Research plan 2005-2010 for Professor John Krogstie at IDI, NTNU

The research that is planed to be done is within the field of information systems, focusing on the use of modeling techniques in the development and evolution of information systems of different types, including in particular enterprise and governmental systems, systems for virtual organizations and mobile/ubiquitous information systems.

The focus of the planned research will be develop and evaluate new methods for development and evolution of multi-channel process support system. The methods will make it simpler to

- develop and deploy new process-support oriented information systems for different types of workers, with a specific focus on symbolic analysts (a.k.a. 'knowledge workers'),
- modify these systems quickly in order to have them fit well with new technology and new and emerging usage patterns

The research comprises specifically

- Enterprise (process) modeling and requirements specification techniques for unclear, inconsistent and unstable user requirements.
- Integrated modeling of enterprise architecture, requirements, and processes to make it easier to evolve the solutions over time
- Support for systems based on interactive models enabling users to have more control over the use, personalization and adaptation of their IT-support.
- An existing framework for quality of models and modeling languages will be applied and adapted to support the development of methodologies, modeling languages and tools in this area.

Motivation and Justification

A larger proportion of work is today done by what is termed the symbolic analysts (Thomson and Warhurst, 1998), whose work resources and work products are primarily symbol-structures such as texts, documents, presentations, models, drawings etc. The proportion of such work is predicted to increase in the years to come, based on profound changes in business environments in connection to increased knowledge intensity, globalization, and virtualization. Learning, innovation and knowledge have become key issues and radical organizational learning and continuous innovation are the true sources of organizational advantage. Consequently, knowledge has become a critical production factor. The main work pattern of the symbolic analysts is knowledge intensive projects often in dynamically networked organizations. Workers such as consultants, designers, reporters, and researchers normally have many tasks going on at the same time, and will be interested in a lot of different information there and then, much of which can not be possible or practical to anticipate fully beforehand. There might be a need for learning on the fly, but also for capturing interesting situations to feed back to the organization supporting knowledge management and organizational learning. Knowledge work will

not be tied to the office only, but will consist of continous collaboration, communication, and co-ordination on the fly among distributed actors. The modern knowledge worker works from many different locations (home, in the clients office, in a hotel, on a plane), using a variety of information processing devices based on what is available and practical at the time, including stationary PCs connected to a LAN or WLAN, portable PCs, and smart-phones connected wirelessly to the network.

1.1 Emerging (information and communication) technologies for knowledge workers

The technology to use is becoming more mobile and ubiquitous. The emergence of new generations of hand-held personal information appliances specifically provides an opportunity to give improved support to knowledge workers, through more complete digitalization, miniaturization, and integration of diverse sets of knowledge.

When supporting work over a multi-platform architecture, we need to keep in mind that mobile information systems differ from more traditional information systems along several dimensions (Abowd, 2000; Ehrlich, 2000, Hirsch, 2001; Krogstie, 2004; Lee, 2003; Siau, 2001). We have grouped the differences within the following three areas:

- User-orientation and personalization
- Technological aspects including convergence and multi-channel support
- Methodology for development and operations to ensure organizational returns

User-orientation and personalization:
Mobile information systems often address a wide user-group, which means that user-interfaces should feature prominently and early in the design process and often need to be very simple. The resulting user-interfaces cannot presume a prior acquaintance with computers, and input and output facilities may be severely restricted (no keyboard, small screen-size etc.) or based on new modalities (speech-recognition and –synthesis etc.). This means that *individualization* of mobile information systems becomes increasingly important, both at the individual level where user-interface details such as commands and screen layout are tailored to personal preferences and hardware, and the workgroup level where functions are tailored to fit the user's preferred work processes including the support of novel workplace designs and methods of work organization that enable collaboration of multi-location and mobile workers.
Individualization means information systems that both automatically *adapt* themselves to the preferences of the user and that can be explicitly *tailored* by users through a specific user-interface. The main goal is to achieve usability of the applications on all possible interfaces, based on adaptation to the different physical devices. This calls for intelligent, adaptive and self-configuring services that enable automatic context-sensitivity, user profiling and personalization in a trusted and secure environment.

Technological aspects including convergence and multi-channel support:
Mobile devices have severely limited processing, memory and communication capacities compared to other kinds of computers. Performance considerations therefore become increasingly important in the first design steps. Analytically-based predictive methods are necessary in order to assess a large number of alternatives during the design of mobile

information systems. Mobile information systems also pose new challenges to achieving information systems dependability, emphasizing the need for systems that secures trust and confidence. The new mobile devices provide integration and convergence of technologies into a wide range of innovative mobile and multi-modal applications. Mobile and other new technologies provide many different ways to offer the same or similar services to the users. Novel approaches for the development and evolution of applications on and across different mobile and traditional platforms are thus needed.

