NIRICT - CeDAS

Netherlands Institute for Research on ICT

Center for Design, Analysis and Synthesis of Dependable Systems

December 16th, 2005

1 Introduction (A+B)

This document describes a combined proposal for a Center of Competence and a Center of Excellence for research on ICT at the 3TU's. NIRICT i.o., Netherlands Institute for Research on ICT, is the CoC (see Section 3). The CoE, called CeDAS in the area of dependability (see Section 4), is part of NIRICT. This is a completely new proposal compared to the previous FES-proposal. This proposal is mainly focused on the Center of Excellence CeDAS on dependability, to be positioned in the general context of NIRICT as Center of Competence.

The A and B in between parenthesis in the section headings refer to, respectively, Center of Competence and Center of Excellence. The number refers to the section in the format required by the board of IST.

2 Vision on research financing (A+B)

Research funding is more and more done in a thematic way, as exemplified by the Framework Programs of the EU, the BSIK programs, and the NWO thematic programs. It is important for the Dutch ICT community to be involved in the phase when the research agendas are defined. Furthermore, with the emphasis on innovation, consortia consisting of industry and academia are formed around these themes. Examples are the European Technology Platforms, the High Tech Campus in Eindhoven, Pôles de Compétitivité etc. To participate in these consortia it is necessary for the relevant research communities to show sufficient critical mass on these themes.

The set up of NIRICT is based on these ideas. By being a partner in discussions on research agendas and in consortia, NIRICT provides on the one hand access to research and innovation funding for its participating chairs, and on the other hand contributes to the innovation process by being a partner in innovation, both at the national and European level. NIRICT does not aim at a comprehensive coverage of all the Dutch research in ICT – a number of important topics that have sufficient critical mass and focus are left to the individual institutions. However, NIRICT does aim at setting a number of new strategic research components by combining expertise from the 3TU's in a coherent fashion, and creating focus and mass through the combination of strong poles of expertise.

The first signs of appreciation of the ideas behind NIRICT are visible. Several major companies and institutions have indicated their interest to channel research and cooperation activities in ICT through NIRICT.

3 NIRICT as Center of Competence (A)

3.1 Goal and Mission

NIRICT bundles ICT research of the 3TU's. By founding NIRICT the following goals are pursued:

- to prepare for EU programs (FP7, FP8 …) in a number of strategic areas
- to create sufficient critical mass around a limited number of research topics
- to strengthen the cooperation and to make agreements on core activities among the three universities
- to increase Dutch influence on the EU ICT research agenda and to play a leading role in the definition of the Dutch ICT research and innovation agendas
- to have impact by focusing on a limited number of ICT topics and ICT applications
- to be preferred partner in ICT research and innovation
- to integrate the knowledge gained in the ICT educational programs.

The NIRICT mission is:
'To be an internationally leading scientific research institute and partner in innovation for the technology of advanced information and communication systems'

3.2 Research Agenda

NIRICT has three types of research agendas:

- Long Term Challenges
- Strategic Research Agenda
- Innovation Agenda

Long Term Challenges
The NIRICT Long Term Challenges are a selection of a few research topics that can be characterized by high complexity, high risk/high return, and high relevance and a horizon of at least 8 years. The first one is "Design, analysis, and synthesis of dependable systems (CeDAS)". More and more applications depend on the reliability, availability, integrity, and maintainability of ICT systems. Due to the increase of complexity at the hardware, software, and communication level, creating dependable systems has become a major scientific and engineering challenge. This topic is discussed in more detail in Section 4. Research on Long Term Challenges will result in new themes for the Strategic Research Agenda.

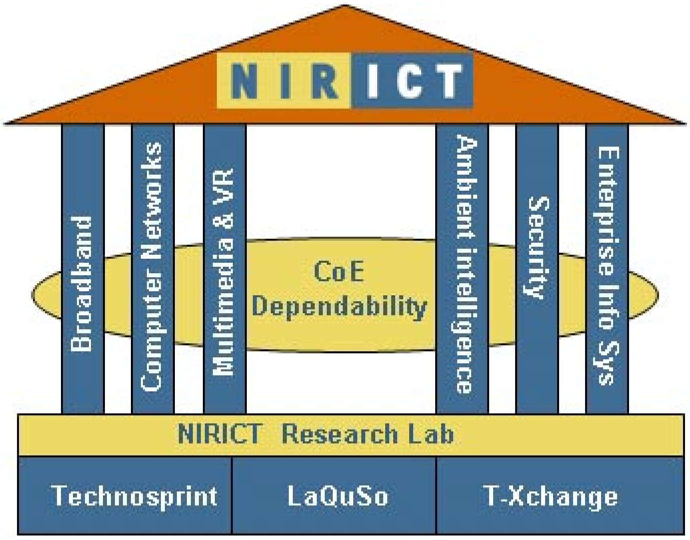
Strategic Research Agenda
NIRICT will focus its main research activity on a limited number of ICT topics with a horizon of 5-8 years. The choices made for the SRA themes are highly based on the NOAG-ICT (national research agenda on ICT) and on the Strategic Plan of ICTRegie. This has lead to the following choice of themes:

- Broadband Communication Systems
- Computer Networks
- Multimedia and VR Systems
- Ambient Intelligence
- Security
- Enterprise Information Systems.

Within these technology-oriented themes NIRICT will focus on a limited number of applications with societal and economic relevance. NIRICT will take the lead in: healthcare, security, mobility, and logistics. In other application areas NIRICT will join initiatives lead by research parties in ICT. In Appendix 2 a short description of the SRA themes is given. Within these themes public-private projects will start.

Innovation Agenda
NIRICT will build upon the existing knowledge transfer and spin-off activities of the 3TU's. To strengthen the knowledge transfer within the themes of the SRA the NIRICT Research Lab (NRL) is founded. Knowledge transfer in specific areas takes place in cooperation with TI, ESI, and TNO-ICT. In Section 13 more detail is provided.

NIRICT Research Lab (NRL)



3.3 Participating chairs (2)

The founding process of NIRICT started at the end of 2004. In the meantime much preparatory work has been done with the goal of officially founding NIRICT early 2006. In total 72 chairs have registered with NIRICT. They mainly originate in computer science and electrical engineering; however, also some application areas are involved. Bringing together ICT and applications is regarded as important. Both worlds can benefit from it, both from a scientific and an innovation point of view. The 1st stream research volume is 40 M euro (permanent staff and infrastructure), the total turnover is more than 75 M euro. The total man power is close to 840 fte's, of which app 270 fte's (mainly the tenured senior staff) are financed by the 1st stream. Due to the funding schemes, most of the externally funded research is only marginally financed. Founding an ICT institute of this size is unique in the Netherlands and its existence will increase the international visibility of Dutch ICT research.

In Appendix 1 an overview is given of the participating chairs. Bsik research funds are administrated under the third stream.

3.4 NIRICT Management (1+4)

The NIRICT Management of the CoC and the CoE are the same. Director is prof.dr. P.M.G. Apers. The MT consists of: prof.dr.ir. P.M. Dewilde (TUD), prof.dr. K.M. van Hee (TUE), and prof.dr. P.H. Hartel (UT). The governmental embedding is done by: prof.dr. J. van Katwijk (TUD), prof.dr. K.M. van Hee (TUE), and prof.dr.ir. T. Mouthaan (UT) -- all of them are dean. The formal governance still has to be decided. It will be modeled in accordance with what will be agreed upon with the 3TU's.

The contact address is: prof.dr. P.M.G. Apers, CTIT, University of Twente, PO Box 217, 7500 AE Enschede; 053 – 489 8031; p.m.g.apers@utwente.nl.

3.5 Relationship with other national organizations (3)

Chairs participate in the following research schools: ASCII, IPA, SIKS, Beta, Cobra, Dimes. 3TU institutes that are involved in NIRICT are: Center for Telematics and Information Technology (CTIT) and ICT Delft Research Centre (ICTDRC).

At the national level the 3TU institutes are cooperating with the Telematics Institute and the Embedded Systems Institute.

4 Center of Excellence NIRICT - CeDAS (B)

4.1 Introduction

Given its size and scientific scope, it is to be expected thatin NIRICT there will be more than one Center of Excellence. It is decided to start with CeDAS, Center for Design, Analysis, and Synthesis of Dependable Systems, a center in an area of research coinciding with the LTA of the NIRICT and with a large amount of excellent researchers and research programs Chairs are selected based on scientific quality and commitment of the chair to the chosen theme. This means that some of the top quality chairs are not (yet) participating in CeDAS. The selected chairs are asked to work out the initial ideas for CeDAS.
NIRICT management team will be responsible for the overall development of CeDAS into a real center of excellence (the senior professors in the management team also have 'excellent' rankings in the most recent visitations and are involved in the topics covered by CeDAS).

4.2 CeDAS - Centre for Design, Analysis and Synthesis of Dependable System

Summary
NIRICT proposes to develop a design methodology and application toolkits that bring modeling, analysis, synthesis, and verification for dependable large-scale ICT systems within reach of every systems engineer.

Challenges
The design, analysis and synthesis of large complex ICT systems require scientifically based methods, better than available today. Like in all engineering disciplines, mathematical models are a major ingredient of such methods, as is the understanding of the physical properties of its components as well as the conception of heuristic synthesis methods that are capable on the one hand of effectively overseeing the system as a whole and on the other hand generate the necessary dependability in an effective way.

CeDAS proposes three measurable improvements to the current state of affairs:

1. The cost of building models of large and complex systems is currently prohibitive. Thus methods and tools are needed to bring this cost down by at least an order of magnitude. Methods to meet this challenge include the development of new modeling and synthesis techniques for functional and stochastic characteristics of systems to cover the main quality attributes.

2. The performance of current analysis methods and tools is insufficient to cope with large and complex systems. Thus methods and tools are needed to improve this performance by at least an order of magnitude. Methods to attack this challenge include the development of distributed algorithms for verification and validation, using grid based systems to farm out analysis tasks.

