1 Introduction

A large number of business and work processes as for instance within the transport, construction and sales domains are inherently mobile and location based. The increasing availability of PDAs, mobile phones and wireless networks potentially enable such business and work processes to be supported by so-called business process and workflow management systems at any location. In modern business process management systems, business and work processes are described in a business process language thereby separating the business process logic from the applications supporting or carrying out the individual tasks in the process. This makes it possible to integrate existing applications and to adapt, analyze and reorganize the business process continuously.

New standards for business process languages are emerging, notably the Business Process Management Notation (BPMN) [53] and the Business Process Execution Language (BPEL) [17] pushed by major industrial players including Microsoft, IBM, Oracle and SAP. However, the proposed standards and software architectures do not explicitly support mobility and adaptiveness. The processes described in the languages as well as the applications performing the individual tasks are immobile and centrally controlled. While process management systems do allow for adaptation and changes of business process descriptions, the actual management process which creates new processes and controls the changes of existing processes can not itself be described as a business process. In technical terms, the current systems only allow first order business processes. A higher order language is needed to describe processes that manipulate processes.

A vehicle for supporting mobility and true adaptiveness as obtained from a higher-order process language is a formal specification of the business process language. BPMN and BPEL, however, are as yet only based on informal and ambiguous specifications.

The aim of the research project is to provide formalisations and implementations of business process languages supporting mobile and adaptive business processes which support the needs
of mobile workers and impact the future commercial business process management systems. To achieve this aim, the research will be informed by challenges provided by developers working on state-of the-art mobile business applications at the industrial partner, the Mobile Applications Group at Microsoft Development Center Copenhagen (MDCC), and studies of real cases of mobile workers, in particular the traveling salesmen business process given below. This example was identified at an envisioning workshop held jointly with MDCC.

The Traveling Salesmen Business Process: A number of mobile salesmen travel between different customers and sell goods. For each customer a salesman has a customer case. A customer case is an active (sub) business process which at any location provides support for sales, i.e. querying and updating the central stock, presenting the usual reductions of prices for a customer or providing statistics on sales for similar customers. Through a sales process management process, the salesman may revise and adapt customer cases, delegate a customer case to other salesmen or create new customer cases, perhaps using existing descriptions as templates.

The customer cases are examples of mobile processes embedded in the salesman's mobile device. The sales process management process exemplifies a higher order process which adapts, creates, and delegates customer cases. Presently this kind of functionality is only provided centrally in the process management system and can not be described within a business process.

The flexibility offered by mobility and adaptiveness makes the construction of correct business process descriptions more complex. We propose to address the complexity by adding type systems to the languages controlling aspects such as proper invocation of subprocesses, mobility of processes and their access rights.

Providing support for mobility and adaptiveness opens a large new market for business software that will strengthen the position of MDCC in Denmark. Providing formal semantics for business processes is recognized as a foothill project towards the UK Grand Challenge of Ubiquitous Computing [50] and as a milestone of the Process Modelling Group [43], an international network of researchers and practitioners instigated by professor Robin Milner (Cambridge), with the aim to enhance the quality of commercial business process software by putting existing theoretical work to use and to further the scientific understanding of business process modeling.

2 Methodology and research plan

The research is an interdisciplinary effort joining key expertises within theoretical computer science, computer supported collaborative work and developers in the newly formed Mobile Applications Group at Microsoft Development Center Copenhagen. The project combines the research of the principal investigator, associate professor Thomas Hildebrandt and his PhD student, Mikkel Bundgaard in formal models of concurrent and higher-order mobile embedded processes, the research of the co-investigators, associate professor Kjeld Schmidt on computer supported cooperative work (CSCW) and assistant professor Henning Niss on distributed systems and programming languages, and the work on formal models of mobile processes of external collaborator, Turing Award winner, professor Robin Milner.

