

# Simula Research Laboratory

## Early days!

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[www.simula.no](http://www.simula.no)

Simula Research Laboratory performs basic research within selected areas of *information and communication technology (ICT)*; improving software design and development processes, developing methods and software for computing and visualization, and investigating and creating communication technologies for the future information infrastructure.

### 1. Background

After a planning period of one year, under the direction of the Research Council of Norway, Simula Research Laboratory was set in operation in January 2001. Let us start with a short review of the history behind Simula Research Laboratory.

#### 1.1. IT and knowledge park at Fornebu

About ten years ago the national assembly of Norway decided to close down the old Oslo airport at Fornebu and build a new international airport at Gardermoen. At the height of discussions about the future use of the old airport facilities, a group of investors suggested that an information technology (IT) park should be established there. After a long political discussion, the final decision was taken by the Norwegian parliament in March 2000. They supported, both politically and financially, the idea of building an IT and knowledge park at the old airport. As a part of this decision the Norwegian government also decided that the IT and knowledge park should contain a research unit. The following quote is from the white paper on national budget for 2000:<sup>1</sup>

“..... a requirement for the success of an IT and knowledge center at Fornebu, is that a Center for Excellence in Information and Communications Technology be established at the site. .... The Government proposes that a total of 45 million NOK be allocated in the year 2000 for the establishment of a Center of Excellence at Fornebu. It will be jointly financed by the Ministry of Education, Research and Church Affairs (30 million NOK), the Ministry of Trade and Industry (10 million NOK), and the Ministry of Transport and Communications (5 million NOK). The Research Council of Norway will be responsible for coordinating planning, but it will be done in consultation with education and research institutions. ....”

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<sup>1</sup> Stortingsmelding nr. 1 (1999/2000)

Note that since the planning period lasted through the year 2000, the center was set in operation in January 2001. If successful, the center will receive an annual funding of 45 Mnok for 10 years.

## 1.2. Other political aspects

Another important part of the history behind Simula Research Laboratory has to do with the new political awareness and understanding of the importance of research, and in particular basic research. The level of research in Norway has gradually been reduced compared to other countries, and as we move into the 21st century, the level of research in Norway is far below the average of the OECD countries as measured against gross national product (GNP). Although stated in several reports during the 1990s, we find most of the arguments in a governmental white paper on research from 1999.<sup>2</sup> Norway has increased its research budgets during the last two years, and it seems that there is a political consensus that Norway must reach the average of the OECD countries in 2005. In particular, research in information and communication technology will have a high priority.

In the 1999 research white paper, the notion of the “center of excellence” was introduced as a mechanism to increase the quality of research. A significant part of the financial resources channeled through the Research Council of Norway will be used to fund centers of excellence on various research topics in the future. The Research Council is in the middle of a selection process.<sup>3</sup> A center of excellence is a research unit of a certain size that performs basic research at a high international level. As a consequence of the political agreement mentioned in Section 1.1, Simula Research Laboratory has not followed the ordinary selection process conducted by the Research Council.

## 1.3. Planning Simula

In parallel with the general process for establishing centers of excellence in Norway, the Research Council was also given the focused task of establishing a research center within the IT and knowledge park at Fornebu. In order to do this the Research Council organized a board for the planning process. The planning process was performed in collaboration with existing research institutions in Norway.

First of all the planning board initiated and ran a process for selecting research topics and groups for the center. This was done by first screening all research groups within ICT at the universities in Norway. Based on this process a number of topics were selected and groups/people were invited to submit proposals. Based on approximately ten submitted proposals and several hearings with the applicants, three groups were selected. These groups and their status as of October 2001 are given in Section 3. It is important to note that the main goal for the planning board was to select groups that had *the potential of becoming centers of excellence* within three to five years, not necessarily select groups that could already claim center of excellence status.

Secondly, the planning board was asked to propose how the center should be organized. The result of this process is that Simula Research Laboratory will be established as a limited company with the University of Oslo (25%), the Norwegian University for Science and

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<sup>2</sup> Stortingsmelding nr. 39, 1999, Forskning ved et tidsskille (Forskningsmeldingen).