3. Model based synthesis tools are used today for a small fraction of the final implementation. Model driven software synthesis is typically limited to code skeletons and platform specific support. In the hardware domain, even the most powerful behavioral synthesis tools are often unable to cope with designs not developed specifically with those tools in mind. Therefore new synthesis methods and tools are needed to increase the fraction of a large complex ICT system that can be synthesized by at least an order of magnitude.

Combining the results of the three measurable improvements proposed by CeDAS we aim to improve the general state of affairs by at least three orders of magnitude.

Scope
CeDAS will be focused on provable quality of dependable systems, based on the application of justified analysis and synthesis techniques, if possible based on formal methods. Dependability is a system aspect that occurs in the field of embedded systems, communication systems as well as in the field of enterprise information systems. In all cases the ICT system is supporting or controlling another system that may fail due to physical causes, which has to be counteracted by the ICT system.

The main idea is to use models of systems in the design, verification and synthesis. These models can be created before the systems are built (which is preferable) or also afterwards (which is often the practice). Modeling is not restricted to the ICT systems but incorporates the controlled systems as well. Special attention will be paid to the following quality aspects of systems:

- Availability: readiness for correct service
- Reliability: continuity of correct service.
- Safety: absence of catastrophic consequences on the user(s) and the environment.
- Integrity: absence of improper system alterations.
- Maintainability: ability to undergo modifications and repairs.

In addition, to ensure that a dependable system is fit for purpose, we require

- Usability: ability of humans to interface efficiently with the system
- Security: protection against misuse
- Performance: optimization of reaction time and usage of resources and graceful degradation in case of failures or lack of capacity.

The results should be applicable to real life systems, so methods that work only for toy problems are out of scope.

ICT-systems can be divided into three layers:

- Application software
- Communication networks
- Hardware components

Each of these layers has its own characteristics but there are many common characteristics. So each layer will have its own architecture but they can be modeled and analyzed by the same techniques. Another relationship is that what is modeled as a black box at one level is detailed at the next level. For each of these levels the scientific challenges within the scope will be detailed.

Challenges for the application software
The big challenge is to be able to verify important properties of large applications, specifically properties concerning dependability. A promising approach, which is still a dream, is to use models of the application software and to prove these properties in the models. The best approach is to use models that are used to design the application software, but if these models are not available we have to discover them with reverse engineering techniques, such as process mining. If we succeed to prove properties in the model we still have to verify that the model is an adequate representation of the application software with respect to the properties under concern. In case of component-based systems we may look for compositionality techniques: if the components satisfy the required properties and the integration is done correctly, then the whole system satisfies the properties. Another, less ambitious approach is to use testing methods. Testing methods are in particular important to verify if software and model fit together. Hybrid methods are probably the most pragmatic approach.

Challenges for the communication networks
The big challenge is to ensure the dependability of the largest man made structure on earth: the network of networks that connects us all. The problem is compounded by the fact that the network is heterogeneous (because it is based on a huge variety of technologies), the network is vulnerable (because cables, equipment and radio links are everywhere), the network represents a huge investment (so we must build on what we’ve got for a long time), and the network was designed for point to point communication (whereas people and businesses increasingly want to communicate with their peers).

Assuring overall network dependability does not only require assuring the dependability of the constituent parts, but also the effect of their, often unexpected, interactions. The fact that some system parts need to be assessed as a black box (with often incomplete specification) does make this an even greater challenge. Design and research challenges exist at all levels of abstraction in the network, hence, in the layered protocol architecture, as well as across these layers, since dependability-enhancing techniques can be applied at various layers.

Adding dependability-enhancing techniques to any system implies the use of more resources, be it computation (time), hardware (space), communication bandwidth or radio spectrum, or memory (information, incl. coding). More resources implies more cost, hence, a trade-off must be found between costs and desired dependability. When designing the system such that the redundancy can be used in normal operation for useful purposes as well (hot standby), part of these extra costs can be made productive. To achieve this so-called dynamic redundancy, network management and control (for self-reconfiguration) needs to be an integrated part of the system design. The components of such very complex systems to be controlled need to be properly designed and analyzed, and made dynamically tunable to an overall controlling system. Theoretical and practical solutions to these problems are yet unavailable, hampering the design of dependable networks.

Challenges for the hardware components

The enormous increase in performance of Microelectronic hardware components yields great opportunities but also great challenges. The opportunities include a massive increase in functionality, the possibility of 'embedded intelligence' and the availability of a multitude of such 'smart' components in the direct environment of a user. The challenges are due to a number of factors that make their correct functioning more problematic than before, namely:

- massive increase in complexity of the hardware system (up to 1 billion components in modern computer chips);
- heterogeneity: combination of various technologies to achieve a higher level of functionality (this is obvious e.g. in chips used for sensor networks that combine sensing, pattern recognition, communication, control and actuation in one system);
- highly diminished reliability of the constituting devices (there are many more devices in one system but their poor reliability makes redundancy unavoidable);
- distributed intelligence: many cooperating subsystems in one environment, the necessity to use 'context awareness' and the introduction of cognitive elements in the hardware.

We rely more and more on (hardware) systems that exhibit the characteristics mentioned. A few examples may suffice: a modern car contains over a hundred integrated sensors that feed their data in signal processing and computing devices, a Personal Area Network consist of numerous devices measuring body functions and communicating with each other, a Wireless Sensor Network (e.g. in a factory environment) provides a large number of scattered data items.

Using the taxonomy of threats to dependability (Avizienis e.a. (o.c.)), the challenges occur at two phases in the life time of a system: the development phase (where systems are designed) and the use phase (when the system is in operation), while due consideration has to be given to the use environment in which the system has to operate.

Besides all these specific challenges, there is the extra challenge of dependable system integration, where all layers (software, communication and hardware) come together to realize a common, dependable system. The challenge here is one of mastering the heterogeneity: the lack of reliability of one component (say a sensor) can be alleviated by reconfiguration using the communication possibilities of the system and the intelligent distributed decision making capability of the underlying software. Dependability will then be achieved by careful study, either at design time or run time, of the statistical properties of the system, involving in depth mathematical analysis. CEDAS will make an extra effort of integration to define design principles and achieve 'dependable system behavior' utilizing the capabilities of all system levels involved.

Working method

CeDAS intends to work in partnership with at least ESI, COBRA, DIMES, IRCTR, MESA+ and the Holst Centre for their expertise, their access to the problem owners, and as a channel for valorization.

Some of the methods CeDAS will develop are domain independent – but as the 'proof of the pudding is in the eating' the aim shall always be to team up with applications as much as possible, while keeping an open eye for general applicability and scientific foundation. Actually, the different domains in which the dependability question arises can learn a lot from each other, bringing the various fields together for a comprehensive investigation of the topic 'dependability' is a major goal of the present project.

The scientific results of the centre will be transformed into software tools, documented methodology and IP that can be used in the laboratories of NIRICT, ESI, Holst Institute and by practitioners, as much as possible.

4.3 CeDAS research groups (5)

The research groups of the CeDAS each investigate dependability from the perspective of their discipline. Four groups focus on the hardware, three on communication and five on software. The groups have been selected on the basis of their research excellence, as evidenced by the most recent research assessment, and/or high citation scores. Some of the chairs have been appointed only recently, in which case we mention the scores of the previous incumbent.

Delft University of Technology

Professor	Chair	Visitation scores
Inald Lagendijk	Information and Communication Theory: Visual Communications	4.5, 5, 5, 5 (2004, INF Delft/Leiden)
Alle-Jan van der Veen	Circuits and Systems	5, 4, 5, 5 (2000, EL ex Otten VSNU)
Arie van Deursen	Software Engineering	5, 5, 5, 5 (2004, CWI, group Klint)
Stamatis Vassiliadis	Computer Engineering	4, 5, 5, 5 (2000, EL VSNU)

Eindhoven University of Technology

Professor	Chair	Visitation scores
Wil van der Aalst	Workflow Management	4, 4.5, 4.5, 4 (2004 T&M)
Henk Corporaal	Embedded System Architecture	5, 4, 5, 5 (ex Jess, 2000, EL)
Jan Friso Groote	Software engineering, design and analysis of systems	4, 4, 4.375, 4 (2004 INF)
Ton Koonen	Broadband Communication Networks	5, 4, 5, 5 (2000 EL, ex Khoe)

University of Twente

Professor	Chair	Visitation scores
Ed Brinksma	Formal Methods and tools for Open systems	4.625, 4.5, 4.625, 4.125 (2004 INF)
Boudewijn Haverkort	Communication Systems	4, 4, 5, 5 (2000 EL, ex Niemegeers)
Pieter Hartel	Distributed Systems	4.5, 4, 5, 4.5 (2004 INF)
Bram Nauta	IC design	4, 2, 5, 5 (2000 EL)

5 Relationship with Sleutelgebieden, FP7, and industry (A+B, 6+7)

5.1 Sleutelgebieden

The Innovation Platform has identified a number of "sleutelgebieden". Perpendicular to this is the "ICT innovatie-as". NIRICT contributes substantially to the latter. Besides that NIRICT has a strong bond with the "sleutelgebieden" High tech Systems, and Materials and Creative Industries. Research is also done in areas that are of societal or economical relevance, such as health, mobility, security, and logistics.

5.2 FP7

FP7 is organized around 4 programs: Cooperation, Ideas, People, and Capacities. Cooperation focuses on large transnational cooperation projects and is of high interest to NIRICT. Of the 9 themes within Cooperation is Information and Communication Technologies the most relevant for NIRICT.

Within Information and Communication Technologies 4 activities are distinguished:
1. ICT Technology Pillars
2. Integration of Technologies
3. Applications Research
4. Future and Emerging Technologies

All ICT Technology Pillars and almost all Integration of Technologies have substantial overlap with the NRICT SRA themes and CeDAS. The activity Applications Research has substantial overlap with the Innovation Agenda (incl NRL).

