European commission of halving the number of road deaths by 2010 when, at the same time, traffic volumes are expected to double, additional efforts are needed to optimize the vehicle systems in relation to the road and communication infrastructure. This optimization will be realized by connecting the vehicle subsystems to road side systems and the different communications networks being built concurrently with the road infrastructure. Due to the many different requirements regarding safety, functionality, quality and environment imposed on these types of systems it is crucial that the communications architecture is well thought-out and constructed based on careful evaluations.

Reliable wireless real-time communications is a core component in CERES for enabling cooperating embedded systems.

2. Problem formulation
The wireless communications protocols available on the market today enables either reliable communications with low error rate or time-critical communications with real-time constraints – but not integrated high levels of both. In order to enable increased traffic safety by cooperating vehicles it is of utmost importance to develop efficient wireless communications protocols for critical real-time communications with requirements on reliable transfer with low error probability.

3. Approach
By formulating critical real-time constraints as so called "Quality-of-Service" (QoS) parameters they can be quantified. To solve the problem of enabling reliable wireless real-time communications, an integrated approach is needed. The latest advances and cutting edge technologies in channel coding and retransmission protocols in the lower layers of the communications stack need to be tailored to the increased requirements of the emerging applications in the upper layers. Design of retransmission protocols and channel coding with different QoS constraints is a relatively new research area, but everything indicates that the applications requirements should be allowed to influence and imbue all layers in the communications stack in order to make the best use possible of the limited resources available in a wireless network.

The purpose of this project is to allow the application requirements, formulated as QoS parameters, to control the lower layers of the communications stack to enable the development of efficient time-critical communication protocols for future mobile wireless networks. Longer term this project has the potential of playing a fundamental role in the implementation of many future intelligent transport services.
4. Results

Two master thesis projects on wireless vehicular communications have been conducted at Volvo Technology under the supervision of Dr. Uhlemann, CERES and Mr. Nygren, Volvo Technology. The thesis “Collaborating Vehicles for Increased Traffic Safety” by I. Khalil and M. Morsi has been awarded with the Triona and WSP scholarship given to the best thesis related to the ITS field. A chapter of the thesis “Test Environment Design for Wireless Vehicle Communications” by P. Lerchaumbaer and A. Ochoa Lopez has been published at the IEEE International Symposium on Wireless Vehicular Communications.

Katrin Bilstrup, CERES Ph.D. student, has several times been invited to Volvo Technology to give seminars, provide technology expertise and convey her research results on vehicular communications. Further, Ms. Bilstrup has received invitations to present her research results at ETSI TC ITS and C2C-CC for consideration in ongoing standardization activities.


PARTNERS AND STATUS

Industrial partner: Volvo Technology Corporation.

Project funding: Funding from the Knowledge Foundation: “Tjänster för Nydisputerade”, the CERES profile and Volvo Technology Corporation.


Project leader: Dr. Elisabeth Uhlemann

PUBLICATIONS


ACTIVE RFID – VLSI ARCHITECTURES FOR SMALL AREA, LOW POWER WIRELESS DEVICES

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The use of Radio Frequency Identification systems (RFID) is growing rapidly. Today, mostly “passive” RFID systems are used because no onboard energy source is needed on the transponders. However, “active” RFID technology, with onboard power sources in the transponders, gives a range of opportunities not possible with passive systems. To obtain energy efficiency in an Active RFID system the data communication protocol to be used should be carefully designed with energy optimization in mind. Also, new architectural solutions for small-area, low-power baseband processing as well as for small-area, low-power RF blocks will be required. This industrial PhD student project focuses on relevant research questions related to these issues.

Keywords: RFID, active RFID, protocol, back-off, carrier sense, energy efficient, wireless networks, active tag, energy consumption, low-power CMOS ASIC

1. Background and Motivation

Radio Frequency Identification, RFID, is used to remotely and wirelessly identify a device named transponder (or tag) by using an interrogator (or reader), see Figure 1. The tag has a unique identity (could be used as an electronic product code, EPC) used to identify the object it is attached to.

The RFID technology can be divided into two main categories, Passive RFID (P-RFID) and Active RFID (A-RFID), where the most common is the P-RFID.

Figure 1. An RFID-system where tags are passing a reader. The tags in range of the RFID-reader identify themselves by transmitting their unique identities.