<sup>3</sup> [www.forskningsradet.no](http://www.forskningsradet.no)

Technology (25%), University of Bergen (15%), University of Tromsø (15%), Norwegian Computing Center (10%) and Sintef (10%) as shareholders.

The recommendations from the planning board were approved by the Research Council of Norway in November 2000, and a board of directors was appointed by the owners. In addition to the board of directors representing the owners, Simula Research Laboratory has established a scientific advisory board with experts from the international research community, see Section 4.

## 2. Objectives

The authorities (and owners) expect Simula Research Laboratory to be active on the international research scene and, through long-term research and knowledge development, to devise innovative solutions for industry and society. In order to fulfill these expectations, Simula Research Laboratory must perform basic research at a high international level, educate people for the workforce of tomorrow and be active on technology transfer towards industry and society.

### 2.1. Basic research

We believe that we currently perform research at an acceptable international level. Researchers and students are active on the international scene, and several papers have been written during the past year. However, we continuously have to improve, and our main objective is therefore:

*Within three to five years the research groups at Simula Research Laboratory shall perform basic research at a high international level.*

This objective requires focus on publications in international journals, visibility on the international conference scene and, last but not least, strong focus on the selected research topics. An overview of the research topics is given in Section 3. More details are available at [www.simula.no](http://www.simula.no).

### 2.2. Education

Another important issue for Simula Research Laboratory is education, primarily done through supervision of PhD students and post doc. candidates. Approximately 50% of the scientific staff of Simula Research Laboratory will be PhD students and post doc candidates.

*Simula Research Laboratory shall, through high quality PhD/post doc. programs, educate people for the workforce of tomorrow.*

In addition to a few supplementary graduate level courses that might be given at Simula Research Laboratory, PhD students have to take their courses and obtain their degrees at one of the universities in Norway. The shareholders agreement, bilateral agreements between Simula Research Laboratory and the universities, and the fact that the senior researchers at Simula Research Laboratory are also professors at Norwegian universities enable Simula Research Laboratory to run PhD programs. Some full-time researchers at Simula Research Laboratory will also give courses at the University of Oslo. All PhD and post doc. positions will be announced internationally.

### 2.3. Technology and knowledge transfer

In general, the IT and knowledge park at Fornebu focuses on industrial innovation and the creation of new businesses related to information and communication technology. Although, we believe that there is a common understanding that basic research is fundamental to the creation of new and innovative solutions for industrial development, there is a certain expectation that research projects in Simula Research Laboratory will have a long-term commercial/industrial potential. The financial situation, as of October 2001, makes it impossible to have very strong and dedicated goals when it comes to industrial development and creation of commercial businesses. However, we believe that it is possible to obtain a certain level of industrial and commercial thinking within all research projects:

*In all projects at Simula Research Laboratory we shall be able to describe the long-term industrial (or commercial) potential of the research activity, and Simula Research Laboratory shall participate in technology and knowledge transfer activities.*

When (or if) research results show an industrial (or commercial) potential, Simula Research Laboratory will support technology and knowledge transfer; and when (or if) new businesses are created, Simula Research Laboratory will be an active owner. Simula Research Laboratory has established incentives similar to those used at Stanford. Briefly, these incentives are such that the researcher(s), the institutions and the investors share ownership based on a set of rules and regulations. These rules and regulations are part of the employment agreement. Simula Research Laboratory will also try to obtain extra funding in order to increase the technology transfer activities and to make possible the creation of new businesses.

## 3. Research activities

Simula Research Laboratory will perform basic research on selected topics within information and communication technology (ICT) and, to the best of its ability, devise innovative solutions for industrial development.