Relevant platforms are: ENIAC, ARTEMIS, e-Mobility, NEM, Manufacture, ERTAC.

5.3 Industry

The groups within NIRICT participate in many national and international projects based on consortia consisting of industry and academia. Think of the many projects in FP6 and Bsik, besides many bilateral contracts. The list of Dutch and European companies is too long to be included (see also Appendix 2). Currently, the NIRICT chairs have working relationships with industry in all 6 themes of the SRA. The interest in dependability is already substantial and is still growing. Companies use different terminology to distinguish themselves, however, they all realize that creating dependable systems is of utmost importance for the ICT economy as a whole. They also realize that they cannot solve this problem on their own. Cooperation with academia is regarded important.

Furthermore, a 'CEDAS Industrial Board' will be created, to assist with the definition of research topics and the utilization of the results. Also the NIRICT Research Lab (Section 13.2) will strengthen the relationship with industry.

6 EU top research groups (B,8)

EU top resarch groups

Professor	
J. Arlat/J.C. Laprie	http://www.laas.fr/laasve/
T. Anderson/B. Randell	http://www.cs.ncl.ac.uk/dependability/
P. Verissimo	http://www.navigators.di.fc.ul.pt/
H. Kopetz	http://www.vmars.tuwien.ac.at/
P. Lagasse	http://www.intec.rug.ac.be

7 Proposals for CeDAS chairs (B,9)

7.1 Delft University of Technology

In the context of dependable systems, TU Delft brings in its expertise in the domains of new public networking paradigms and multimedia processing. The contributions of TU Delft in the international networking scene are well known, the terms ‘personal networks’ and ‘federated networks’ were originally proposed by the Delft research teams and have been adopted by the European community. In the area of Media Processing, the Delft group has an undisputed reputation of excellence. The contributions from Delft would be realized via the creation of two new chairs: one in the area of ‘ad hoc networking’, to be seen as the main new type of wireless networking in the future, and the other in the area of ‘media processing in dynamic networks’, covering one of the most important application domains for dynamic networking in the future.

Chair: Dependable Ad-Hoc Networking
Ad-hoc Networking is a new paradigm for future wireless computing and communication systems in which devices that are within each others wireless reach spontaneously form a network. Such networks will most likely become dominant in the end-user domain. Besides being essential for comfortable handling of the manifold of ambient intelligent devices surrounding a future user, they will become the basic vehicle for communication in crisis management situations, the realization of home networks and the provision of the personal network environment of every user. A major problem with the new ad hoc networking paradigm is the fact that ad hoc networks are constituted of components that are intrinsically unreliable (nodes and radio links). Connections between nodes appear and disappear with the mobility of the devices. Yet, the operation of the network must satisfy the most stringent requirements of dependability, on a par with what we are now expecting from fixed networks. The new chair will concentrate on architectures, protocols, mechanisms and distributed algorithms designed to achieve the desired level of dependability given the characteristics of the constituting devices and radio links, as well as the demands of the applications. The resulting research will be both fundamental and experimental.

Chair: Dependable Media Processing in Dynamic Networks
In all forms of communication the classical concept of ‘one sender and one receiver’ is being replaced by a dynamic network, in which routes between network nodes are being established and disappear dynamically, and where failing nodes can be avoided. A lot of attention is being given to compression and scaling methods to accommodate these multimedia streams in a dependable fashion. Quality aspects such as ‘Quality of Service’, security and maintainability play a dominant role. These aspects then lead to various new information theoretical and signal processing concepts for multimedia communication. The new to be defined chair Dependable Media Processing in Dynamic Networks will contribute to the dream of ‘always connected’ any time any where in a dependable fashion. Dependability of multimedia communication plays an important role in all aspects of society, but becomes critical around the themes of health and security such as mobile patient monitoring and surveillance.

7.2 Eindhoven University of Technology

In Eindhoven CeDAS is distributed over two departments: Mathematics & Computer Science and Electrical Engineering.

Mathematics & Computer Science chair: security of information systems and embedded systems
The department of Mathematics & Computer Science has a strong track record in the area of dependable software (dating back to prof. E. Dijkstra) and has recently appointed full professors in different areas, with a focus on dependability.
The professors are relatively young, the only older one (Van Hee) has already a successor (Van der Aalst). The department has already strong theoretical expertise in the area of CeDAS. There are two weak points: the lack of industrial experience and a weakness in security, where we have no full-time professor. Therefore, we propose:

1. Full-professorship in security of information systems and embedded systems. Many organizations are very dependable on their information systems and one of the main threats is unwanted behavior and misuse of the systems by persons from inside as well as from outside the organization. Therefore information systems need a special layer for security. The verification of the security layers in component-based enterprise information systems is one of the main challenges. The use of mining techniques on system logs is a promising approach to check security violations a posteriori. In embedded systems similar security threats occur but they have different forms and require different treatment. This chair should cover both application fields and the professor should have a strong background in industrial applications.
2. To compensate the other weakness, lack of industrial experience, we would like to appoint three part-time professors for dependability, who have a position in industry and a strong scientific background. Specifically for the groups of prof. J.G. Groote (dependability in embedded systems) and prof. M.van de Brand (dependability in software engineering) and dr. Lukkien (dependable architectures).

Electrical Engineering chair: communication network protocols
The departments of Electrical Engineering and of Mathematics and Computer Science both have strong expertise in the area of networking. We propose a new full-time professorship that is shared between both departments and that ensures a strong integration of the research in this area, currently distributed over two different groups, one in each department. The professor will be appointed for 80% in the Electrical Engineering department and for 20% in the Mathematics and Computer Science department.

The full professorship is in communication network protocols and in particular on managing and controlling the lower network layers, such as the physical layer close to the hardware. The focus is here on broadband communication networks and the specific protocols for such networks.

The main challenges of this chair are the functional modeling of the characteristics of the hardware components and the analysis (performance and conformance) and synthesis of new network protocols with a predictable performance which improve the reliability and availability of the network, safeguard quality of service levels, provide adequate traffic load handling, and offer robustness against for hardware failures.

3 TU embedding
TU/e will be leading in dependability issues of broadband communication and enterprise information systems, which are the two SRA's of NIRICT with leadership in Eindhoven. Security in Eindhoven and Twente are complementary: Eindhoven focuses on Cryptographic & security protocols, Tamper resistance & side-channels, and Identity management, whereas Twente focuses on Access Control, Distributed Systems & Network Security, and Biometrics.

7.3 University of Twente

Teaching and research in ICT at Twente is centered on four themes: (1) End-to-end Communication systems and services, (2) Requirements and software engineering, (3) Multimedia, virtual reality and Human computer interaction, and (4) Embedded systems. The main application areas include Healthcare, Transport and logistics. For both application areas, Ambient Intelligence is the key innovation driver.

Dependability is an essential aspect of all four themes. In (1, 4) redundancy is essential to make communication and embedded systems dependable. In (2) model based design and analysis are used to create systems that are dependable by design, in (3) the human influence is of critical importance for dependability.

All themes contribute to foster Ambient Intelligence in the applications. This requires, ubiquitous, unobtrusive, autonomous, dependable, communicating sensing and processing devices deployed in massive numbers. Specifically, in theme (1) we focus communication on short range radio because of severely limited energy budgets of battery powered and self powered devices. In theme (2) we focus on open systems because of the impossibility for any component of an ambient system to know the rest of the system. In theme (3) we focus on better interaction with the user because the chosen application areas are human centric. In theme (4) the focus is on the integration of hardware, software, communication, and applications.

Twente plans to appoint two NIRICT chairs to strengthen its research in two of the four themes. In area (1) a chair “short range radio” to concentrate the radio activities of the TE, SAS, ICD and CADTES groups, and in area (2) a chair “formal methods and tools” to concentrate activities in model based analysis and design of the FMG, SE, IS, DACS and DIES groups.

Chair: Short range radio
Ambient Intelligence puts the focus on the human user, who will be surrounded by a plethora of devices. Wired or optical line of sight connections are clearly impractical, and so are power lines. The only viable option is to use energy efficient short range radio. The services provided in an ambient intelligent environment will range from entertainment to life saving medical appliances and ambient assisted living. Therefore the dependability of the services and particularly the radio is of paramount importance. Technical challenges include (a) ultra low energy consumption, (b) cognitive radio to make efficient use of the scarce radio spectrum, and (c) scalability and dependability.

Chair: Formal methods and tools
Ambient intelligence requires systems and services that are able to initialize, configure, and maintain themselves, without the human user having to intervene. This is particularly challenging to achieve in an environment that is not fully known, and in constant flux. To ensure the quality of service in such a dynamic environment we develop systematic modeling and analysis methods and tools. Technical challenges to be addressed include (a) modeling and analysis of stochastic and hybrid systems, (b) model based testing, (c) scaling of the tools.

3TU embedding
Twente has a world class reputation in Formal methods and wishes to strengthen the activity further by continuing the present Chair “Formal methods and tools”. Twente is the leader of the Smart Surroundings BSIK, which is the national flagship project in Ambient Intelligence funded by public money. Many ICT research groups from the 3TU and beyond actively contribute to Smart Surroundings and use the general domain of Ambient Intelligence as a source of inspiration for their research. The proposed Chair “Short range radio” concentrates the radio activities of related groups on the unique focus of Twente on energy efficient radio.

7.4 Relationship with Focal points

In Delft the chair Dependable Ad-Hoc Networking contributes to the focal point formed by the combination of dependability and computer networks, and the chair Dependable Media Processing in Dynamic Networks to dependability and multimedia.

In Eindhoven, the chair Security of Information Systems and Embedded Systems contributes to the focal point formed by the combination of dependability and enterprise information systems (and the broad area of embedded systems), and the chair Communication Network Protocols to dependability and broadband communication systems.