Scenarios for RFID might for instance be in the logistic chain, tracking goods from the producer to the consumer, where the goods can be a single product or up to several hundred products on a single pallet. Items must be identified fast by the RFID-reader when e.g. a fork lifter transports them (Figure 2, lower) and passes an RFID-reader. In this realm, RFID could also be used for automatic inventory of the stock in a warehouse (Figure 2, upper), where the reading delay is not critical but where there is a huge amount of tagged goods to identify.

In the fork lifter scenario (assuming there is a narrow passage) only a small amount of transmitted and received energy is needed, due to the short distance, but fast readings are needed due to the vehicle velocity. For the warehouse scenario, with long distances, more energy is needed, but this scenario has no hard time restrictions.

Figure 2. The fork lifter scenario, where the goods on the pallet have to deliver their identity fast when the fork lifter passes the RFID-reader (lower). The warehouse scenario, where a large amount of goods are stored and have to be continuously updated in the inventory database (upper).

2. Problem and Results

To obtain energy efficiency in an Active RFID system the data communication protocol to be used should be carefully designed with energy optimization in mind. This has been the primary focus of the first two years of the project, and the results of this work have been presented.
in Björn Nilsson’s licentiate thesis. The thesis describes how energy consumption can be calculated, to be used in protocol definition, and how evaluation of protocols in this respect can be made. The performance of such a new protocol, in terms of energy efficiency, aggregated throughput, delay, and number of air collisions is evaluated and compared to an existing, commercially available protocol for Active RFID, as well as to the IEEE standard 802.15.4 (used e.g. in the Zigbee medium-access layer). Simulations show that, by acknowledging the payload and using deep sleep mode on the tag, the lifetime of an Active RFID tag is increased.

For all types of protocols using an air channel for transmitting and receiving information it is obvious that the utilization of that channel is maximized when no collisions occur. To avoid and minimize collisions in the air interface it is possible to listen to the channel (carrier sense) and know its status. Knowing that the channel is occupied should result in a back-off and a later retry, instead of persistently listening to the channel which would require constant energy consumption. The effects on tag energy cost and packet delay incurred by some typical back-off algorithms (constant, linear, and exponential) used in a contention based CSMA/CA (Carrier Sense Multiple Access/ Collision Avoidance) protocols for Active RFID communication are studied. It is shown that, by selecting the proper back-off algorithm coefficients (based on the number of tags), i.e. the initial contention window size and back-off interval coefficient, the tag energy consumption and read-out delays can be significantly lowered. Thus the adaptation of the protocol parameters to the usage scenario is a significant key to lowering energy consumption and thereby extending the lifetime of the tags.

The post LIC studies are now focused on the design and evaluation of a complete Active-RFID system. While for the RFID-reader there are no hard constraints in power consumption, the tag needs to be carefully designed to get long working life time. The production cost of a tag is also more sensitive than that of an RFID-reader because of the great number of tags produced. This implies that keeping the external components on the tag as few as possible decreases the production cost. Therefore it is important to optimize the CMOS ASIC design for the tag to fulfill constraints on both power consumption and production cost.

Another ongoing project at CERES, “Egon – Active Backscatter Radio”, is focused on designing a low power wake up radio, resulting in a CMOS ASIC that is on its way. The fusion between the research on protocols and the Egon project has resulted in the design of a new protocol and a completely new Active RFID system. An ongoing work at Halmstad University in collaboration with Chalmers University of Technology is aiming at building a new test platform for a complete Active RFID system. Potential patents have been identified during this work.

PARTNERS AND STATUS

Industrial partner: Free2move AB.

Project funding: SME PhD student funding from the Knowledge Foundation, Free2move AB.


PhD student: Björn Nilsson, employed by Free2move AB.

Researchers: Lars Bengtsson and Bertil Svensson (project leader) from CERES; Per-Arne Wiberg from Free2move and CERES.

Results from the project formed the licentiate thesis of Björn Nilsson, presented in November, 2007.

PUBLICATIONS


REMOTE – REAL-TIME MOBILE TELECOMMUNICATIONS

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We foresee an even wider use of wireless communication in industry settings, the transportation sector and as a tool for ambient intelligence. Especially, the possibility to provide guarantees for time-critical applications becomes an emergent issue when wireless communication is used to interact and control a physical process, as in, e.g., control theory and real-time systems. The standards for wireless communication that are available today lack a general strategy of striving to deliver information reliably before a deadline and as such do not support the concept of concurrent timely and reliable delivery. These aspects make current wireless protocols less suited, or in some cases not suited at all, for real-time applications. This calls for research efforts leading to new wireless protocols for time-critical traffic. The requirements on timeliness and its effect on of the fundamental parts of information and communication theory is an urgent research task.