Methodology for development and operations to ensure organizational return
Mobile information systems are often radical and therefore reward an increased focus on idea generation early on in the requirements and design process. Understanding the mobile users requirements for new services us thus of large importance. One need both to be able to develop these systems and to address the major hurdles for the deployment of applications and services for the user. Another effect of the radically new approaches enabled by technological solutions is that the introduction of mobile information systems often spawns several other initiatives for changing other information systems within an organization. It is important to focus on the interoperability of services and service environments including e.g. working, billing, payment, ticketing and accounting services, as well as seamless access to corporate and government resources from the mobile devices.

This plan recognizes that new information and communication technologies are rapidly transforming the work processes of knowledge workers. ICT-supported co-operation will accelerate the transformation and integration of the traditional enterprises into new and more dynamic markets. At the same time as new channels to information is provided, existing channels such as traditional PCs over a LAN will still be used, thus one need to support a multi-channel approach, where the same functionality and information resources is available across a large range of processing devices in a manner that suites the devices characteristics.

1.2 Approach relative to current research

Our approach to this problem-area will, in particular, be directed to the support of emergent non-routine work-processes, where systems supporting these tasks have unclear, inconsistent, and unstable user requirements, and where they can benefit to be accessible on a number of platforms. Traditional enterprise systems (e.g. ERP-systems) tend to be quite inflexible, hardly adaptable at runtime, and primarily support routine processes. Existing workflow management systems have typically been focused on dealing with exceptions and have thus offered some support for adaptive processes (Klein, 1998). These types of systems, however, have typically overlooked emergent processes, which seem to encompass an increasing part of knowledge workers' activities. On the other hand, only supporting the emergent work style of the individual is at times inefficient, because routine parts of the work can be prescribed and automated, and because sharing of explicitly defined work processes facilitates co-ordination, collaboration and communication between multiple parties. Thus there is a need for a balance between prescription and emergent representations.

In our vision, information systems for knowledge workers should be based on *interactive models* (Wegner, 1997; Wegner, 1999, Jørgensen, 2001, Krogstie & Jørgensen, 2004). The outset for this thinking is that models can be useful tools in a work situation, even if the models are changing and are partly incomplete and inconsistent. The requirements to the system are thus developed only to the degree necessary at an early stage of the development of a new system. During actual use, the user is included as an interpreter and potential modifier of the models underlying the system, filling in the gaps and extending the systems as appropriate.

Models should be the basis for information system development, personalization, and use. The models are both of the information system itself, and of the environment of the system including the usage situation.

Modeling techniques can be used for the development of a large range of information systems. In connection to our work we can identify the following problem fields for increased utility of the techniques developed as part of a model-based approach:

Modeling of requirements to enterprise solutions: Requirements Engineering for business solutions have so far primarily dealt with the elicitation, specification, validation, management and change to information systems to be accessed through PCs and workstations (Krogstie, 2001c). As multi-channel solutions including also mobile front-ends are applied in more and more situations, additional challenges will meet those that specify the requirements to these applications. As highlighted above, the traditional view of RE (Kotonya and Sommerville, 1998), where a requirements specification is developed early in a project, and then undergoes only minor changes under development and further system evolution, only partly applies. Rather it will be important to deal with unstable, unclear, and inconsistent user requirements that evolve and emerge through actual use.
Existing modeling techniques used in RE involves goal modeling (Mylopolous, 1999), conceptual modeling (Sølvberg, 1999), actor modeling (e.g. i*) and process modeling (including UML use cases (Booch, 1999) and hierarchical task analysis from usability literature). Enterprise process modeling and enterprise models of various kinds have become widespread also related to this area. In enterprise modeling, a primary focus so far has been on analysis and understanding of production-oriented enterprises described by detailed process models. Traditionally, support for the enterprise workers in actually performing its processes has only been provided to a limited extent.

Active process support for knowledge workers
Research into system modeling has concentrated on systems *development* activities. Models of work environments have for a long time been used to analyze the problem domain, to capture and structure user requirements. Most of these approaches focus on the relationship between model elements and the real world objects that they represent. Individual, social and situational aspects of model *usage* have had less influence upon mainstream information systems engineering. A fresh look at the role of models to manage and change system *operation* can complement this, enabling information systems to better meet local user needs and changing environments. Supporting learning and

knowledge management is another main motivation. (Chen et al, 1999) has pointed to active modeling as a major future direction for research in conceptual modeling, including model execution, end user participation, interaction etc. (Greenwood et al, 1995) argue that active models can enable IS to meet many business needs that traditional technologies fail to support.