In Twente the chair Formal Methods and Tools contributes to the focal point formed by the combination of dependability and Security (and the broad area of software engineering), and the chair Short Range Radio to dependability and ambient intelligence.

8 Technological dream (B,10)

Nightmare: The cost of the C2000 communication system for the emergency services in the Netherlands has largely exceeded the original estimates. The introduction of the system has been severely delayed. The system is plagued by many problems, such as radio interference with commercial equipment in the 380 - 381,5 MHz frequency band.

Progress in modern society probably depends in equal measure on computers and networks, labor, and energy. However the cost of building increasingly complex computer and network based systems in all sectors of the industry is spiraling out of control. For example in 2015, the cost of embedded systems in the automotive industry is projected to rise to about 50% of the total cost (EU Artemis Strategic Research Agenda). Enterprise information systems in manufacturing, the service industry and the public sector are so crucial that major disasters may occur if information systems break down for a long time. For instance airlines and banks may go bankrupt if their information systems fail for only a couple of days.

So society is heavily dependent of IT systems and this will increase fast in modern society. The complexity of these systems is growing even faster. We cannot avoid this complexity increase because subsystems are increasingly linked via networks, to foster cooperation, to enhance functionality, to increase safety and security, and to reduce energy consumption. So why is this complexity increase so costly? Firstly, because all (sub)systems can fail (often in unpredictable ways), and secondly, because failure modes increase exponentially, if no special attention is devoted to new types of measures ensuring dependability.

Imagine the simple case of connecting N systems, each of which can fail with probability P. Then the composition can fail with probability: $1-(1-P)^N$.

We have to distinguish several causes of failures: physical failures occurring in the hardware components of IT-systems, logical failures caused by errors in the design that were not discovered by testing, failures due to unforeseen random or chaotic behavior in the system (as happen when overloads occur) and failures due to unforeseen incompatibilities between newer and older components in an evolving system. Some failure types can be compensated, for instance by redundant system components, reconfigurability, the use of automatic testing or by 'intelligent' software. Other failure types are completely unpredictable. For really dependable systems an array of provisions has to be put in place, both in the system design phases and to influence run time behavior (methodology, models, self-organization, verification, handling failures, understanding environmental interactions). .

There is a direct relation between the number of failure modes and the cost of a system, because most of the cost of a system occurs in designing "the right thing", and testing "that it does what it is supposed to do". This is what dependability is all about: dependability is the field of study devoted to improving the reliability, safety, availability, integrity, and maintainability of systems, including hardware, software and networking. The technological dream of CeDaS (and Artemis etc.) is "knowing how to make our complex, distributed and evolving systems dependable" e.g. by knowing how to "get the design right, the first time, every time".

9 R&D Agenda for CeDAS (B,11)

Research challenges to be addressed in CeDAS were described for application software, communication networks, and hardware components from a disciplinary point of view (Section 4.2). To emphasize the integral character of dependability and to integrate the work done on Long Term Challenges with the Strategic Research Agenda, we have chosen the combination of dependability and the themes of the SRA as the basis for the R&D Agenda for CeDAS. Around these 6 combinations the focal points are formed.

The focal points within the Center of Excellence CeDAS are:

- **Delft:** combination of dependability with computer networks and with multimedia,
- **Eindhoven:** combination of dependability with broadband communication systems and with enterprise information systems,
- **Twente:** combination of dependability with ambient intelligence and with security.

To strengthen the bond between research and innovation, the NIRICT Research Lab (NRL) is started with the themes requirement (T-Xchange, Twente), analysis (LaQuSo, Eindhoven), and design (Technosprint, Delft), to transfer the CeDAS knowledge into tools and engineering methods. See Section 13. These labs operate according to the rules of the 3 TU innovation lab.

10 Master Programs (A+B, 12)

10.1 Master programs

The mission of the participating faculties is to educate academic engineers and scientists in the fields within the ICT domain. The general master programs in computer science and electrical engineering contain specialist and profiling tracks, strongly related to the research in each location.

Next to these general master programs, two kinds of 3TU ICT masters are identified, joint masters and specialist (profiling) Master programs. Specialist masters reflect the different orientation of the research on the different locations, while joint masters are established to address master areas that are common (and strong) on all three locations.

10.2 Joint masters

Joint masters are masters in a given subject that are strongly related to research carried out jointly in the three institutes. Research fields related to the SRA's of the NIRICT and fields related to the core of the Center of Excellence are potential areas for joint masters. Joint masters consist of a common core, a set of courses jointly developed and given at each of the three locations, as well as a common structure for the remaining part. The content of the remaining part is related to the particular strong points in research in each of the different locations. Starting point is that the volume constraints are met on each of the locations where the courses are given. The institutes involved have committed themselves to the joint master program "Embedded Systems", currently under review by the accreditation organization NVAO. This MSc program naturally fits within the domain of dependable systems. To start with courses developed in the area of dependability will be integrated in the joint masters. We are confident that the master will be successful and in cooperation with industry, we next will develop a master variant in the area of Dependability.

10.3 Specialization (Profiling) Masters

Next to commonalities and complementarities in the various research themes, the faculties involved have their own, unique, specializations. In a limited number of cases, the market demands for graduates in such a research direction are such that a specialization (profiling) master on the area of the specialization is effective. TU Delft recognizes specialization masters Computer Engineering and Media and Knowledge Engineering as profiling Masters. TU/e recognizes a Master in Business Information Systems and UT recognizes Masters in Human-Media Interaction, Business Information Technology, and Telematics. Next to the aforementioned existing Master programs, TU/e, UT and Nijmegen consider establishing a Master program in Security Technology. A relationship with the dependability courses will be established.

11 Infrastructures (A+B, 13+14)

Below an overview of labs exceeding a value of 1 M euro is given. Within each university and among the three universities there is an agreement about who requires what type of lab, such that there is no duplication. Besides these labs, NIRICT will start the NIRICT Research Lab (Section 13.2).

Delft University of Technology
- DIMES Technology Centre
- IRCTR Millimeter Wave Laboratory
- Delft University Chamber for Antenna Tests (DUCAT)
- Transportable Atmospheric Radar (TARA)
- Delft Atmospheric Research Radar
- IRCTR/CWPC network laboratory

Eindhoven University of Technology
- Electro-optical Communication lab
- Mixed Signal Microelectronics lab
- ECR and EM antenna/microwave lab

University of Twente
- ICD Laboratory – chair Integrated Circuit Design
- VR Lab – chair Design, Production & Management

12 Added value 3TU cooperation (A+B, 15)

12.1 Effects and Support

A strong NIRICT will help the 3TU's to get better involved with important national and European ICT activities, as well with forming consortia such as the European Technology Platforms, the High Tech Campus in Eindhoven, Pole de Compétitivité, as with contributing to research agendas.

Effects of founding NIRICT
The intended effects of founding NIRICT are:
- to contribute to innovation by being a partner in innovation for industry and academia.
- to create an attractive climate for new R&D labs
- to have more impact by looking at the combination of ICT and applications
- to continuously improve the quality of the courses and to graduate more students
- to extend business development

Support for NIRICT
NIRICT can count on substantial support of:
- ICTRegie (see Strategic Plan ICTRegie);
- InnovatiePlatform (see the section on NIRICT in "ICT als innovatie-as, kansen pakken met ICT") and ICT~Office
- TI, ESI, and TNO-ICT (NIRICT participates in the TI and ESI; shortly a cooperation agreement with TNO-ICT will be signed).
- Industry, such as Philips (discussion office at the High Tech Campus), IBM (funnels, like Philips, all ICT research discussions through NIRICT), Thales.
- Ministries OC&W and EZ.

12.2 Quality improvement and focal points

NIRICT enters a process to form a strong institute that is a natural partner for discussing research agendas and that is a preferred partner in research and innovation during the implementation of the agendas, both nationally and internationally.

Starting point
The current situation can shortly be described as follows:
1. ICT research at the 3TU's covers a broad spectrum of topics; there is, at some place starting and at other places already strong and growing, cooperation between computer science and electrical engineering and in all places a growing relationship with groups working on ICT applications.
2. In general the research is of good to very good quality, with groups of excellent quality and with some groups below the line; furthermore, in some – vital – areas groups operate at a sub critical level.
3. Through the current round of Bsik projects initial focal points have been formed (think of Freeband and Smart Surroundings), however a next step is necessary to give these focal points more substance to be able to have impact.
4. Valorization is receiving more and more attention, however, in a fragmented manner.
5. All three locations have their own plan for ICT chairs.

12 Added value 3TU cooperation (A+B, 15)

Goals

The goals set for the coming 5 years are:

1. To create focus, to further stimulate the cooperation between computer science and electrical engineering, and to strengthen the cooperation with ICT applications via the themes of the NIRICT research agenda.
2. To further strengthen the quality in NIRICT (by creating CoEs) in such a way that this excellence reflects on NIRICT as a whole.
3. To play a role in defining national and international research agendas and to participate in new consortia sufficient critical mass around a limited number of topics is required; this will be done by forming focal points.
4. To create sufficient critical mass to make valorization work.
5. To set up a common plan for ICT chairs within NIRICT, which will be kept up-to-date on a regular base.

Approach

1. Focus and themes

To make ICT applications work an integral approach is required, which involves cooperation between electrical engineering, computer science, and an application discipline. This integral approach is pursued by choosing themes that on the one hand address societal or economical applications and on the other hand require cooperation among the various disciplines. These themes should be in line with the themes of the EU, ICTRegie, and NOAG-ICT. NIRICT will on a regular base with the actors in the ICT field keep its research themes up-to-date.

2. Quality

Quality improvement can be obtained by various actions. Chairs participating in NIRICT will have to fulfill a number of criteria, which are based on:

- Last evaluation score
- Volume of second and third stream
- Involvement with Bsik and EU-framework programs
- Cooperation with industry
- National and international awards
- Contribution to the research agenda of NIRICT.

Before founding NIRICT the list of participating chairs will be finalized.