1. Background and Motivation

The wireless feature itself implies three immediate benefits in factory communication systems. Firstly, it reduces the number of wires. This was once the main driving force behind the development of wired fieldbus systems, where multiple signals to/from sensors, actuators, field controllers and human interfaces were multiplexed on the same wire instead of using a single wire for each individual signal. Secondly, motions, vibrations, heat variations and aggressive substances put mechanical and chemical stress on wires which eventually break, or even worse, introduce transient and intermittent signal errors. The use of wireless communication eliminates these problems. Thirdly, the use of wireless communication results in increased mobility and a new dimension of freedom for operators and service personnel since the human interface can be portable. Further, the increased flexibility implied by the use of wireless communication enables autonomous guided vehicles and handheld terminals to communicate directly with the surrounding machines.

The important issue that differentiates these systems from general communication systems is that the communicated information is used to control physical processes, obeying strict physical laws which imply that late, lost or erroneous information can be disastrous for the control of a physical process. It is important to point out that late delivery of information can, for the control of most physical processes, have the same effect as lost information. This kind of system, where the information delivery has an absolute expiry date in the time domain, a deadline, is referred to as real-time communication systems.

2. Problem

Wireless communication standards available today can transport large amount of information wirelessly and the provided average throughput is often high. The problem is that even if the average throughput is high, it does not mean that each individual packet of information is delivered deterministically with respect to time.

If a data symbol or a packet of information, contains non-correctable errors or is lost, it is usually retransmitted from the original information source (or some other source having the same information) to the destination in order to improve the reliability. Due to the noise on the communication channel there is a (small) probability that this error event is repeated infinitely many times. This implies that, strictly defined, as soon as 100% correct information delivery is required it is not possible to guarantee timely delivery, i.e., deterministic behavior cannot be provided. The problem is thus to provide as reliable packet delivery as necessary (as required by the application) before the deadline, while using a minimum of resources.

3. Approach

The research methodology is to apply a framework where the deadline and the probability to successfully deliver a communication message before this deadline are thought of as quality of service (QoS) parameters. By strictly applying these parameters jointly and on each individual protocol layer, a protocol stack with transparent interfaces can be achieved. This enables each layer, a high level protocol or the application to negotiate the delivery service in a transparent manner. To be able to provide reliable wireless real-time communications, a cross layer approach is needed such that also the three lowest protocol layers, i.e. physical layer, link layer and network layer are tailored to the specific QoS requirements of the application. By applying this framework, and by individually investigating different protocol layers and their plausible interaction, the final goal of a general protocol stack which is able to provide time-critical
guarantees, while keeping the layered structure for engineering efficiency, can be fulfilled.

PARTNERS AND STATUS


The project period: January 1999 – present.

Project leader: Per-Arne Wiberg.

Results from the project formed part of the Lic.Eng. and Ph.D. Theses of Elisabeth Uhlemann, defended in November 2001 and October, 2004 respectively, and part of the Lic.Eng. and Ph.D. Theses of Urban Bilstrup, defended June 2005 and December 2008 respectively. Two spin of companies have been formed as result of the project: Free2move (2000) and LeptonRadio (2007).

PUBLICATIONS


The BERT (Budgeting for Embedded Real-Time Systems) project is focusing on how to, primarily in early design, cope with the growing system complexity. To increase engineering efficiency, we develop scheduling, allocation and analysis methods that can be integrated into a tool to help in the design of distributed embedded computer systems.

1. Background and Motivation

The aim of the BERT (Budgeting for Embedded Real Time Systems) project is to make and evaluate a method for early design evaluation. This is needed since, as system complexity grows, engineering efficiency does not. As a result of the research so far we have implemented a systematic method for derivation of non functional constraints available at design time which made it possible to verify the implementability of a certain design and also make implementation a much clearer task. This is not only needed since systems of increasing complexity have to be developed but also since the cost for failing has proven to be too high. So, the problem has been to develop a method that will derive the design time constraints into implementation time constraints, maintaining the traceability for the individual constraints, and early on get indications whether a project is about to fail or not.

