Software Engineering, SE
Development and maintenance of large, complex and possibly distributed software systems

for NFR, Oslo, June 27, 2000 (adjusted 18.9.2000)

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1. Goals

Context:
UiO/NTNU have cooperated for 6-7 years, the last 4 through common R&D projects (SPIQ, PROFIT, and NAWUS). We are 6 teachers/researchers, 10 PhD students, and 35 MSc students. In the framework of an attractive Center of Excellence (SFF-Fornebu), we would like to be an **international competence center in software engineering** by:

- Establishing new, validated insights in relevant areas of software engineering
- Cooperate with industry with two aims:
  - Achieve better research results – industry is our lab!
  - Disseminate new insights and thus improve industrial practice
- Achieve a ”lighthouse” effect: Educate and recruit students
- Couple us closer to existing international contacts and establish new ones
2. Motivation

- Software is essential in many important societal activities. There are 50-60,000 system developers in Norway – many without formal SW education. Still many challenges wrt. software quality and delivery on time and budget, cf. [US Standish report, 1995], cited in [PITAC, 1999]:
  - 31% of projects stopped before completion, with annual losses of 81 bill. $ (1% of GNP!)
  - 53% of projects have serious overruns (189% in costs on average), 59 bill. $ annually

- Why should we be part of a Center of Excellence?
  - A cooperation between NTNU og UiO will have synergy effects:
    common research and shared education
  - We have had and will continue to have an industrial focus
  - We have competence in research in software engineering based on empiri, which we regard as crucial to improve technologies and processes for software development
3. Scientific Profile

Six themes:

<table>
<thead>
<tr>
<th>Theme</th>
<th>Responsible(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object-oriented development and maintenance</td>
<td>D. Sjøberg</td>
<td>App. 1</td>
</tr>
<tr>
<td>Incremental and component-based development</td>
<td>R. Conradi, D. Sjøberg</td>
<td>App. 2</td>
</tr>
<tr>
<td>Methods to achieve quality of Web-based, distributed systems</td>
<td>L. Jaccheri</td>
<td>App. 3</td>
</tr>
<tr>
<td>Estimation, planning and risk evaluation of software projects</td>
<td>M. Jørgensen</td>
<td>App. 4</td>
</tr>
<tr>
<td>General software process improvement and quality work</td>
<td>R. Conradi, T. Skramstad</td>
<td>App. 5</td>
</tr>
<tr>
<td>Empirical software engineering</td>
<td>M. Jørgensen, T. Stålhane</td>
<td>App. 6</td>
</tr>
</tbody>
</table>

Research method: Model construction and subsequent validation in industry, among students and through international cooperation.
Results

• Scientific and popularized articles, research reports
• Experimental designs, with data + models
• Web-site: Portal towards our research area
• Seminars and industrial courses
• Common educational material and courses, UiO and NTNU:
  – Software engineering, quality improvement of products and processes, software architecture, object-oriented methods, research methods (especially for empirical software engineering)
  – Dissemination through NAWUS cooperation (”Norgesnett”)
Industry is our lab!

- Both IDI, NTNU and ISU, UiO has had an industrial focus over some time. We expect that SFF-Fornebu will offer even better possibilities for industrial cooperation.
- Since 1993 we have published the following published papers, 1/3 based on industrial cooperation:

<table>
<thead>
<tr>
<th>Institution</th>
<th>Total number of papers</th>
<th>Papers with int’l colleagues</th>
<th>Papers with nat’l/industrial colleagues</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTNU</td>
<td>150</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>UiO</td>
<td>60</td>
<td>17</td>
<td>13</td>
</tr>
</tbody>
</table>
Published papers so far in 2000, based on industrial cooperation

<table>
<thead>
<tr>
<th>Bedrift</th>
<th>Publikasjoner</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSB/Navia</td>
<td>17. Tor Stålhane and Kari Juni Wedde: &quot;Safety Validation with Focus on Testing&quot;, ICSTEST - International Conference on Software Testing, April 5-7, 2000, Bonn, Germany</td>
</tr>
</tbody>
</table>

Presentation of Center of Excellence (SFF-Fornebu), NFR, Oslo, June 27, 2000
4. Cooperative Aspects

- NTNU and UiO are cooperating well: an open environment with mutual trust, have had common research seminars twice per year for three years
- We have good experiences in organizing joint project work: SPIQ, PROFIT, ...
- We have great recruitment (undergrads and MSc/PhD students), which we use actively in empirical work internally and towards industry
- We have much cooperation with well-known international partners:
  - EU projects, ISERN network etc. (see lists on next two foils)
- We have much cooperation with industry:
  - Much contacts via SPIQ/PROFIT-projects including Telenor + others + DnV (se also previous foil)

Emphasis on creative scientific/social work environment!
International cooperating partners, with candidates for guest researchers/adjunct teachers

1. Professor Chunnian Liu, dr.ing. (NTH 1983). Beijing Polytechnic University, PBR China, Area: software engineering, process support, distributed systems.