Quality improvement will further be pursued by having regular international research evaluations, including the corresponding internal evaluations in between. The policy is to further strengthen the excellent groups at the cost of others.

3. Focal points

Increasing the impact of the 3TUs in the area of ICT can be achieved by forming focal points. The ultimate goal is to achieve focal points for the whole of NIRICT. With starting to do so for CeDAS the first step towards this goal is taken.

Within CeDAS the focal points are identified based on the themes of the SRA. Interaction between dependability and these themes is regarded extremely important, and therefore one university is made responsible for the combination of dependability and one of the themes of the SRA: computer networks and multimedia (Delft), broadband communication systems and enterprise information systems (Eindhoven), and ambient intelligence and security (Twente). This assignment does not preclude strong activities at other locations in the given SRA theme, but it makes clear where the CEDAS responsibilities are located.

The SRA themes are based upon the themes of the NOAG-ICT. The theme of CeDAS runs through all SRA themes, so there is interaction between the work done in the SRA themes and the dependability work in CeDAS. The focal points are based on the combination of the SRA themes and the theme dependability.

4. Valorization
To bundle the fragmented valorization efforts within the chairs the NRL is founded. It helps the chairs to focus on what they are good at and at the same time it makes knowledge and valorization more professional (Section 13).

5. Common plan for ICT chairs
The deans involved in NIRICT have agreed on pursuing a common plan for ICT chairs. Agreeing on this is a substantial step. This plan will identify the topics to be strengthened, and the topics to be terminated, taking the educational obligations into account. Economically, the ICT sector is currently improving, and based on historical data this means that both the volume of research performed by industry and the number of enrolled students will increase. Based on reports of the ICT Taskforce and the ICT Forum one can conclude that a substantial growth in academic staff is required for ICT research and education to keep in line with the developments in industry. This growth will be realized by terminating weak activities, effectively replacing them by new, strong activities and by additional 1st stream funding.

The common plan for ICT chairs will be drawn up by the deans and the scientific directors and sent to the three Boards for approval.

13 Valorization Component (A+B, 16)

13.1 Approach towards valorization

One of the goals of NIRICT is to contribute substantially to innovation. NIRICT research creates knowledge which can be used in the development of new ICT products, applications, and services. Because of the enabling character of ICT, there is both a large variety of potential application domains and a whole range of ICT research disciplines. The Innovation Platform considers ICT as an innovation-axis, since it enables market and process innovation in many key domains of the Dutch economy. Besides that NIRICT has a strong bond with the "sleutelgebieden" High Tech Systems and Materials and Creative Industries, research is also done in other areas that are of societal or economical relevance, such as health, mobility, security, and logistics. Entrepreneurship and the creation of new jobs require a knowledge-rich environment. Concentration of knowledge can take place within a physical environment ('valley' or 'science park') or within a virtual heterogeneous network organization of large companies, SME's and knowledge institutes (or a combination of both, NIRICT).

Innovation requires that ideas which have a commercial potential move from the laboratories into the marketplace. NIRICT will build upon the existing knowledge transfer and spin-off activities of the 3TU's. To strengthen the knowledge transfer within the six Strategic Research Agenda's and the NIRICT Center-of-Excellence CeDAS, the joint NIRICT Research Lab (NRL) has been founded.

NIRICT Innovation Agenda and NIRICT Research Lab (NRL)

1. Graduates and research projects

The Dutch economy is becoming ever more knowledge-based; this demands a more highly-skilled workforce. The most important way in which knowledge is transferred from the 3TU's into the wider world is through the skills and experience gained by the numerous graduates and PhDs. In externally funded research projects, knowledge transfer takes place between the participating universities and the industrial project partners (often larger companies and/or high-tech SME's). In general, these - more traditional - aspects of knowledge transfer are taking place within the SRA's.

2. NIRICT Research Lab

NRL will facilitate the further development and the transfer of knowledge, especially for SME's. Because these SME's have a strong basis in their region, NRL will have three locations, although it will be managed as one organization (one board). Each branch will have his own expertise / specialization and a front desk to serve the own region. NRL will be managed by one director and three branch coordinators. Preferably, the NRL activities will be performed by employees of the 3TU's.

3. Licensing and spin-off companies

Licensing of university intellectual property and consulting have long been the traditional methods by which universities have spread their skills and experience into the wider world beyond. In the past few years, the creation of spin-out (or start-up) companies has become an important additional mechanisms through which the knowledge and expertise developed by universities flows directly to industry. Knowledge transfer performance is not easy to measure but if the rate of ICT spin-outs is any guide, the track record of the 3TU's is impressive. NIRICT will build upon the existing successfully spin-off activities of the 3TU's, which will be further professionalized within the 3TU Innovation Lab (o.a. stimulation and development of the required mentality and skills of the researchers, TOP arrangements). Coming up with nice ideas and turning them into clever technologies is not sufficient by itself. A clear understanding of how each new technology addresses a real market need is essential, and for this, new skills and dedicated ICT networks are needed. Besides, in contrary to most other disciplines, the possibilities to take out a patent (which can form the basis for a potential business case) are rather limited in the ICT (software) sector; alternative business strategies are required. Therefore, NRL will play a specific supporting role in the process of setting up ICT-knowledge based spin-off companies (although NRL will make use of the standard facilities and knowledge provided by the 3TU Innovation Lab). The cooperation between NRL and ICT-based Business Accelerators (such as Smart Systems) will speed up the expansion of favorable young ICT-based spin-off companies.

4. Website, demo center, brokerage events
NRL will make the NIRICT research results easily accessible for potential (industrial and/or governmental) users via a website specifically addressing particular target groups. Web-based and mobile demonstrators presenting various aspects of NIRICT research (e.g. context-aware ICT services, intrusion detection, mobile eHealth services) will show potential end users the possibilities of research results. At the same time, NRL will play a coordinating role in the organization of meetings such as 3TU customer days and other brokerage events with a focus on the matchmaking between supply (knowledge institutes) and industrial demand.

13.2 NIRICT Research Lab (NRL)

Besides the above research labs, NRL is started to put more emphasis on integrated tool and prototype development for various aspects of requirements, analysis, and design to obtain tool boxes. These tool boxes and prototypes will make the research results more concrete and will stimulate the interaction with both larger companies and SMEs.

T-Xchange
The T-Xchange room and the T-Xchange process are meant to facilitate capturing the requirements of the definition of a product or service (not limited to ICT) from the various stakeholders involved by using gaming and Virtual Reality to visualize the consequences of design decisions taken. During the process several scenarios are discussed to better define the requirements and to better understand the possible solutions and their cost. The goal is to reduce the cost in this phase of design. T-Xchange can also function as outlet for research prototypes by discussing additional functionality with e.g. SMEs. Currently, T-Xchange is a joint venture between Thales, University of Twente, and a number of High Tech SMEs. By making it part of NRL it will become available for all NIRICT partners. To broaden the scope of applications further tool development to support scenario discussions is required.

LaQuSo: laboratory for quality software
LaQuSo is a laboratory of the department of mathematics and computer science of Eindhoven. LaQuSo has a clear focus: the development of methods, techniques and tools to detect errors in software artifacts. Software artifacts can be models of a system as well as source code of even executables. Different methods and techniques are developed, such as empirical testing, model checking and assertion proving. There are many approaches to error discovery, however very few are really applied in practice; therefore LaQuSo wants to validate her methods, techniques and tools in practical case studies. The "instrument" of LaQuSo is a coherent set of software tools that allow, besides storage and retrieval of software artifacts, model reconstruction from source code, transformations of models and last but not least a set of tools with which the analyzes can be performed. Since case studies are the way to validate the methods, there is a strong interaction with the industry, which guarantees the valorization of developed methods, techniques and tools. The assets of LaQuSo are the set of software tools and the knowledge of the software engineers who are able to apply the tools.

13 Valorization Component (A+B, 16)

Design platform for Dependable Systems (pilot of Technosprint, Delft)
A ‘design platform’ is a collection of tools, cell libraries, interface definitions, UML descriptions, Design Patterns, well documented design examples and a design methodology which should make it possible to re-use previous designs, document good design practice and lead to fast original new designs as combinations of existing IP (Intellectual Property), derived a.o. from the NIRICT community. The design platform is intended to be accessible to its members (at least the NIRICT community) possibly with restrictions for individual pieces of information, as they may constitute proprietary IP. We propose to set up such a design platform for dependable systems. Tasks would be, besides the collection of all the data from the various projects, the definition of the methodology, the organization of the library, the regulation of the IP and the accessibility control. The prime responsible party for setting up the platform would lay with Technosprint at Delft University of Technology for the whole NIRICT community.

14 Budget (B, 17+18)

14.1 A remark upfront

The goal of NIRICT is to set up a common research plan and to implement it. To do so NIRICT will play a stimulating and facilitating role to obtain external funding for research. To be recognized as a serious partner, NIRICT needs to act on behalf of the 3TU's. A governance model to make this possible is required.

The total NIRICT – CeDAS proposal is budgeted for roughly 25 M euro. In the context of the 50 M euro for the 3TU's to stimulate cooperation, this proposal request funding for 12 M euro.

NIRICT will seek external funding for its SRA themes separately, e.g. NIRICT will act proactive for the forthcoming FES rounds.

14.2 Strengthening

Chairs: plus and minus
The CoE CeDAS is seen as a vehicle to further improve the excellence within NIRICT on a well focused, scientifically and societal highly relevant area, called dependable systems. The NIRICT plan for ICT chairs is leading for strengthening of the scientific excellence in the area of dependable systems and by strengthening the interaction between the topic of dependable systems and the SRA themes. In all cases new chairs are created by appointing excellent researchers and giving them the opportunity to appoint new academic staff to create a complete chair. In some cases it concerns the continuation of well-running chairs, in others a substantial redirection of weaker chairs. If a complete new chair is established it will be done by terminating weak research activities or weak groups.