2. Basic Implementation Constraint Derivation (BICD) method

Based on available resources, performance restrictions and the task set with its constraints, a budget containing intermediate constraints for all tasks is generated. This procedure is repeated and the most promising budgets are stored in a set of implementation budgets.

To get the basic method as generally applicable as possible, a number of extensions are needed. One example of extension is to support the combination of task graphs with different periods of execution. Another important issue is to develop methods to analyze communication performance of complex interconnection networks. This is in order to include communication delays in the budgeting of complex networked embedded systems and to be able to find good mappings of the network traffic, or even to adapt the network architecture to the traffic.

3. Results

We have implemented a systematic method for derivation of non functional constraints available at design time which made it possible to verify the implementability of a certain design and also make implementation a much clearer task. Moreover, we have developed a method to simulate the implementation process, making it possible to evaluate design and implementation methods in a cheap and repeatable way. Each implemented task results in a cost and a worst-case execution time.

To support switched interconnection networks in our targeted distributed systems, we have developed a method to choose topology. The method can even be used to choose different topologies to reconfigure between during run-time when having several working modes to switch between. We have also developed a preliminary solution to analyze a switched network using the knowledge about the task graph properties, in order to increase the amount of possible guaranteed real-time traffic.

PARTNERS AND STATUS

The project is coupled to other CERES projects, primarily ERTCENS with the following industrial partners: Combitech AB, Ericsson AB, and Saab Microwave Systems.

Project leader: Magnus Jonsson.

PhD candidate: Mattias Weckstén.

PUBLICATIONS


ADAPT – AUTONOMOUS DRIVER ASSISTANCE IN PUBLIC TRANSPORT

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ADAPT, Autonomous Driver Assistance in Public Transport, is a research project aimed at investigating pros, cons and methods of autonomous and distributed fleet operations management with the aim to increase passenger throughput using available vehicles and possible solutions to the distributed control of systems of mobile entities, e.g. public transportation networks, transport and logistics operations and the flow of private transportation vehicles through a road network.

1. Background and Motivation
Systems involving vehicle fleets have for several years now employed IT-solutions to the monitoring and control of the fleet status and activity. The technologies used in these systems are typically a centralized server solution with wireless connectivity to each individual vehicle.

The adaptation of these technologies has up until recently been uncoordinated and involved many actors of diverse sizes. The momentum, though, is building up and the larger players and institutions, such as auto manufactures and the EU, are currently coordinating a joint infrastructure and service framework for the future of mobile (vehicle bound) IT.

2. Problem

The, previous, ad-hoc growth of the application area and subsequent realizations of systems supporting the fleet management and control, have given rise to complex, heavily centralized solutions. These rely on interrelated databases, dedicated application servers and point-to-point communications schemes such as GSM/GPRS/EDGE and the like. These, arguably evolved, architectures fail to support some important systems goals, notably: dependability and scalability.

Dependability is jeopardized in the sense that the centralized system hub is a single-point-of-failure and scalability is reduced as adding entities and/or functionality to the systems grows harder by the size of the system.

Also, the entities in the system often harbor a substantial computing power that is not used and the centralized communication give rise to hotspots.

The infrastructures envisioned by the main actors continue the path of the centralized system solutions while proposing standard interfaces to deal with many of today’s shortcomings. In that process, though, they are also adding more functionality to the systems increasing their complexity.

3. Approach

We propose to search for solutions to fleet management systems that do not rely, solely, on centralized command and control but instead use distributed control mechanisms. The rationale is that by imbuing the respective mobile entities in the network with a level of autonomy, turning them into active agents of the system, much of the system operation and control may be automated and distributed.

Automation reduces the human controller workload freeing resources to handle the less frequent but most complicated situations. Distribution can reduce the bandwidth needed to the central and facilitate robust operation in the face of communications problems. Data related to a specific situation stays “in the field” where high bandwidth, cheap, short range wireless equipment may be used and the computing power of the agents may be efficiently utilized.

The central questions of this project are which systems services are possible to cost-effectively distribute onto the fleet agents, what technologies are applicable and how to use them.

4. Results

The expected results of ADAPT are better time-keeping and lowered demands on total vehicle transport capacity, and thus operating costs, and lessened environmental impact. The project is, as of March 2008 in its inception and definition phase.

5. References

TBD
PARTNERS AND STATUS

Industrial Partner: None

Project funding: CERES profile funding from the Knowledge Foundation, SAVE-IT industrial research program.

The project period is October 2006 – December 2009.

Project leader is Per Söderstam.