Information and communication technology (ICT) will be one of the key factors in the 21<sup>st</sup> century – it will transform the way we live, learn, work and entertain ourselves. Advances in software, computing and communication technologies create new infrastructures for business, scientific research, social interaction and public services. The rapidly expanding digital infrastructure will provide us with new tools for worldwide communication, and information will be available wherever we are and whenever we want. ICT will help us understand the world we live in – including the natural environment and the secrets of the human body. Within this broad picture, Simula Research Laboratory will perform basic research and will devise innovative solutions. In the huge and expanding realm of ICT research, Simula Research Laboratory is currently concentrating its research efforts on topics within the following areas:

- **Software engineering** – improving software development processes
- **Communication technology** – investigating and creating communication technologies for the future information infrastructure
- **Scientific computing** – developing methods and software for computing and visualization

After the initial investment phase at Fornebu, Simula Research Laboratory will expand its research activities from 2003. Some thoughts about this expansion are given in Section 3.4.

### 3.1. Software engineering

The research activities within software engineering are on object-oriented analysis and design, incremental and component-based development of software systems, and estimation, planning and risk analysis in software projects. More specifically, the group focuses on models, methods, techniques and tools for systems development in an industrial context and empirical research methods for validation of such technology, including case studies and controlled experiments. The group is concerned with technical, organizational and human issues that affect systems development processes. The main goal is to extend the empirically based knowledge about the influence of different models, methods, techniques and tools on processes and products. The activities in software engineering can be divided into three main categories:

- **Object-oriented analysis and design** Object-oriented technology is often used in combination with component-based development processes and processes that support change (incremental and evolutionary development). Included in this work are class and schema evolution in object-oriented systems and object-oriented metrics, e.g., the novel concept of dynamic coupling.
- **Planning, estimation and risk analysis** Companies that develop software are notorious for exceeding time and cost budgets. Poor estimation, planning and risk analysis often lead to unsatisfactory quality of the delivered product, dissatisfied customers and frustrated developers. The Software engineering group at Simula Research Laboratory focuses on developing new models, processes and tools for estimation, planning and risk analysis in software projects. This activity also includes work on improving existing models, processes and tools.
- **Process improvement and product quality** To improve how software is developed in companies and organizations, weaknesses must be identified and changes initiated. Important issues are experience databases and learning organizations. The Software engineering group at Simula Research Laboratory collaborates with industry to identify useful methods for ensuring satisfactory quality of products and processes.

The Software engineering group collaborates with Norwegian University for Science and Technology (NTNU), and professors at NTNU have part-time positions in the group. Moreover, the group has collaborated extensively with NTNU and the research foundation Sintef in the software process improvement (SPI) projects supported by the Research Council of Norway. In addition to extensive collaboration with approximately 15 companies in SPI projects, the software engineering group also collaborates directly with three other IT companies on case studies and experiments. The software engineering group also collaborates with NTNU in the national project INCO (Incremental and Component-based development), supported by the Research Council of Norway.

The software engineering group has international collaboration within ISERN (Int. Softw. Engineering Research Network), and the EC Network of Excellence project ESERNET (Experimental Softw. Eng. Research Network). We will also mention collaboration with researchers at Carleton Univ., Ottawa, Canada; Keele University, UK; and Univ. of Glasgow, UK. A more comprehensive list of scientific collaborators can be found at [www.simula.no](http://www.simula.no).

During the past two years, the group has produced an increasing number of publications, and it has introduced novel ways of running experiments (with professionals as subjects and sophisticated experiment support environments). The weaker aspects are that the group has insufficient exchange with international research groups. In particular, the researchers must visit other research groups more frequently. Moreover, the group must improve its conduct of joint long-term research with industrial partners. Finally, the group's members are young, and it includes only one full-time professor.

We aim to become one of the world's leading groups on software engineering experimentation with both students and professionals as subjects. To help us reach this aim, we are currently developing a sophisticated database system with a web-based support environment to run distributed experiments in industry. In addition to the web-based system, the group is planning a laboratory for conducting experiments with real-life software projects in industry. Industrial partners are invited to conduct their software projects or parts of these projects in the laboratory. Experiments with students will also take place in the laboratory. One of the main challenges is to create a laboratory environment for conducting experiments on software evolution.