In the next 5 years, NIRICT expects that 8 chairs will be established in the context of CeDAS, at the same time a number of weakly performing chairs will be terminated. In Section 7 proposals for 6 new chairs are given. The other 2 chairs are decided upon during finalizing the NIRICT common plan for ICT chairs. After the period of 5 years the financial impulse will have lead to significant quality improvement, a clear focus on dependability in relationship with the SRA themes, and the implementation of the NIRICT plan for ICT chairs.

Currently the proposal requests funding for 6 full professors.

Material expenses
For equipment we expect a total of 4 M euro, expected to be spent in the first two years. An indication of the required material: Upgrade Network Analyzer, Signal sources, Mixers and amplifiers, Wideband signal generation, Probe stations, Network components, Noise measurement system, Biomedical specials etc. Currently the proposal requests 635 K euro of funding.

NIRICT Research Lab
NRL will stimulates innovation in a research environment by allowing chairs to appoint scientific staff at a limited number of key positions to stimulate knowledge transfer, to appoint some development capacity to work on industrial strength prototypes, and to facilitate infrastructural needs to enhance innovation.

14.3 Overview Budget

The budget items are specified in K euro.

Budget item	2006	2007	2008	2009	2010	Total
Chairs	1215	1240	1270	1290	1315	6330
Material expenses	745					745
NRL	945	965	985	1005	1025	4925
Total per year	**2905**	**2205**	**2255**	**2295**	**2340**	**12000**

Appendix 1

Overview NIRICT CoC chairs

Delft University of Technology

Leerstoelhouder		**1e gs**	**2e gs**	**3e gs**	**total**
Roos	Algoritmiek	3.10	5.60	1.60	10.30
Andriessen	Arbeids- en Organisatiepsychologie	1.50	0.00	1.60	3.10
Reinders	Bioinformatica	1.80	7.20	7.60	16.60
Dewilde	Cicuits and Systems	2.80	6.90	2.60	12.30
Vasiliadis	Computer Engineering	7.20	4.80	15.40	27.40
Jansen	Computer Graphics	3.00	5.40	3.60	12.00
Veen	Edutec	0.90	0.00	1.60	2.50
Long	ELCA	3.30	3.20	3.40	9.90
Sarro	Electronic Components, Technology and Materials	5.90	2.40	4.40	12.70
van den Berg	Elektromagnetisme	3.30	0.00	0.00	3.30
French	Elektronische Instrumentatie	4.30	16.20	3.20	23.70
van den Hove	Ethiek en ICT	0.80	1.00	1.00	2.80
van Oosterom	GIS	1.50	2.00	2.00	5.50
de Vreede	HITEC	4.80	6.80	9.20	20.80
De Ridder	Informational Ergonomics	7.50	0.00	5.40	12.90
Wagenaar	Information and Communicationtechnology	0.80	0.00	4.00	4.80
Biemond	Informatie- en Communicatietheorie	2.30	0.80	3.20	6.30
Lagendijk	Informatie- en Communicatietheorie	4.23	10.38	1.60	16.21
Neerincx	Mens-Machine Interactie	3.50	0.80	10.40	14.70
Van Mieghem	Networks, Architectures and Services	3.70	3.20	1.70	8.60
Sips	Parallel and Distributed Systems	3.30	5.30	8.40	17.00
Young	Quantitative Imaging	3.90	2.40	8.80	15.10
Van Deursen	Software Engineering	3.40	2.40	7.00	12.80
	Systeemkunde	3.00	0.00	9.80	12.80
Ligthart	Telecommunicatie- en Teleobservatietechnologie	6.00	9.00	6.80	21.80
Niemegeers	Wireless & Mobile Communications	3.30	4.00	9.80	17.10
	Total fte	**89.13**	**99.78**	**134.10**	**323.01**

Eindhoven University of Technology

Leerstoelhouder		**1e gs**	**2e gs**	**3e gs**	**total**
De Berg	Algoritmiek	2.50	6.00	0.80	9.30
van Hee	Architectuur van Informatie Systemen	2.45	1.60	0.00	4.05
van der Aalst	Business Proces Management(BPM)	7.10	4.80	0.80	12.70
van Tilborg	Coding en Cryptografie	2.80	1.60	0.00	4.40
Woeginger	Combinatorische Optimalisering	2.30	4.23	2.49	9.02
van den Bosch	Control Systems	1.50	0.80	4.20	6.50
De Bra	Databases en hypermedia	2.35	2.40	3.30	8.05
Otten	Electronic Systems	3.50	0.00	11.20	14.70
Koonen	Electro-Optische Communicatiesystemen	4.10	2.80	12.20	19.10
Baeten	Formele Methoden	5.90	1.60	3.60	11.10
Grefen	ICT Architectures (ICTA)	6.00	0.80	1.60	8.40
van Roermund	Mixed-signal Microelectronics	2.05	4.80	4.10	10.95
Groote	Ontwerp en Analyse van Systemen	4.03	5.00	0.00	9.03
Smit	Opto-Electronic Devices	3.00	4.20	7.10	14.30

Fledderus	Radiocomunicatie	3.00	0.00	2.80	5.80
Bergmans	Signal Processing Systems	4.08	3.62	15.62	23.32
vacature	Software Construction	4.90	0.00	0.00	4.90
Van Genugten	Software Engineering	1.25	0.00	0.00	1.25
Boxma	Stochastische Besliskunde	2.80	5.10	1.80	9.70
Lukkien	Systeem Architectuur en Netwerken	4.80	4.00	12.40	21.20
Roorda	Systems Engineering	3.85	0.80	5.90	10.55
Van Wijk	Visualisatie	3.40	5.00	6.50	14.90
	Total fte	**77.66**	**59.15**	**96.41**	**233.22**

University of Twente **Leerstoelhouder**		**1e gs**	**2e gs**	**3e gs**	**total**
van Sinderen a.i.	Architecture and Services of Network Applications	8.43	1.60	7.26	17.29
van Maarseveen	Centre for Transport Studies	2.30	0.60	10.10	13.02
Krol	Computer Architecture & Embedded Systems	5.23	4.13	13.98	23.34
Van Amerongen	Control Engineering	0.75	1.44	0.80	2.99
Apers	Databases	5.57	4.33	3.42	13.32
Haverkort	Design and Analysis of Communication Systems	6.97	3.60	5.75	16.32
van Houten	Design, Production & Management	7.90	0.00	4.00	11.90
Hurink a.i.	Discrete Mathematics and Algebra	3.94	1.40	2.11	7.45
Hartel	Distributed & Embedded Systems	4.31	5.87	7.60	17.78
Wouters	Finance & Accounting	4.42	0.00	0.80	5.22
Rensink a.i.	Formal methods and Tools	3.35	11.11	0.22	14.68
Nijholt	Human media Interaction	6.47	5.08	12.68	24.23
Wieringa	Information Systems	6.43	4.40	4.00	14.83
Hillegersberg	Information Systems & Change Management	4.31	0.00	0.06	4.37
Nauta	Integrated Circuit Design	2.03	4.50	6.40	12.93
Polderman a.i.	Mathematical Systems and Control Theory	1.79	1.07	1.03	3.89
van Harten	Operational Methods for Production and Logistics	5.80	0.00	5.20	11.00
Achterhuis	Philosophy	1.10	0.00	0.00	1.10
Verweij	Psychonomics & Human Performance Technology	2.50	0.80	3.20	6.45
Slump	Signals and Systems	6.09	2.53	6.48	15.10
Aksit	Software Engineering	3.06	1.60	7.20	11.86
Alberts	Statistics & Probability / Finance and Insurance	2.50	0.80	0.00	3.30
Boucherie	Stochastic and Operations Research	3.98	0.70	3.07	7.75
Bagchi	Stochastic System and Control Theory	2.77	2.40	3.92	9.09
Rip	Studies of Science, technology and Society	1.20	2.27	0.13	3.60
van Etten	Telecommunication Engineering	1.52	1.52	6.90	9.94
	Total fte	**104.68**	**61.75**	**116.33**	**282.76**
Total NIRICT fte		**271.46**	**220.68**	**346.85**	**838.99**

Broadband Communication Systems

Broadband telecommunication means are of vital importance to run our modern society, which is becoming ever more dependent on information, at any time, anywhere. These means form the arteries and the veins for economic activities ranging from research to manufacturing, for transport, health care, banking, logistics, leisure activities, etc. They need to span the globe, but also have to reach out to the individual users. Broadband communication technologies are needed providing transparently ample communication capacity, both wireless and wired, yielding a traffic-jam free communication world.

All network levels need to co-operate tightly in order to achieve flawless end-to-end communication. Our vision is a seamless ultra-broadband communication network, where connections between the hierarchical network layers are made fully transparent and end-to-end all-optical communication is established, with a possible exception for the last link to the user devices which in the majority of cases will be by wireless radio signals (potentially also wireless optical signals). It encompasses all-optical traffic routing and interworking with wireless high-capacity last drop links to the end users, such that the user experiences a virtually congestion-free instantaneous access to any service demands he may have. The vision opens the route to the ultimate in flexibility and capacity of telecommunications, and augmented by means of seamless wireless (optical) connections to the user also to the ultimate in user mobility; thus the "anywhere-anytime-anything-anyhow" provisioning of broadband telecommunication services can be achieved.

The common goal in this SRA theme is to provide the technological basis for such a wide-ranging self-organising (cognitive) network, which possesses the intelligence to locate by itself the resources with the adequate capabilities requested by the user. To reach this common goal, three research tracks are foreseen:
1. to explore techniques which enable to exploit a wide frequency range in the radio spectrum, e.g. 0.5-10.6 GHz, or several GHz around an e.g. 60 GHz carrier.
2. to explore techniques for adaptively establishing a communication channel in this range, meeting the capacity and Quality of Service (QoS) demands of the user, while minimising the interference with channels serving other users (cognitive networking).
3. to explore techniques for establishing signal-transparent communication tunnels between geograhically spread user areas, thus extending the coverage of cognitive networking, and their capacity.