PUBLICATIONS

None.
The real-time image forming in future, high-end synthetic aperture radar systems is an example of an application that puts new demands on computer architectures. Is it at all possible to meet the demands with state-of-the-art technology or foreseeable new technology? We need to understand the computational flow, with its associated memory, bandwidth and processing demands. In this project we analyze the application in order to, primarily, understand the algorithms and identify the challenges they present on a basic architectural level. The processing in the radar system is characterized by working on huge data sets, having complex memory access patterns, and doing real-time compensations for flight path errors. We propose algorithm solutions and execution schemes in interplay with a two-level (coarse-grain/fine-grain) system parallelization approach. The results of this “upstream” study will serve as a basis for further, more detailed architecture studies.

1. Background and Motivation

A challenge for architects of embedded computers is the processing in future, advanced image creating sensor systems, where complex transformations of massive sensor data sets are carried out, transformations that require efficient coordination of processing, memory and communication resources. An example is the signal processing in low-frequency synthetic aperture radar (SAR) systems (see Figure 1). The MISPA project focuses on the image formation, done in the time domain using the computationally efficient fast factorized back-projection (FFBP) algorithm [1].

Figure 1. Stripmap processing. The integration length may be tens of kilometers

2. Problem

Even though the FFBP has been implemented in software, and tested on radar data, it has not yet been thoroughly investigated from a real-time computer realization point of view. In these SAR systems the integration time is typically several minutes during which huge amounts of data are collected. In the larger systems a working memory of hundreds of gigabytes, with a complicated addressing scheme, will be needed. Interpolation kernels are swept along curved paths in the memory space during the execution. Due to changing geometry proportions, the shapes and positions of these paths vary as the image forming progresses. In addition, the exact properties of the curves are not known a priori, because these are dependent on compensations for non-linear flight paths and thus must be extracted on the fly. These compensations require geometrical calculations, which need to be intermixed with the actual image calculations. The calculation demands can also be considerable, depending on, e.g., the chosen interpolation methods. The need for efficiency in the FFBP execution is emphasized by the fact that the embedded processing has tight power and size requirements.

3. Approach

The algorithms are analyzed with regard to the fundamental principles for parallelization. The analysis can then serve as a basis for further, more detailed architecture studies for various platform types (from small, one-engine aircrafts to large surveillance systems). Figure 2 illustrates the radar data collection.

Figure 2. Collecting radar data. $M \times N$ resolution cells are illuminated.

The task for the signal processor is to integrate, for each resolution cell in the output image, the instantaneous response that a target in that particular cell would have. This is done using the FFBP algorithm, illustrated in simplified form in Figure 3.
4. Results

The parallel processing is preferably performed on different levels of granularity. On a coarse level the whole data set is split over a number of (loosely coupled) processing nodes (see Figure 4). On a fine granularity level the processing within a subset can be carried out by exploiting instruction level, thread or data parallelism.

To compute a resulting data row, data must be fetched from the contributing apertures (see Figure 3) along non-linear paths, which get increasingly distorted over the iterations, and the indices for pointing them out are obtained by complex geometrical operations. A critical issue is the execution of the hot-loops, where contributing data elements are combined to new data elements, after complicated index calculations and data interpolations. The chosen interpolation method affects the total performance and memory demands significantly. Figure 5 illustrates how the requirements on computational performance and memory size vary depending on the chosen method for interpolation.

An efficient execution scheme for a sliding interpolation kernel has been developed. The detailed implementation of the interpolation kernels should exploit the great inherent data parallelism by executing in a systolic or SIMD fashion.

5. References


PARTNERS AND STATUS

Industrial Partner: Saab Microwave Systems
Project funding: CERES profile funding from the Knowledge Foundation, Saab Microwave Systems
The project period was February 2005 – May 2007.
Project leader was Anders Åhlander.
Results from the project formed part of the PhD thesis of Anders Åhlander, defended May 29, 2007.

PUBLICATIONS

The aim of the project is to strengthen Swedish small and medium sized companies’ ability to use research as a strategic resource in their product development by supporting them in creating new products out of interesting ideas. The application area of the project is health care and the technological areas are intelligent and embedded systems.