More concretely, we base our language design on formal models and semantics of mobile concurrent processes, field studies of concrete mobile work processes, and on real cases provided by the Mobile Applications Group at MDCC. The language design will be interleaved with development of prototype implementations, to be used in the field studies and to ensure that the proposed languages are measured against the technological possibilities in design of distributed systems and meet the requirements of mobile work processes in practice. The formal
models ensure a sound basis for the complex language primitives for higher-order adaptiveness and mobility and will be used as a foundation for the prototypes and development of type systems. Impact on future process management systems and standards is obtained by feedback to the Mobile Applications Group as well as participation in reviews performed by the relevant standardization groups (e.g. OASIS) and by scientific as well as popular publications.

The project continues the current PhD project (funded by Danske Bank) on exploring ways to minimize the gap between a business process model and the actual IT implementation of that model, carried out by Steen Brahe and co-supervised by Schmidt [6]. The project includes and continues the current ITU funded PhD project of Bundgaard on models, reasoning techniques and types for higher-order mobile embedded resources [24, 9, 10, 18]. Further, the project applies the foundational research [8, 3] carried out within the Bigraphical Programming Languages (BPL) project [5] funded by the Danish Research Agency grant no. 2059-03-0031 with the aim to develop programming languages for ubiquitous context-dependent mobile systems and in which Hildebrandt, Niss and Bundgaard participate. Finally, the project continues recent work by Hildebrandt, Niss and two MSc students [26, 25, 54, 40] providing a framework based on the bigraph formalism in which to prototype formalised implementations of business process languages suitable for experimental studies in CSCW. Jointly, the work above shows a promising path to successfully reaching the goal of the research project.

The research project divides naturally into two PhD projects and a one year Post Doc project. The primary goal of the first PhD project, supervised by Hildebrandt, will be to undertake research in formal semantics of higher-order mobile business process execution languages and develop prototype execution engines based on the formalisations and continuing the work of [25, 40]. The primary goal of the second PhD project, supervised by Schmidt, will be to identify the adequate business process execution language constructions based on ethnographic field studies of mobile work processes combined with experimental prototyping. Both PhD projects will be co-supervised by Niss so as to guarantee strong coherence within the research project with a view to implement research-based prototypes of mobile business process execution languages. By employing Bundgaard as Post Doc for one year after he completes his PhD project in August 2007, the knowledge obtained within his PhD project is transferred to the CosmoBiz project and applied to research and development of type systems, and reasoning techniques for higher-order mobile process calculi applied to the domain of business process models.

3 State-of-the-art and relationship to previous and current work

The next generation of IT-supported business and work processes are envisioned to be described in high-level notations such as BPMN and translated to executable languages such as BPEL. So far, BPEL is based on an informal ambiguous specification. Pioneering work [1] has provided a formal foundation of general workflow processes in the Petri Net model [41] and a complete Petri Net semantics of BPEL has been provided [27]. Extensions of the Petri Net model supporting mobile and higher-order processes are only now emerging. In contrast, process calculi for mobile and higher-order processes are well understood [35] and have been advocated for formalizing mobile business processes [51, 52].

Bigraphical reactive systems developed by Milner [30, 36, 29, 38] is a recent promising general semantical framework for mobile embedded communicating processes. Milner and his PhD student Høgh-Jensen have shown that both Petri Nets and the pi-calculus can be expressed as bigraphical reactive systems [37, 31] and this work has recently been extended to higher-order mobile resources, context-dependent mobile systems and typed pi-calculus by Hildebrandt, Niss and Bundgaard (see below). In the last couple of years types have played an increasingly im-
portant role for calculi for concurrency and mobility [34, 13, 12, 18, 19], and for the pi-calculus in particular [42, 2, 28]. Types have, for instance, been applied for controlling and reasoning about capabilities and mobility of mobile processes [23] and for controlling access rights [7].

Research in the area of CSCW has been exploring and developing advanced information technologies that may support the coordination and integration of distributed activities in complex work settings. Significant progress has been made in understanding both how cooperating actors effortlessly align their activities by exploiting their knowledge of material settings and embodied actions to be aware of the changing state of affairs [20, 44], and how they devise and employ coordination constructs such as workflow specifications to handle complex interdependencies [45, 47]. At the same time, notable progress has been made with respect to the development of advanced technologies to support coordinative practices [49, 48, 15]. There is a visible gap, conceptually as well as technologically, between the technologies that regulate pre-defined workflows and technologies that facilitate embodied practices of improvised and adaptive coordination [46]. This deficit becomes acutely visible when mobility of actors and resources is taken into account. An overview of this line of research can be found in [32].