### 3.2. Communication technology

In general, the research areas of the group will be on network architectures and distributed systems. With emphasis on research problems emerging from the world-wide convergence between telecom, media and information technology, the Communication technology group focuses on open and adaptive middleware, QoS management including QoS-based routing and switching, network architectures, and performance evaluation. Networks and distributed systems are important parts of the information infrastructure, and the important challenges can be summarized as follows:

- *heterogeneity* of networks, end-systems, services and applications
- *optimization* of performance and consumption of computer and network resources
- *non-functional requirements* like quality of service and security
- *construction* of distributed systems that are effective and robust

Principal solutions are needed, and in our work we will address architectures for open, dynamically adaptable distributed systems with particular emphasis on heterogeneous networks and end-systems. The group will organize its research under the umbrella of three main research activities that will each be organized as a set of related projects:

- **Flexiware** Under this activity we will address the development and application of new architectures for distributed systems, constructed from the beginning with adaptivity in mind. Middleware platforms for distributed systems and applications will be given particular attention. The most important challenges to be addressed are problems related to heterogeneity in networks, end-systems, services and applications, and differentiated quality of service provisioning to applications in light of ubiquitous computing and ad-hoc networking.
- **I-lab** This activity will focus on the challenges of providing a variety of service levels in the Internet as well as in different network technologies (layer two). This research is seen in light of important developments such as an increasing level of heterogeneity in the network and a wider range of quality of service requirements for network-based applications. One broad goal of this activity is to provide knowledge on how the design of low-level protocols and network components influence overall network

performance, in particular with respect to service levels. Another goal is to contribute to the realization of the ambition to provide true service guarantees from complex and possibly heterogeneous network infrastructures.

- **Cross-over** A *cross-over project* is planned between the Flexiware and I-lab activities with the goal of extending the scope of middleware to include network functions. In this context we aim to make research contributions in the area of open, dynamically adaptable distributed systems with particular emphasis on provision of quality of service (QoS) in heterogeneous networks. Our plan is to establish a working environment in which the specialties of each group member contribute to the solutions. The unifying goal of this research activity is to develop knowledge on how to provide QoS guarantees to networked applications. This, in general, requires vertical integration of QoS functions across several architectural layers – from link level to middleware.

The Communication technology group collaborates closely with the Communications systems group at the University of Oslo, the Open Distributed Systems group at the University of Tromsø and others through the ENNCE (Enhanced Next-Generation Networked Computing Environment) project funded by the Research Council of Norway. Through another project funded by the Research Council on distributed media journaling (DMJ), the group collaborates with the Digital Signal Processing and Image Analysis group at the University of Oslo. The main focus in this project is the development of a framework for real-time content-based analysis of distributed media streams. The group has strong relations to Telenor, and will, through the potential EU –programs, establish new relations to industrial partners.

Members of the group have participated in various EU projects including ARCHES and SCI-Europe, in which collaboration with a number of European universities and research institutions are established, including Trinity College (IRL), Université Pierre et Marie Curie (F), CERN (CH/F), and SINTEF (N). The group is also currently active in various initiatives towards the 6<sup>th</sup> framework program within the EU, both research and network programs. The group has enjoyed a long period of collaboration with Lancaster University (UK) in the area of distributed systems and middleware. Within the DMJ project mentioned above, collaboration with Aalborg University, Denmark has been fruitful. A more comprehensive list of scientific collaborators can be found at [www.simula.no](http://www.simula.no).

Over the past years, the group has established a fairly broad international network of contacts, which will be important for our future development. The principal members of the group are internationally recognized and have international experience from EU projects and as members of program committees of various international conferences and workshops. The publication rate is currently good. However, the group must strengthen its efforts to increase the frequency of publications in the most prestigious conferences and journals. Higher international visibility and recognition is important as a means to attract and recruit new scientists to the group.

We plan to further develop our skills in component-based approaches to distributed systems, the use of reflection to support adaptation, and open network architectures supporting a variety of service levels in the Internet. Near-future tasks of the Communication technology group include establishing a laboratory, which will be a test environment for heterogeneous networks and distributed systems ranging from wireless and mobile technologies to gigabit networks. This laboratory is also closely linked to a Linux cluster, which is also important for the Scientific computing group, see below.