1. Background and Motivation

Technology and knowledge transfer are two important missions for the universities. During the last decade Halmstad University and CERES have been a part of the KK-foundation’s expert competence programme teknIQ and minST. TeknIQ addressed the area of embedded systems and minST is addressing the area of micro- and nanotechnology. The aim is to utilize the new opportunities created by the technologies to increase companies’ profitability and belief in the future. As a spinoff CERES started teknIQInnovation (TQI) as a pilot project in 2005. In contrast to teknIQ and minST, TQI also supports research work. It also has a focus on a specific application area and line of business, namely Healthcare technology.

2. Objective

The aim of the project is to strengthen Swedish small and medium sized companies’ ability to use research as a strategic resource in their product development. To fulfil this the university and companies work together in projects that require support from researchers to get successful in creating new products.

3. Approach

TQI is working with an easily comprehensible working method in three steps.

1. Generate ideas
2. Carry through a pre study
3. Continue with promising case to a more comprehensive but limited research project together with the company. The design of this step is worked out in the pre study.

It is important that the companies are participating in the whole process. The fourth step is to put the idea and results into a new or improved product, and this work is the company’s responsibility.

Generating ideas is done through different kinds of seminars together with the company and researchers. The pre study follows a TQI pre study template. In the research project the content is decided on as a result of the pre study and the step can for example consist of:

- Limited research task
- Proof-of-concept design
- Application for funding
- Thesis work on master or PhD student level

4. Results

The number of projects is limited and the results are confidential during the project. Some projects are open, e.g. the “intelligent wheelchair” which won the Embedded Student Award in Sweden 2007.

![Servo assisted wheelchair.](image)

**Figure 1. Project process.**

**Figure 2. Servo assisted wheelchair.**

**PARTNERS AND STATUS**

Industrial Partner: 10-15 companies within the Healthcare technology area.

Project funding: KK-foundation


Halmstad University and School of engineering, Jönköping University cooperates in the project.

**PUBLICATIONS**

R. Thörner, L. Eskilsson “teknIQInnovation-metoder och lärdomar”.
MINST, EXPERT COMPETENCE MICRO/NANO TECHNOLOGY

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minST is a project with focus on increasing competence in the area of micro/nano system technology by supporting cooperation between universities, research institutes and SME. The aim is to increase SMEs knowledge’s and competitiveness in this technical area. This is done by supporting SMEs in adjusted courses and education, support product development and create seminars as meeting places for knowledge transfer.

1. Background and Motivation

Halmstad University has a long tradition of cooperating with industry and SME. The cooperation benefits product development as well as education and research.

The university and CERES is a part of the KK foundations national expert competence programme teknIQ and minST. teknIQ addressed embedded and intelligent systems and the activities in the project ended in 2006. minST addresses the area of micro/nano system technology and continues the way of working with SME - in cooperation between universities and research institutes - that was started in teknIQ.

The project minST is in Halmstad University based at EIS. The location gives access to knowledge’s and research skills well related to the project.

2. Objective and method

The objective is to increase SMEs knowledge’s and competitiveness. This is done by support to SMEs in adjusted courses and education, assistance in product development and by seminars created as meeting places for knowledge transfer.

The subject area is new products based on, or including micro/nano system technology and focus is on commercial micro technology.

minST continues the work started in teknIQ by encouraging SME to meet researchers and experts. This work brings new ideas to the stage of product development and new opportunities for SME. The approach aims to improve the process towards new products parallel to education.

3. Cooperation

Halmstad University together with the research institute Imego operates in south west of Sweden. Since the project is in cooperation between universities and research institutes all over Sweden the connections to competences is excellent.

Experts and researchers from EIS as well as experts from Imego are often engaged in the meetings with SME and in the following processes. This contributes to improve the results and increase cooperation.
4. Results
The project benefits product development as well as education and research.

Figure 3. The project benefits product development as well as education and research

During 2008 a number of student projects and researcher projects started in cooperation with SME. About 10 are now finished or will soon be finished.

SME has got the possibility to use advanced instruments in cooperation with researchers.

During 2008 one course has been developed focused on increasing the knowledge of collaboration with the industry among the staff at the university.

5. Future
New ways of cooperation is continuously developed and examined in minST. Sensor center is one idea. Another is called “academia contacts” and aims to take care of experiences in cooperation and development, to bring out New contacts with SME will be taken during the project period and the work with keeping up old relations to industry will go on.

PARTNERS AND STATUS
Project funding: KK-foundation

The project started in 2006 and is planned to end 2011.

Project leader in Halmstad University is Magnus Hållander.