4 Project investigators

Thomas Hildebrandt achieved his PhD in 1999 from University of Aarhus on process models for concurrent interacting systems. He has authored more than 20 internationally peer-reviewed publications and organised and served on the program committee of several international workshops in the areas of models for concurrency, global ubiquitous computing, and in the combination of theory and systems building [14].

Hildebrandt is co-investigator on the Bigraphical Programming Languages (BPL) research project and the Calculi for Mobile Security project (Danish Research Agency grant no.: 2059-03-0031 and grant no.: 272-05-0258). He supervises PhD student Mikkel Bundgaard on process calculi for higher-order mobile embedded resources [24, 19, 10, 8, 11] and co-supervises PhD student Søren Debois on the BPL project [4, 3]. As part of the BPL project Hildebrandt, Niss et al have initiated research in bigraphical models for mobile context-dependent systems [3] and supervised two MSc thesis projects [54, 40] developing a prototype of a distributed XML-based implementation of the bigraphical reactive systems framework using a novel peer-to-peer XML persistence layer [22]. Two research papers demonstrate its use for respectively context-dependent mobile systems [26] and formalisation of the business process execution language BPEL [25].

Jointly with associate professor, Finn Kensing, ITU, he has recently received funding as supervisor of the PhD project From Clinical Guideline to Clinical IT within workflow management systems for the healthcare sector (Danish Research Agency, grant no.: 645-06-0025), equally co-funded by ITU and the industrial partner Resultmaker. The project is an interdisciplinary effort between Hildebrandt and Kensing joining theoretical computer science and CSCW having a high degree of synergy with the proposed research project.

Kjeld Schmidt has been involved in the research area of Computer-Supported Cooperative Work (CSCW) for the last 20 years. He has played a key role in defining the field and has been Editor-in-Chief of the journal Computer Supported Cooperative Work since 1992. His research generally addresses the theoretical underpinnings of CSCW and focuses on developing the conceptual and technological basis for computational notations that enable ordinary workers to express, appropriate, execute, modify, combine, and perhaps circumvent computational coordinative protocols such as workflows and classification schemes. Schmidt is currently supervisor of two PhD projects that bear on the proposed research: Jens Pedersen and Lars Rune Christensen, both funded by ITU and studying coordinative issues of mobility in cooperative
work. Schmidt co-supervises Steen Brahe, who is exploring ways to minimize the gap between a model of a business process and the actual IT implementation of that model. Schmidt and Hildebrandt have jointly organized and lectured courses on mobile applications.

Henning Niss obtained his PhD degree in 2002 from University of Copenhagen on novel techniques for region-based memory management and has a solid experience in development of type systems and research-based software, in particular to evaluate the applicability of research ideas; ranging from a commercial Year 2000 conversion tool [16], advanced memory management [21], over library glue code (mGtk) [33], to research prototypes e.g. for the XML Store project [22]. He co-supervises PhD student Ebbe Elsborg on formalizations of context-aware systems.

5 Impact on future research and research training

Providing a formal semantics for commercially used business process execution languages and mobile and adaptive business processes is a milestone for the international research efforts on process modelling and global ubiquitous computing [50, 43]. The proposed research project and the two PhD students contribute to a number of research projects associated with the FIRST PhD School within the areas of software technology for business systems and mobile context dependent systems, notably the NEXT project [39] jointly between ITU, DIKU and MDCC researching next generation ERP systems, the research consortium on User Supportive Embedded Configuration (USEC) jointly between ITU, DTU, SDU and 4 industrial partners, and the 3gERP project recently funded by the foundation for advanced technology, jointly between CBS, DIKU and MDCC. Finally, the project is tied to the current teaching and research efforts within Healthcare IT at ITU by a recently funded PhD project to be supervised by Hildebrandt and Kensing. Together the activities provide a critical mass of students for the FIRST PhD School to arrange research seminars, develop and teach courses in software technology for business systems and process aware information systems in particular.

References