### 3.3. Scientific computing

The Scientific computing group at Simula Research Laboratory focuses on software methods and tools for PDEs (partial differential equations), parallel computing, simulation of processes in the human body (mainly the heart), computational finance and “high-end-low-cost” computing and visualization. The basic research problem in the scientific computing group concerns how to develop efficient, reliable, and maintainable software addressing mathematical models based on partial differential equations. Our activities can be grouped into three main categories.

- **Scientific Software** In this area, the main issue is how to develop numerical software. In particular, the software should be well suited for parallel computers. The group has participated in the development of a comprehensive software library (Diffpack) for the numerical solution of partial differential equations. Moreover, the group has also played a vital role in the development of a parallel version of this software. The Diffpack software is available commercially through Numerical Objects AS., see [www.nobjects.com](http://www.nobjects.com). This activity also includes activities on real-time visualization of huge data sets and photo realistic rendering.
- **Computing in medicine** This activity involves three projects concerning applications of partial differential equations in computational medicine:
  - Computing the electrical activity in the human heart; in cooperation with the Faculty of Medicine at the University of Oslo and the Department of Engineering Science, University of Auckland, New Zealand.
  - Computing the flow of blood in the left ventricle; in cooperation with the Faculty of Medicine at the University of Oslo.
  - Computing ultrasound waves; in cooperation with the Digital Signal Processing Group at the Department of Informatics, University of Oslo.
- **Numerical Methods** This activity is about mathematical and numerical challenges related to the use of partial differential equations and development of software solutions for simulation. In particular, the activity focuses on the development and analysis of numerical methods for applications in reservoir engineering and mathematical finance.

In addition to the partners mentioned under computing in medicine, the group collaborates with researchers from University of Oslo, University of Bergen, The Norwegian University of Science and Technology (Trondheim), Sintef Applied Mathematics, Norwegian Computing Center and the Forsvarets forskningsinstitutt (FFI). We will also mention collaboration with researchers at The Department of Engineering Science, University of Auckland, New Zealand; Department of Information Technology, University of Uppsala, Sweden; and Department of Applied Mathematics, University of Dortmund, Germany. A more comprehensive list of scientific collaborators can be found at [www.simula.no](http://www.simula.no).

In addition to the scientific cooperation, the group cooperates closely with Numerical Objects AS. The purpose of this cooperation is to make our research results available to a wider audience. The company has customers all over the world. The group also has strong links with Springer-Verlag. Springer has handled four of our books, and recently one of them has been translated into German.



In past years, the group has had strong applicants for new positions, and collaboration with researchers in Norway and abroad is well established. Senior researchers have supervised many PhD students during the past years; they have arranged six international conferences and workshops in Norway, and several books have been edited or written. Some points of concern are that the group has grown quickly and some activities need time to settle. There are only two full-time professors in the group, and a more systematic exchange of people with leading international groups is necessary. There is also a greater potential when it comes to extending the collaboration with researchers at the University of Oslo. Finally, the group must strengthen the modeling aspects of scientific computing.

The group has grown significantly over the last couple of years and it is now time for consolidation. We plan to further develop our skills in the scientific software area, as well as in the area of numerical methods for partial differential equations. We will continue to strengthen our efforts in computational medicine, and we continue to work on the numerical methods underpinning all our software. In addition to establishing a Linux cluster for high performance computing, the group is considering a smaller test cluster for building specialized clusters for computing and visualization. The group will also install a display wall for high resolution graphics.

### **3.4. Extending the activities**

During 2001, Simula Research Laboratory has established three research groups. After the initial investment (infrastructure, computers, furniture, etc.) period is finished some time in 2002, there will be room to extend the activity. The management is running a process, and our plan is that a final decision will be taken by the board of directors in June 2002. Several alternatives will be outlined. The scientific advisory board (see Section 4.1) will be involved in the process during spring 2002.

### **3.5. PhD and Post doc. programs**

All projects will include a number of PhD students and post doc. researchers. The number of students will depend on the size of the projects and the level of financial support in addition to the basic funding from the Research Council of Norway. Other funding sources will include support from the owners, industry, projects within EU programs, and support from research programs at the Research Council of Norway. Although supervised at Simula Research Laboratory, PhD students take their courses and obtain their degrees at one of the universities in Norway. Since the full-time senior researchers at Simula Research Laboratory are also professors at the University of Oslo, most of the PhD students will also get their degrees from the University of Oslo. Approximately 50% of the scientific staff at Simula Research Laboratory will be PhD students and post doc. candidates. The balance between PhD students and post doc. researchers will depend on the availability and quality of candidates.