University of Mälardalen (programme leader), research institute Imego and Acreo, Jönköping Technical University and Halmstad University cooperates in the project.
IMEGO, the Institute of Micro- and Nanotechnology in Gothenburg, and CERES/IS-lab at Halmstad University have further developed their cooperation within the Triple N project, a pilot project sponsored by VINNOVA for increasing collaboration between universities and research institutes. IMEGO and HH have signed a contract to be strategic partners and continue to cooperate in the forms developed in the pilot project.

1. Background and Motivation
During 2007 VINNOVA sponsored pilot projects in which universities and research institutes developed their cooperation, aiming at permanent strategic collaboration. One of the six projects was Triple N – New technology, New products, New companies.

The project had three coordinated activities:

- More efficient use of common resources for research: personnel, expert knowledge, and laboratory equipment
- Commercialization of research results – in new companies as well as in established ones.
- Collaboration with small and medium-sized enterprises (SME). Competences and research work that the company needs as a development resource are identified, in particular in the areas of sensor systems and embedded systems.

2. Activities and Results

More efficient use of common resources

The goal was to find “complementary competences” with particular potential. IMEGO has the group “Systems Design” with 18 qualified employees, and CERES/IS-lab has 43 researchers and PhD students within similar areas. Of these more than 60 people, 29 have a PhD degree. Two discussion groups were formed, one with a focus on electronics and wireless communication, the other with a focus on intelligent signal processing.

Both groups came up with concrete suggestions about important competence areas of great value for both parties (such as sensor technologies, wireless technology, ASIC design, self-learning systems); further about technology platforms that could be jointly developed (such as sensor/radio nodes, intelligent home environments, and energy scavenging); and finally about concrete ways to cooperate (such as joint applications and projects, guest lectureship, joint seminars, and exchange of researchers). The “threads” are continued in more focused sub-groups.

Commercialization of research results

The goal of this activity was to make commercialization efficient and fast. The partners have started to build a common concept for the process, further to make use of IMEGOs competence in the PhD education at HH. Some ideas/results that are possible to commercialize have been identified, and the contact points between the two organizations have increased significantly.

Collaboration with SMEs

During the project period, 15 joint visits to companies were made; four continued meetings around specific ideas were arranged; two of these threads continued as pre-study projects. One joint product development project has started. Further, one ongoing project has extended its competence by bringing in staff from the other partner.

The process of working with SMEs has been further developed to fully utilize the specific expertise of the two partners. IMEGO and HH also together arranged a nano seminar targeted at SMEs.

3. Evaluation

The pilot project was evaluated by innovation system researchers from HH. They found, e.g., that
- it is important that the collaboration grows out of concrete projects
- economical resources for collaboration are needed to enable long-term planning generating permanent success
- the collaboration has support within the organizations, from the management as well as from all staff.

PARTNERS AND STATUS

Institute Partner: IMEGO, the research institute of micro- and nanotechnology, Göteborg, Sweden.

Project funding: VINNOVA
The project period was April 2007 – January 2008.
Project leader was Dan Larsson, IMEGO. Local project leader at Halmstad University was Bertil Svensson. Hans-Erik Eldemark and Roland Thörner were leaders of sub-activities.

The final report of the project is available.
Embedded systems are often used in applications with high requirements on safety and reliability. The embedded system must be dependable and behave as expected in order to not cause any risks. A product can include an embedded system for increasing safety. The three partners in the project SP, Halmstad University and Jönköping University will cooperate in order to support SME with development of embedded systems with high requirements on dependability. This initiative is mainly directed towards enterprises in Västra Götaland, Halland, Småland and Skåne. Keywords: dependability, reliability, embedded, real-time, SME.

1. Project Goals
The partners will cooperate in order to support SME with development of embedded systems with high requirements on dependability. This initiative is mainly directed towards enterprises in Västra Götaland, Halland, Småland and Skåne. The goal of the cooperation is to support at least 5 projects during 2008 where the partners work together. Through a deepened cooperation within the area of dependable products and embedded systems the three partners will become an even better R&D and technical partner for SME as well as large enterprises.

2. Expected effects and results
The work shall result in a formulation of the common partner competence and at least 5 common pre-studies together with SMEs shall be performed. The idea is that these shall lead to 5 product related projects during 2008. An expected project result is also a strategical agreement between the partners containing cooperation statements concerning contacts and research offerings to the industry. Cooperation will be documented in a report which may be applicable in other technical areas. Experiences from common contacts with SME and large enterprises as well as international contacts will be compiled.