Research issues in track "Wideband communication techniques"
- Low-power wideband radio transceiver frontends (tunable), transceiver architectures
- Wideband radio antennas
- Determination of propagation characteristics of wideband signals
- Antenna diversity for wideband communication
- Multi-antennas/Multi-Input Multi-Output (MIMO) techniques for wideband communication
- Fast (ultra) wideband scanning receiver techniques and their implementation
- Signal processing for (ultra) wideband scanning
- Adaptive coding and modulation schemes; may be based on OFDM (Orthogonal Frequency Division Multiplexing) type of signals to allow frequency diversity

Research issues in track "Self-organised adaptive spectrum utlisation techniques"
- Theoretical spectral efficiency benchmarks for ad-hoc temporal and spatial (re-)use of the frequency spectrum
- Fully and partially distributed transmit power control schemes for ad-hoc spectrum (re-)use
- Self-organised smart analog frontends, including high-speed converters, that facilitate these functions, adaptitivity and flexibility

- Efficient cooperation of antennas, frontend and digital baseband hardware and software for intelligently setting and optimising channel characteristics
- Robust low data rate signalling network to support efficient ad-hoc (re-)use of the frequency spectrum
- Spectrum management (frequency allocation policy)
- Shared access protocols, incl. fairness issues, QoS, security
- System dynamics and stability

Research issues in track "Flexibly routed format-transparent signal transport"
- Wireless optics (free-space in-room communication with narrow well-directed optical light beams, enables very high capacity (Gbit/s) terminal connectivity; issues: beam capturing and tracking, eye safety, high sensitivity reception, MIMO for combatting line-of-sight limits, …)
- Techniques for transport of (ultra-)wideband signals over fibre, coping with fibre network dispersion, non-linearities
- Transparent in-building/access communication tunnels, ad-hoc reconfigurable, flexibly interconnectable, stackable; system architecture, performance analysis, co-hosting of wired and wireless service delivery mechanisms
- Wideband power-efficient opto-electric converters, for carrying analog (ultra-)wideband wireless signals over fibre infrastructures (radio over fibre)
- Optical multiplexing techniques for combining multiple (ultra-)wideband wireless signals and wired (e.g. GbE) signals into a common fibre-based backbone network ; e.g. adaptive wavelength assignment techniques
- All-optical signal processing devices and modules for (ultra-)wideband signals
- Strategies for access to multi-dimensional optical backbone, e.g. wavelength assignment strategies
- Optical flexible (ultra-)wideband signal tunneling functions; a.o. optical crossconnecting of radio-over-fibre signals in fibre network nodes, optical add/drop/continue functions

Within these research tracks, close co-operations are foreseen between the industries and the university groups, encompassing joint experiments in laboratories, traineeships for knowledge transfer and hands-on exercises, on-the-job training for new employees and/or re-education for employees in job rotation. The research is related to industrial interests at Philips, TNO-ICT, TNO-FEL, Lucent Technologies, KPN, TI-WMC, Thales, Draka Comteq Fibre, Genexis, Lionix, Cedova, … Moreover, there will be international exposure, a.o. by the involvement of the university partners in many international and national projects (such as presently in e.g. the EC's 6th Framework Programme, the WWRF, several projects in the national programmes Freeband, IOP GenCom, …).

Computer Networks

In this SRA we want to address new networking paradigms and applications that are not yet covered by the traditional evolution of networking, yet are of great practical importance and would enhance the overall functionality, dependability and applicability of computer-communication networks. We want to focus in particular on the following four issues, each at a different level of networking:

1. Society-wide network-applications provisioning: all sectors of our public life can be seen as nodes in an economic and societal network. We want to concentrate in the first place on the organization of dependable trans-sectoral networking, i.e. how networking in one sector (say public authorities) can interact effectively, but also in a dependable way with another sector (say e.g. banking). These questions of 'federated networking' on a large scale are particularly important for network operators (participating in this part of the project).

2. 'Liquid bandwidth': the self-adaptation of networking systems so that user's are seamlessly connected any time, anywhere, any how, thus providing the best available quality ("Quality of Service") in a resilient way for a given budget. This requires making all the components of the network in some sense 'intelligent', or better, adaptive to changing circumstances. This is known as 'cognitive networking', or, in a broader sense, the design of so-called "selfstar" systems, being systems that adapt in many ways to changing needs and circumstances.
3. Networks on a chip: At the other side of the networking spectrum from very large to very small, networks are making their entrance into the extremely small scaled but increasingly complex integrated systems design, with the Netherlands being a big player in this area. It is widely accepted that in the near future NoC will be based upon unreliable components and 'uncertain channels'. That is: each interconnect (together with its feeding circuitry) has to be considered a noise-prone channel, so that coding is necessary for all connections. Designing networks that in addition to the usual network requirements so that communication paradigms are needed even at this level of signal transmission.

Personal and federated networks. Personal Networks (PN) is a new person-centric concept related to the emerging field of pervasive computing. It extends the concept of a Personal Area Network (PAN) to communicating clusters of personal digital devices, devices shared with other people and even infrastructure-based systems. Personal Networks have an unrestricted geographical span. Ferderated Networks are the next level of communication complexity where PN's interact and make larger federated units. Network protocol design insuring functionality and dependability (in particular security) are the main topics for research.

The proposed activities have great and direct relevance both to societal needs and economic developments, more precisely:

1. the trans sectoral part of the program which aims at modeling and understanding service provision across economic and societal sectors, allowing for interaction and homomorphism (the same mechanism in completely different applications) would allow a communication service provider (KPN in our case) to offer much enhanced and user oriented services on the one hand, and companies that are specialized in one type of service (banks etc…) to offer trans sectoral access using well understood common mechanisms.
2. the transition to 'cognitive networks' is of crucial importance to network operators such as KPN who want to provide their users with maximum flexibility and functionality.
3. the new NoC paradigm we propose is an instance of what one could call 'micro-networking', a topic in differentiating layers in the overall network architecture.
4. in the case of Personal and Federated Networks it is worth mentioning that the Netherlands are a great player in this area, both by initiating new concepts (PN and FedNets are Dutch proposals that have been adopted by the EU and have a great chance of being adopted worldwide).

Industry: KPN, Philips, TNO-ict, Lucent, Siemens, Utellus. Tyco, WMC, Utellus, Ericsson.

SRA Multimedia, Interaction and Virtual Reality

Environments equipped with Ambient Intelligence (AmI) technology provide social and intelligent, adaptive, personalized support to their inhabitants. Through ambient displays, interfaces and internet technology AmI environments can connect people and devices. In these environments we have mixtures of human and computer generated stimuli to support us in our daily work and home activities. Support that is provided is context-aware and knows about individual preferences. It also requires storage, retrieval and display of multimedia information (audio, video, text, pictures, and virtual reality) that has been made accessible through automated analysis. The following two viewpoints guide the research in this area:

- Rather than to develop local interfaces to computers, the research on interface technology needs to address interfaces to a diversity of devices (mobile robots, wearables, furniture, handheld devices) that interact with each other, the inhabitants of the environments and the sensor-equipped environments (smart homes, smart offices, smart public spaces) themselves. Computing power is becoming embedded in environments, but current human-computer interface technology is not meant to interact with disappearing computers. New interface technology is needed, rather than further exploiting interacting with the desktop there is a need to consider interaction in and with smart environments: real, augmented and virtual.
- Rather than to develop local multimedia retrieval applications we want to address storage, retrieval issues in smart user contexts and the integration of retrieval research with interaction research. Tools and techniques for easy access to multimedia, including multimedia information in large digital archives, exploit the synergy that exists between video and image processing, language & speech technology, and database technology. The results can be used in innovative applications that support various content management tasks, e.g. automatic indexing of large text collections and disclosure of audiovisual archives, search technology and filtering of dynamic information streams as needs to be done in smart environments.

Issues that in particular will be addressed are (1) the multi-party and multi-user view; and (2) the natural interaction point of view. That is,

1) Multi-party and multi-user. In home and office environments and in public buildings and spaces we have people interacting with each other and displaying behaviors depending on that of others. Can this interaction and behaviour be supported as well? Hence, the environment is asked to sense the context, to understand the interactions and the behaviour of its human inhabitants and their support and information needs in the context of all its smart devices. This requires more advanced (computational) theories of interaction and behaviour than are now available. It also requires research into user experiences in ambient intelligence and augmented/virtual reality environments.
2) Natural multimodal interaction. Current interaction and retrieval technology research hardly addresses cognitive issues related to the fusion and fission of information. These issues are important to detect and to interpret, but they allow meeting the individual preferences of users in retrieval and presentation of multimedia and in interaction with multimedia devices in smart environments. A main research question is how to sense, fuse, represent and interpret the users' verbal and non-verbal interactive cues so that the environment (including its smart devices) can act not only as an intelligent, but also as a social partner of its inhabitants. This also requires models (indexing) of available content, users and use contexts. It certainly requires interfaces that are intuitive, assistive and conversational in style.

The research in this strategic research area takes into account European ISTAG advices on research and development on multimedia, multimodal and multi-user access and interaction technology. The kinds of designs delimited here are welcomed by IT companies, e-Commerce firms, security initiatives, e-Culture and ambient self care initiatives. In addition to Philips (ambient intelligence), Océ R&D (smart office environments), Thales/Decis (smart crisis management environments) and DAF (smart mobile environments) there are numerous small and medium-sized enterprises that are interested in the results emerging from this research area.

SRA Security

Security plays a role in every aspect of daily life. People are plagued by viruses, spam, phishing, and identity theft; Businesses suffer from hackers, denial of service, web site defacing, copyright infringement, and fraud; Governments are threatened by terrorists, piracy, and espionage; Equipment with sensitive information is lost or stolen. The problem is not that the scientific community has not acted to develop methods and techniques to mitigate the risk of any particular threat. On the contrary, many such methods and techniques are available. However, the problem is that there is no comprehensive solution to the whole complex of security problems. We do not even know whether such a solution is feasible. What is urgently needed is research towards a respectable discipline of secure systems engineering. A complicating factor is that security is essentially multidisciplinary. Technical solutions will only work if people trust and use them, and if they are supported by legislation.