Simula Research Laboratory will also start a research leadership program, which some of the PhD students and young researchers will be invited to join. It is our plan that this program will start in 2002.

### **3.6. Annual projects w/guests**

A portion of the budget has been set aside for projects that we have called “annual projects w/guest.” These projects can be described as follows:

- Researchers (from Norway or abroad) are invited to propose projects on some suitable research topic. The topic must be within or close to the activities in one of the research groups.

- The projects will be conducted at Simula Research Laboratory; however, they should be organized so that researchers from other places will stay for shorter or longer periods.
- The duration of the projects can be from 4 to 15 months.
- The budget for each project should be within 0,5 and 1,5 million Norwegian kroner.
- Each project should either end with an international workshop or contain a seminar series.

In 2002 we will conduct two annual projects w/guests:

- *Communication in optical fibers using solitones* with participation from NTNU and Simula Research Laboratory in Norway and researchers from University of Missouri, US; University of Kiev, Ukraine; and Chalmers Institute of Technology, Sweden. Although, this effort is concerned with communication technology, the content of the actual project falls under scientific computing. This project is therefore organized as a part of the scientific computing group under numerical methods.
- *QoS Beans: Introducing Quality of Service Management into (Configurable and Re-configurable) Enterprise Component Architectures* with participation from University of Tromsø and Simula Research Laboratory in Norway and University of Lancaster, UK. This project is about quality of service of reflective enterprise component models in heterogeneous and dynamically changing distributed environments. This project is organized as a part of the communication technology group under the flexiware activity.

This project mechanism is established in order to increase international collaboration and visibility through exchange of research staff with leading international research groups.

### **3.7. Conferences and workshops**

In recent years, several members of the scientific staff have been active in organizing international conferences and workshops, both in Norway and abroad. In addition to the workshops and seminar series, which will be arranged as part of the annual projects, our plan is to host international conferences and workshops on relevant areas.

## **4. Miscellaneous**

### **4.1. Boards and management**

The board of directors has one representative from each of the owners, one person appointed by the Research Council of Norway and two employee representatives, elected by the employees. The employee representatives cannot be members of the management group. The management group consists of the managing director, the research director (group leaders) and the assistant director responsible for the administration (economy, information, IT infrastructure, external relations, etc.).

The board of directors has appointed a group of international experts to serve as a scientific advisory board for Simula Research Laboratory. In general, these experts will meet once a year with Simula Research Laboratory and, in particular, with the research groups. Based on this meeting, the annual report and other documentation provided by Simula Research

Laboratory, the scientific advisory board will provide a short report containing their findings and recommendations.

#### **4.2. Funding**

Simula Research Laboratory was established by the Research Council of Norway in collaboration with the owners, and it has a 10 year funding contract with the Research Council of Norway starting in 2001. Other funding sources are industry, EU programs and research programs at the Research Council of Norway.

#### **4.3. Evaluation**

Simula Research Laboratory will be evaluated by a panel of international experts in 2004/2005. These experts will be appointed by the Research Council of Norway. Funding for the five-year period 2006-2010 will depend on the recommendations and findings of this evaluation.

#### **4.4. Simula – the name**

Object-orientation was invented and developed by two Norwegians, Kristen Nygaard and Ole Johan Dahl, more than thirty years ago. Their ideas, which today have become a fundamental basis for almost all programming languages and system design techniques, was realized through the programming language Simula.

#### **4.5. Location**

Simula Research Laboratory is located in new offices on the fourth floor of the old airport terminal building at Fornebu. The building will also include various ICT companies ranging from education and consultancy businesses to product developers. The telecommunication company Telenor with its R&D unit will also be one of the neighbors. The Fornebu facilities are 7 kilometers from University of Oslo campus. Our offices and laboratories at Fornebu are planned for 120 people, including approximately 40 graduate students.