A model is *active* if it directly influences the reality it reflects, i.e. if changes to the model also change the way some actors perceive reality. *Model activation* is the process by which a model affects reality. Model activation involves actors interpreting the model and to some extent adjusting their behavior accordingly. This process can be

- *Automated*, where a software component interprets the model,
- *Manual*, where the model guides the actions of human actors, or
- *Interactive*, where prescribed aspects of the model are automatically interpreted and ambiguous parts are left to the users to resolve.

Fully automated activation implies that the model must be formal and complete, while manual and interactive activation also can handle incomplete and partly informal models. Completing this conceptual framework, we define a model to be *interactive* if it is interactively activated. That a model is interactive entails a co-evolution of the model and its domain. A model that does not change will not be able to reflect aspects of reality that changes, nor can it reflect evolution of a human actor's understanding. It contributes to change but does not reflect this change. The process of updating an interactive model is called *articulation*. The interplay of articulation and activation reflects the mutual constitution of interactive models and the social reality they reflect. The software components that support intertwined articulation and activation are termed *model activators*.

The most comprehensive theoretical approach to this field is Peter Wegner's interaction framework (Wegner, 1997, Wegner and Goldin, 1999). The primary characteristic of an *interaction machine* is that it can pose questions to users during its computation. The process can be a multi-step conversation between the user and the machine, each being able to take the initiative.

Process support technologies are typically based on process models, which need to be available in some form for people to change them to support their emerging goal. Thus ”living, interactive models” should be supported (Ellis, 2000) in a way that the knowledge captured in the RE-models are reused and refined. The systems should also be able to save the adapted models for process improvement and potential reuse of novel processes (Jørgensen, 1999). Approaches such as ServiceFlow (Wetzel, 2002) points to the need for such flexible solutions, although not taking a model-based approach. In the EXTERNAL-project (EXTERNAL, 1999;Lillehagen, 2002a, Lillehagen, 2002b, Krogstie, 2002b), we developed such a model-based approach which enables the change and adaptation of instance-models by the users themselves. The operating environment is so far only available through a traditional web-interface, and not supported across multiple channels. Added challenges here are primarily focused at the effective development of usable user-interfaces. A literal translation from the web to wireless is inadequate. Merely squeezing data into small screens detracts from the user experience on mobile devices (Billsus, 2002). At SINTEF, one are currently investigating how to combine conceptual user interface components with modeling patterns as a promising direction for model-based cross-platform user interface development (Nilsson, 2002).

Development of systems on a wide range of client platforms:
Several approaches to customize the presentation of the contents of distributed information systems wrt the terminal device are reported. Most of the proposals concentrate on the generation of HTML pages for the web, and WML pages for WAP. Nowadays, the research interest is devoted to the automatic generation of multi-channel access systems.

Recently, work within user interface modeling has focused increasingly on mobile user interfaces (Eisenstein, 2001; Muller, 2001; Pribeanu, 2001; Schneider, 2001). This is often done to facilitate some level of common models for the mobile user interfaces and more traditional ones. A central element in this is the development of model-based approached that are powerful enough to be used as a basis for the development of user-interfaces on the multitude of platforms needed, but still general enough to represent the commonalties in a single place. One approach is to define user-interface patterns with general usability principles as powerful building blocks. Several other researchers have examined how patterns can be used in usability-oriented work (Borchers, 2001; Granlund & Lafreniére, 1999; Sutcliffe & Dimitrova, 1999; Welie & Trætteberg, 2000) and have described how patterns can fit into all the different phases of a usability-engineering life-cycle.
A main challenge for model-based approaches for developing multi-interfaces is to have a set of concepts that are, on the one hand, abstract and general enough to express specifications across a number of quite different platforms and, on the other hand, powerful and expressive enough to support mapping to different platforms.

The common approach is to not follow model-based approaches. Although most software engineers are aware of model-based methodologies and many companies claim to base their development processes on them, model-based methodologies are seldom followed in great detail in practice. On the other hand, the use of enterprise modeling seems to be increasing e.g. to create so-called enterprise architectures, but these models are seldom taken over into information systems models, but merely acts as context to IS-models. Also most current multi-channel approaches do not focus on the use of a rigorous model-based technique. The Oxygen Project (Dertouzos et al, 1999), developed at the MIT, focuses on the concept of "pervasive computing" from a technical point of view introducing a novel network technology in which mobile devices can recognize each other, and dynamically configure their interconnection in order to form "collaborative regions". Odyssey (Noble et al, 1997) defines a platform to manage adaptive applications for different mobile devices using mobile agents. The Portolano Project (Esler et al, 1999) investigates the emerging field of invisible computation. It envisions a user interface that combines the data gathered from location sensors, identification tags, and on-line databases in order to determine user intents rather than relying on user commands. In contrast to these projects that focus on automating the support by partly guessing what the worker is interested in, the Ninja Project (Fox et al, 1998) aims at developing a software infrastructure for the next generation of Internet applications which is more open for adaptation in use, although not taking full benefit from a model based approach.