2. Professor Alfonso Fuggetta, Politecnico di Milano, Italy, Area: software engineering, software architecture, feature engineering, middleware.


5. Prof.s dr.s Victor R. Basili and Marvin Zelkowitz, Univ. of Maryland, with a sister institute of IESE in software engineering (FC-MD), Area: software engineering, software process improvement and software quality, inspection techniques, COTS, experience bases, metrics, empirical studies of software engineering.

6. Associate Professor Lionel C. Briand, Ph.D. (Paris, France), Carleton University (Ottawa), Area: Inspections and testing in the context of object-oriented. Software quality assurance and control. Project planning and risk analysis. Technology evaluation, Experimental software engineering.

7. Professor Ray Welland, Head of Computing Science Department, University of Glasgow, Area: software engineering, Web application development, software tools, design methods.

8. Professor Malcolm Atkinson, University of Glasgow, Area: Persistent programming, language design, (distributed) information systems, software engineering.

9. And more ...

Presentation of Center of Excellence (SFF-Fornebu), NFR, Oslo, June 27, 2000
Candidates for postdocs

1. All our previously educated PhD candidates: ca. 15 researchers, working mostly in industry.
5. Dr.ing. / dr.habit. (99) Bernhard Westfechtel, RWTH, Achen, Germany. Area: software engineering, CAD/CM, process support, OO/UML.
7. Assist.prof. dr. Per Runeson, Lund, Area: software engineering, testing, requirement analysis, process improvement, metrics.
10. dr. Forrest Shull, (PhD U. Maryland), FC-MD/U.Maryland, Area: inspection techniques.
11. dr. Ioana Rus (PhD U. Arizona), FC-MD/U.Maryland, Area: system dynamics, inspection techniques.
12. dr. Mikael Lindvall (PhD U. Linköping), FC-MD/U.Maryland, Area: requirement analysis, software maintenance, working with SMEs, experience bases.
13. And more ...
SFF and cooperating partners

SINTEF

DnV, Telenor, ...

…> 20 Norw. Companies, partly in PROFIT

SE (UiO/NTNU)

Int’l contacts

ISERN network

Other projects

NTNU T.heim
5. Size/Cost

Annual budget in 1000 NOK (8 NOK = 1 Euro = 0.9 USD)

<table>
<thead>
<tr>
<th>Position</th>
<th># fulltime</th>
<th>Unit wage</th>
<th>Sum wage</th>
<th>Tr/exp rate</th>
<th>Sum travel/expenses</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof., also part-time</td>
<td>3</td>
<td>650</td>
<td>1950</td>
<td>150</td>
<td>450</td>
<td>2550</td>
</tr>
<tr>
<td>Assis.prof., also part-time</td>
<td>4</td>
<td>550</td>
<td>2200</td>
<td>150</td>
<td>600</td>
<td>2950</td>
</tr>
<tr>
<td>Post.doc./junior guest.res.</td>
<td>5</td>
<td>504</td>
<td>2520</td>
<td>80</td>
<td>400</td>
<td>3000</td>
</tr>
<tr>
<td>Senior guest researcher</td>
<td>1,5</td>
<td>1000</td>
<td>1500</td>
<td>100</td>
<td>150</td>
<td>1750</td>
</tr>
<tr>
<td>PhD fellowships</td>
<td>12</td>
<td>385</td>
<td>4620</td>
<td>70</td>
<td>840</td>
<td>5530</td>
</tr>
<tr>
<td>Adm./techn. Assistant</td>
<td>1</td>
<td>385</td>
<td>385</td>
<td>50</td>
<td>50</td>
<td>485</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>26.5</strong></td>
<td><strong>13175</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>16265</strong></td>
</tr>
</tbody>
</table>

20% of SFF resources spent at NTNU/Trondheim to achieve a "win-win" situation, otherwise NTNU will be tapped for researchers and cannot mobilize own resources.
## 6. Personnel

<table>
<thead>
<tr>
<th>Institution</th>
<th>Actual candidates</th>
</tr>
</thead>
</table>
| NTNU        | • Professor Reidar Conradi  
• Professor Torbjørn Skramstad  
• Professor Tor Stålhane  
• Ass.prof. Letizia Jaccheri  
• Three existing PhD students, plus 3 PhD fellowships being announced; all will be affiliated to SFF-FBU, but mainly be placed in Trondheim.  
• NTNU will use funds from SFF-Fornebu to employ at least one extra ass.prof. full-time at SFF-Fornebu. |
| UiO         | • Professor Dag Sjøberg  
• Ass.prof. Magne Jørgensen  
• Ass. prof. NN  
• PhD student Bente Anda  
• PhD student Erik Arisholm  
• PhD student Lars Bratthall  
• PhD student Amela Karahasanovic |
Organization