The NIRICT Security SRA will concentrate on technical issues, because sociological and legal issues are addressed in other contexts, such as Sentinels. The specific research areas include:

- Policies: Developing a unified framework for expressing security policies from the business process level down to the level of security tool configuration.
- Protocols: Developing automatic methods for the analysis of security protocols.
- Methods: Narrowing the gap between the formal and computational interpretation of security.
- Certification: Specification methods and tools for secure systems design.
- Languages: Developing methods and tools to analyse code for security vulnerabilities.
- Implementations: Methods and tools for side channel analysis aimed at preventing fault, power and timing attacks.
- Information: Methods and tools for secure information management and processing, particularly with regard to outsourcing, privacy protection, copyright protection etc

To show the economic relevance of the theme we quote two more or less randomly selected sources. The 10th annual CSI/FBI Computer Crime and Security survey amongst 700 businesses and government organizations in the US reports that Virus attacks are the greatest source of financial loss, followed by unauthorized access and theft. The 2002 Sarbanes-Oxley act has begun to have an impact on businesses. The International Federation of the Phonographic Industry (IFPI) estimates that in 2003 alone, the EU alone has lost 17,000 jobs due to piracy.

The inevitable conclusion is that no person, business (Philips, Shell, Akzo, DSM, Thales, IBM, Atos Origin, Pink Roccade, ABN Amro, Rabo, ING), organisation (Universities, Inland Revenue Service, Pension Funds, Hospitals), or government is immune to security attacks. So we all stand to benefit from a well orchestrated approach towards solving the problem of developing secure systems engineering.

Ambient Intelligence

The SRA Ambient Intelligence is centered around the idea of ubiquitous computing which was first articulated by Mark Weiser of Xerox PARC in 1991. The research in this strategic research area is investigating a new paradigm for bringing the flexibility of information technology to bear in every aspect of daily life. It foresees that people will be surrounded by deeply embedded and flexibly networked systems that provide easily accessible yet unobtrusive support for an open-ended range of activities, to enrich daily life and to increase productivity at work. These systems will be quite different from current computer systems, as they will be based on an unbounded set of hardware artifacts and software entities, embedded in everyday objects or realized as new types of device. However, this vision will only be viable if they support many diverse applications concurrently, and if they remain open towards unforeseen uses. Such applications will execute on behalf of different stakeholders with potentially competing and conflicting interests. Their execution will involve many software entities across distributed and embedded devices. Users, applications and devices will compete for resources such as processing time, memory, communication bandwidth, and sensors/actuators, and they will need to be able to negotiate access. The multitude of devices and computational processes all require energy for their operation, but energy will be a particularly scarce resource that needs to be carefully managed not only at device-level but across entire ambient systems. As ambient intelligent systems will typically integrate large numbers of interactive devices and artifacts, it has also to be kept in mind that human attention is a precious and scarce resource. As a consequence, resource management is an extraordinary challenge in ambient systems, exacerbated by large scale and dynamics of entities to be coordinated to maintain coherence for people's interactions with their environment.

The vision is to develop a new generation of architecture for pervasive computing environments that supports at their core the evolutionary features in the world we inhabit today. The architecture that we envision promotes co-evolution of pervasive computing environments and their users, and of embedded digital infrastructures and their physical settings.

Scope and Challenges

Our approach to enable ambient intelligent systems depends on highly distributed, reliable, and secure information systems that can evolve and adapt to radical changes in their environment, delivering information services that adapt to the people and the services that use them. These distributed systems must easily and naturally integrate devices, ranging from tiny sensors and actuators to hand-held information appliances. Such devices will be connected by short-range wireless networks, as well as by high-bandwidth local backbones. Data and services must be secure, reliable, and high-performance, even if part of the system is down, disconnected, under repair, or under attack. The system must configure, install, diagnose, maintain, and improve itself – this applies especially to the vast numbers of sensors that will be cheap, widely dispersed, and even disposable.

In order to make this possible we need to build an underlying architecture for pervasive environments that "opens up" to allow a diverse set of stakeholders to control, manage and influence the process of change in order to create sustainable future environments. We approach our vision with a programme of research in which fundamental innovation activities that address the need for new principles, models, methods, and tools are interwoven with experience projects that study contexts of use in different settings.

To scope our research we will concentrate on a set of core challenges that we consider most important for the realization of this vision. The research work will further be framed by a focus on a set of application settings. The core challenges that we identify are:

- Embedded Networking. Embedded devices vary largely in their wireless communication requirements and therefore interoperability across different technologies needs to be investigated. In addition there is still a need for new protocols that meet the requirements of very low-power and low-resource embedded devices.

- Competition. Experimental ubiquitous computing environments typically support a very small number of 'assumed to be friendly' applications but future ambient systems will only be viable if they support many diverse applications executing on behalf of different users with potentially competing and conflicting interests. Users, applications and devices will compete for scarce resources in a dynamic heterogeneous environment, posing resource management challenges at a new scale of complexity.

- Adaptability. The sheer number of entities that make up ambient intelligent systems implies that access to resources will be extremely competitive. Hence, these systems will have to embody adaptability on an entirely new scale. For example, communication will need to become adaptive to sustain high densities of devices, and computations may need to split and migrate to adapt to available energy and communication.

- Integrated development. Ubiquitous computing systems and applications are developed ad hoc as we lack the abstractions, tools, methods and development frameworks required to easily integrate infrastructure components.

• Low-power microelectronics. As the devices will be integrated in the environment, small size and energy efficiency will be essential. This requires the development of technologies in the areas of low-power RF, mixed-signal microelectronics, energy scavenging, System on chip, and MEMS.

• Architecture and foundations. The most fundamental challenge is to identify the overall architecture that will be underpinning the future ambient intelligent systems. Conceptual frameworks are needed to capture design knowledge and to support evaluation and comparison of systems.

The general research approach we take is necessarily multidisciplinary, as many of the identified challenges need to be addressed in an inclusive way that considers systems, environment and user in close correspondence. The particular scientific methods to be used will range from mathematical modeling (e.g. for resource optimization problems), simulation (e.g. of network protocols), hardware/software prototyping (e.g. of smart devices), and system measurements to scenario design, contextual analysis, and system evaluation in situ.
The SRA is fundamentally relevant to IST from a scientific and technical perspective, as well as from a societal and strategic viewpoint. It adheres completely to the strategic objectives of the IST. It is also in line with the vision of several Bsik initiatives, such as Smart Surroundings, Freeband, and MultimediaN. There are numerous industries highly interested in this area, including larger companies such as Philips, Thales, TNO, Océ, LogicaCMG, as well as small and medium–sized enterprises such as Nedap, Chess, Roessingh.

Enterprise Information Systems

Enterprise information systems (EIS) are software systems that support administrative processes within or between large organizations, such companies in the financial sector, government organizations, hospitals or manufacturing companies.
Research in software engineering has focussed on the producer end of the software value chain. It usually assumes that the software engineer writes programs starting from scratch, and has yielded a large array of programming methods and techniques. It has ignored the problems faced by companies at the consumer end of the software value chain, companies that assemble their EIS from large, commercial components and want their systems to be aligned to business processes against as low a cost as possible. For these component-based systems the programming task has been replaced by identifying, selecting, configuring and integrating components. These systems behave in an organic way, where components are upgraded, reconfigured or replaced periodically. The governance of this process is strongly dependent on an architectural model of the system(s).

The aim of this SRA is to develop and validate methods, techniques and software tools for sourcing, aligning, configuring and integrating EIS from commercially available components. We will divide the problem into five parts.

1. Alignment. Alignment of ICT and business processes is, the extent in which ICT supports business processes in a way that the business processes are supported by the ICT systems, in such a way that the business value is maximized. Architecture of processes and systems is a key instrument here and the QoS (Quality of Service) is the main performance indicator.
2. Sourcing. Components offer services. Given an architecture in the form of component specifications, the question is: how to incorporate the components in our system? There are several fundamental questions to be answered: Can we buy them, can we “rent” them from an ASP (application service provider) or do we have to build them? In the first and last case we have to decide if we want to operate and maintain them ourselves or that we outsource these activities. Here methods and techniques are required for selecting and testing components or there services.

3. Configuration. Assuming that we have found the right components, the next problem is to configure them. This requires a mapping from the business processes and business functions to the parameters of the software components. Languages for configuration of commercially available components are often very primitive, although the use of process models, business rules and data schemes as parameters, is increasing. The verification of consistency in configuration of components is an important issue.
4. Integration. Integration of components is a main problem in the world of component-based systems. The correct and efficient coordination of the cooperation of components is called the orchestration and is a main concern. For this task there are dedicated orchestration components, also called workflow engines or middleware. Integration is reduced then to configuration of the orchestration components. Verification of the correctness of orchestration is a major issue for which several techniques are available, but there are still many open questions.
5. Componentization. One question not addressed yet is: how do we define new generic components, i.e. components for a wide variety of applications. This is what the developers of product software do. What are the methods and techniques to identify reusable functionality on the scale of EIS, how do we determine if it is worthwhile to componentize such functionality and in what form is it best offered?

EIS's are assembled from commercially available components produced elsewhere. Today companies have to make hard choices concerning in/outsourcing, integration with existing systems, alignment of EIS with business processes, continuously changing business requirements, and architectural mismatches between different components. These problems are aggravated because businesses cooperate in various ICT-enabled networks.
The methods, techniques and software tools developed in this SRA are very important for system integrators, ICT-departments of the user organizations and last but not least for software factories that produce generic software components. Industry: CapGemini, LogicaCMG, Ordina, ING, Philips, local government