John Krogstie, and the research groups he is affiliated to has a long tradition with modeling languages and tools for requirements modeling (Krogstie, 2001b, Krogstie, 2001c, Sindre, 2000), process modeling (Krogstie, 2004, Gulla, 1994, Carlsen, 1998, Jørgensen 1999, Nysetvold 2005), combined with structural, rule, and actor-oriented approaches (Krogstie, 1995, Carlsen 1998, Sølvberg 1999), and user-interface modeling (Nilsson, 2002; Krogstie, 2003a, Welie, 2000). In the project this work will be extended. We will also extend the work previously done on the quality of models (Krogstie, 2004, Krogstie, 1995; Krogstie, 2001b) to cater for the needs of interactive models.

The models are made on top of standard solutions, components and (web)-services implementing the necessary functionality, rather than generating low-level code from the models. This is similar to what is currently known as web services orchestration where the co-ordination of different e-Services can be described in languages such as WSFL (Leymann 2001) and BPML/BPMN. A difference is that the proposed languages for this so far are only meant to be used by system developers. In our approach, being validated e.g. in the EXTERNAL and ATHENA projects, the models are no longer only meant for the professional system developers, but are user-oriented and useful already at an early stage of development. More importantly, the models also continue to be useful in a usage situation.

Although isolated applications of various kinds of enterprise models is a hot research topic across a range of disciplines, few researchers have been developing frameworks for enterprise modeling that are sufficiently general to accommodate multiple uses of the same enterprise model or parts thereof through the use of different model activators. The work in EXTERNAL has been continued in the Norwegian Research Council project MONESA (2003-2005), and the EU 6FP IST project ATHENA (2004-2006). A new EU project based on this technology (MAPPER) will start Autumn 2005. On the other hand, in EXTERNAL, MONESA and ATHENA, we do not enable accessing the model-based solutions through a multi-channel architecture. Providing the concepts, theories and tools for such frameworks would be beneficial in many ways.

The technical and scientific results from this work comprise

- Model-based approaches for establishing and evolving the requirements for information systems in unstable environments
- Model-based approaches for personalization and adaptation of the information system based on the application of interactive models
- An overall methodology for a model-based development and personalization of multi-channel information systems integrating the above results

The results should give significant results related to the development of new methods and tools for developing and personalizing multi-channel process-support systems for knowledge workers. An overview of research challenges in general for mobile information systems is summarized in (Krogstie et al. 2004).

Research cooperation and funding

The basis for the research is as earlier indicated from past and current research projects where I have participated, both within EU (specifically EXTERNAL, UEML, ATHENA, INTEROP and MAPPER) and on a Norwegian level (specifically MONESA, EFFIN, WISEMOD, and MOSES).

The research will be done as part of the IS group at IDI, NTNU. As a starting point, I currently am the primary advisor for two PhD-students in connection to the WISEMOD and MOSES projects. In addition I am secondary advisor for 3 PhD candidates at NTNU (being funded by the projects ADIS, IKT-WEBTEK and WISEMOD respectively), and one at the University of Melbourne (financed by SINTEF through the EFFIN project where I act as project leader).

WISEMOD (Web Information Service Modeling) is a project within IKT-2010 in cooperation with Guttorm Sindre. MOSES is a KMB project in the IKT Program, with Telenor, DnBNOR, Veritas and OLF as additional partners.

Over some years it is envisaged to build up the research activity to a stable size of 3 to 4 PhD students, and a similar number of PhD students were I am secondary supervisor. 1 to 2 Post-docs/research positions should also be related to the research work.