• Each theme (foil p.5) is organized as project groups with:
  – 2 researchers/univ.teachers
  – 2 postdocs/guest researchers
  – 3 PhD students
  – 5-8 MSc students
  – 1-3 industrial partners

• The same person can participate in several projects

• Each PhD student has a main advisor and a co-advisor, preferably from both UiO and NTNU
7. Time frame

15/9-2000: First presentation meeting for industry and students
15/10-2000: The first postdocs in place
1/1-2001: Support functions and first PhD students in place, real startup
1/4-2001: Second preentation meeting for industry and students
1/6-2001: Employment of the first guest researchers/teachers

.....

- Scientific evaluation after 3, 5 and 10 years
- Monthly scientific common meetings
- Monthly scientific management meetings
Appendix 1: *Object-oriented development and maintenance*

The use of object-oriented (OO) methods, techniques and tools are now commonly used in today’s IT-industry, but little strict scientific work has been carried out to evaluate the advantages and disadvantages of this type of technology.

We want to carry out empirical studies to evaluate in what situations / projects / environments and in what ways the different OO technologies should be applied.
Appendix 2: *Incremental and component-based system development*

Incremental and component-based system development is an attempt to reduce risk by having shorter development periods, e.g. by "timeboxing" in 3-6 months intervals. We can also achieve better quality, reduced costs and shorter leadtime by reusing available components (e.g. COTS).

However, the two aspects, incrementality and component-basing, implies that user requirements must be managed in a more active way, by repeated renegotiation and reprioritization. For instance, the desired delivery time or available components may imply that some requirements must be amended -- so not a classical waterfall model any more. Many of the ”data scandals” in the Norwegian public sector can be traced back to poor handling of such problems. Further, there are no good architectural models to achieve formal analysis and estimation of a proposed architecture based on COTS.

In all this, the industrial interest is enormous, so the relevance is high. Cooperation with the PROFIT and partly DAIM projects in NFR’s industrial PROGIT program seems natural.
Appendix 3: *Methods to achieve quality of Web-based, distributed systems*

We are presently lacking effective methods and techniques to ensure good architecture, integrity and maintainability of Web-based systems. The goal is to develop new and to improve old methods, techniques and tools for Web-based development. A special challenge is to manage the dynamics (unpredictable and fast changes) in knowledge-intensive organizations.
Appendix 4: Estimation, planning and risk evaluation of software projects

Organizations that develop software has a very bad reputation concerning overruns of budgets and deadlines. Insufficient estimation, planning and risk evaluation in development projects often lead to poor quality of the delivered product, dissatisfied customers and frustrated developers. The goal is to focus on understanding of existing and development of new models, processes and tools for estimation, planning and risk evaluation of software projects.
Appendix 5: General software process improvement and quality work

Process improvement has received much international attention in the last 13 years. However, many of the offered method frameworks (TQM, CMM, SPICE, partly ISO-9000) are designed and most well-suited for larger companies, with corresponding resources and required stability.

In the Norwegian SPIQ project in 1997-99 we assembled a pragmatical method book (in Norwegian) for process improvement in Small and Medium sized Enterprises (SMEs), but the method framework is still immature. The coupling to organizational learning and experience bases is also a challenge. Luckily, the industrial interest in this area is very large, cf. the PROFIT follow-up project of SPIQ in 2000-2002 under NFR’s PROGIT-program.

We still consider it necessary to strengthen the method side by further research in the context of SFF-Fornebu. A cooperation with PROFIT is natural.
Appendix 6: *Empirical software engineering*

The discipline of informatics and in particular software engineering has, not without reason, been criticized for lack of practical validation of proposed methods, languages and tools. For instance, the area of object-orientation, being almost 35 years old, has hardly been scrutinized in a scientific way. Of course, there are many practical and methodological problems in carrying out validation of new software technology. It has therefore been built up a community of researchers, e.g. through the International Software Engineering Research Network (ISERN, lead by Univ. Kaiserslautern), where both NTNU and UiO are active. A spectrum of empirical methods can be utilized -- from student experiments to post-mortem case studies. These methods are themselves subject to scrutiny and improvement.

Concretely we propose to work on sets of repeatable experiments which can be repeated by researchers elsewhere. In this work, we will use own students, as well as case studies from many cooperating companies.