3. Project Planning
During the project the following activities are planned:
- A clear formulation of the combined competence and relevance for the industry and planning how the competence shall be coordinated.
- Exchange of personal for a short period of time.
- Common contacts with SME.
- Common work in at least 5 prestudies directed to SME problems which require special competence from more than one partner.
- Common contacts with 2 large enterprises in order to understand how the common research competence is required internationally.
- Common seminar with SME and the three partners.
- Signing a strategical cooperation agreement for further cooperation between the partners.
- One person from each of SP, Halmstad University and Jönköping University will attend the other partners for at least 10 working days.

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Duration: May 2007 – February 2008
Project leader: Lars Strandén, SP.

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"TRYGG HEMMA"
(Swedish, approx. “safe and secure home environments”)

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"Trygg Hemma" (Swedish, approx. “safe and secure home environments”) is a collaborative project which provides technology to support older people to stay longer in their homes if they desire.

The project is formed by three parts. The first part is on involving the different stakeholders in the development process of health care technology. The stakeholders can be the older person, the older person’s relatives, nursing staff, medical staff, the housing company, organizations and health care companies. The goal is to develop a system to capture the user centric aspects of the requirements and to do an inventory of ideas.

The second part of the project is concerned with the everyday life of the older people. The home is obviously an important part, but the environment outside the home is as important. The technology provided here is often embedded system, not interfering with the resident. Examples of this technology is radio communication, body worn sensor systems, efficient energy efficient battery operated hardware, sensor networks, sensors, intelligent decision support algorithms.

In the third part of the project the technology and standards that promote the integration of functions is studied. In many cases today there exist good functions, often the integration of these functions in systems fail. There is a need to standardize and build systems of integrated functions. In this part of the project new business models are investigated.

1. Background and Motivation

The project was motivated by these main factors:
- The demographic change – the elderly will increase rapidly in the near future in Sweden as well as in Europe. This is an opportunity for and expanding market.
- The principle of staying at home in contrast to moving to an elderly setting.
- A proactive view is beneficial for preventing problems in the future.
- Quality of life and well-being is crucial.
- Technology and services can assist elderly to an independent life.
- The common stereotypes of elderly need to be revised. This is a very heterogeneous group.
- Being safe at home requires also being safe away from the home. Shopping, social context and physical well-being is examples of life necessities.

2. Project Setup

The main idea for the project was to work with a practical demonstrator for technologies that allow elderly to stay independent longer in their homes. This physical platform was very important as a tool for talking about and demonstrating the role and functions technology can provide for different target groups.

The project was centered on three sub-projects:
- Better techniques to make use of the elderly and careers, and relatives knowledge and needs. This part was performed as focus groups with inspiration lectures as well as a study where mainly caregivers made an inventory of needs and ideas of products in their area of expertise. 350 caregivers were guided in the demonstrator apartment and the technology discussed.
- Existing technology for support of elderly in their homes and the extension of the home. Here, 10 companies provided technology and equipped the demonstrator apartment; see e.g. Figure 1-4.
- Integration of products into a system was the foci for the last sub-project. The technology aspects were shown to be less important. Business models and different barriers preventing innovations from were explored in a study by Victoria institutet in Gothenburg.

The project was a collaboration between the Halland regional office, the university, the municipal healthcare organization and ten companies.

Figure 1: A lock system developed as a collaboration between SMEs and caregivers in Halmstad.
3. Results

The main results of the project were:

- Working innovation system – the focused way the project was organized was successful. All partners contributed in an active way.
- Big need for competence in the area – 350 caregivers was shown the apartment. The companies had someone to talk to, dialogue about ideas and solutions.
- The potential for further developing methodologies to better take care of users need is great. “Living labs” started as spin-off.
- There is a big need for developments of the business models and the way technology can benefit the elderly. Many barriers in the way technology is purchased (the European way is significantly different from e.g. the American way). The larger housing companies (approximately 10 000 apartments) can act as a service provider, thus a way to make business.
- Attracting media is a lot easier with a demonstrator apartment. We arranged seminars, guided tours and as a grand finale an open house with 20 000 visitors.
- Real impact of the project – EU applications, founding of a “Trygg hemma rådet” a board for handling assisted living issues with a broader group of stakeholders.

The work is now continued in an application to the Structural Funds of EU. Expansion is made with more municipalities and more partners.