To achieve this, I need to be able to be involved in selling research projects both nationally and internationally. Ongoing projects which is funding some of my existing activity on the research area I have outlined is

- MONESA: Model-driven networked collaboration, a Norwegian BIP project (user run project) in the PULS research program in cooperation with Veritas (prime), Troux (previously Computas), and the Norwegian Defence. Especially Veritas and Troux I have worked together on in many projects over a number of years and expect to be able to continue this cooperation. METIS, an enterprise modeling tool from Troux, we have used and plan to continue to use in connection to courses that I will be involved in, specifically in the course 'Modeling of Information Systems'. I was the initiator of the MONESA project, establishing the consortium and developing most of the proposal. I am the project leader of the project.
- EFFIN: Efficiency through User Involvement in Public Sector. A more basic research oriented project in the NFR, FIFOS program (research on public sector). Cooperate here with the TIK-center (Technology, informatics and Culture) at the University of Oslo, Accenture and Cap Gemini. Especially the co-operation with Accenture is one that I plan to continue, also based on my many contacts in the company through previous work as a consultant there (1991-2000). Accenture has earlier also funded PhD-research and projects at IDI through the Accenture research fund. In EFFIN, I am project leader. The project involves people with very diverse background, including software engineering, information systems, psychology, sociology and anthropology.

- WISEMOD, a basic research project within the IKT-2010 program. The proposal was developed by Guttorm Sindre and me in cooperation.
- In the ongoing EU-projects ATHENA and INTEROP, I had only a minor role in connection to the proposal development. In connection to a follow-up project to the EXTERNAL project which will start in the Autumn of 2005 (MAPPER), I acted as the coordinator of the proposal and the development of the DOW based on this.

Likely sources of funding in the future will be

- The Norwegian Research Council, especially through more basic research projects (e.g. SUP, and projects through for instance the VERDIKT, VIOS and BIA (Brukerstyrt InnovasjonsArena)
- EU: There are possibilities here both in the last calls of the 6.th FP (where I am involved in several consortia), and especially in the 7.th FP which appear to be more geared towards basic research
- Bilateral projects with companies such as Troux, Veritas and Accenture.
- Membership in research organizations such as ERCIM e.g. for Post Doc-financing

I will also keep a 20% senior advisor position at SINTEF, which will be helpful for establishing new projects through the contacts that I have established there over the last five years.

In case a new round of YFF-grants will be available in the next three years, this is also a potential source of funding. New SFFs is announced in 2005 with startup in 2007. Similarly the new SFI-instrument where SINTEF and NTNU is expected to cooperate.

The proposed research area has strong links to a number of people currently working at IDI. First of all it follows in the tradition of PPM and PPP from the late 80' and early 90', which was continued both through my own work and the work of Steinar Carlsen on APM and Håvard Jørgensen on Workware. Jørgensen work currently in Troux. There is also a strong link to the work of many of the current associate and full professors of the IS and SU groups of IDI:

- Guttorm Sindre through the WISEMOD project and through common work earlier on requirements engineering and quality of models
- Jon Atle Gulla on the area of enterprise process models and enterprise systems
- Arne Sølvberg on conceptual modeling in general, including links to research on semantic web technologies
- Hallvard Trætteberg on linking process modeling and user interface modeling, specifically relevant for the development of Multi-channel solutions
- Monica Divitini and Alf Inge Wang on CSCW and mobile information systems.
- Øystein Nytrø vs. health informatics

Cooperation with other parts of NTNU is planned coordinated through the new IKT program on eGovernment

Internationally, I plan to keep up the involvement in IFIP (especially IFIP TC 8 where I am the national representative, and which have supported the MOBIS-initiative on mobile information systems, and IFIP8.1 where I am currently Vice-chair, and which I have been involved in over the last years most notably in the arrangement of the EMMSAD workshops). Many of the members of IFIP8.1 are also members of the INTEROP NoE, contacts I also plan to follow up on. I will also look into ways of increasing the co-operation with ERCIM. In 2007, I will act as general chair of the CAiSE-conference to be held in Trondheim in June

Publication and dissemination of research results

With a stable group of PhD-students, and my own work, looking back at my publication record in the previous years, we should aim for around 15-20 scientific publications yearly, of which 3-4 should be in international journals. The majority of these publications should be in for a that is recognized to be rewarded, although some workshop publications should also be aimed at for newer PhD students. At the start of the work as a Professor, we would expect somewhat fewer publications, given that also PhD-students will have to be recruited or be in a starting phase of their studies.

Identified candidate conferences and journals for targeted publications are both within the areas of enterprise and workflow modeling, requirements engineering, mobile and multi-channel systems and model driven development in general, including more traditional information systems conferences and workshops.

The following concrete candidate-arenas for publication has so far been identified

- CAiSE
- ICEIS
- RE
- ICRE
- Various relevant IFIP conference and workshops
    - MOBIS
    - EMMSAD
    - Method Engineering

- RE Journal
- BPMJ
- JDM
- Information System
- IST
- IJMC
- IJMIS

Dissemination will also be done towards Norwegian industry and government, and material developed as part of the research will be included in relevant university courses.

Course material might also be spread through international networks such as the EIC (developed through ATHENA) and INTEROP as part of international master programs.

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