Seamlessly Distributed & Mobile Workflow or: The right processes at the right places*

Position Paper

Mikkel Bundgaard Thomas Hildebrandt
Espen Højsgaard

IT University of Copenhagen, Denmark
{mikkelbu, hilde, espen}@itu.dk

Abstract

We briefly outline some of the paths being explored within two recently initiated research projects on Computer Supported Mobile Adaptive Business Processes (CosmoBiz) and Trustworthy Pervasive Healthcare Services (TrustCare) to provide flexible process languages and models that allow seamless, trustworthy distribution and mobility of workflows and business process. In particular, we consider higher-order mobile embedded business processes, declarative versus imperative process specifications, and communication-centric architectures versus distributed shared storage.

1 Introduction

Concurrent and distributed processes are becoming increasingly present, taking many different forms: as machine code deployed on multi-core processors, as parallel algorithms executed on grid computing networks, as service orchestrations, or even as computer supported workflows and global business processes. A common challenge is that the level of concurrency and distribution is *not* statically fixed or a priori known. It typically depends on the availability of resources and capabilities of different processors, servers or localities.

Below we briefly outline some of the paths being explored within two recently initiated research projects on Computer Supported Mobile Adaptive Business Processes (CosmoBiz) and Trustworthy Pervasive Healthcare Services (TrustCare) respectively, in addressing the challenge to provide process languages and models that allow for seamless distribution and re-distribution of workflows and business process. In particular, we consider higher-order mobile embedded business processes, declarative versus imperative process specifications, and communication-centric architectures versus distributed shared storage.

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2 Higher-order Mobile Embedded BPEL

Services implemented and orchestrated by processes written in languages such as WS-BPEL are being put forward as a means to achieve loosely coupled and highly flexible computer supported business and work processes.

In the current architectures, the service topology is *flat*, i.e. no service is a priori administrated by other services. In many applications however, an instance of a service will be acting as a sub-instance of another service, which e.g. should be reflected in the situation when one of the services terminates abnormally. Another limitation of current architectures is that services are deployed and managed by *meta-level* tools, i.e. one cannot write a business process that automate deployment and management of processes.

In the paper [1] we propose and formalize a higher-order WS-BPEL-like language called *Higher-order mobile embedded BPEL* (HomeBPEL), where processes are values that can be stored in variables and dynamically instantiated as embedded sub-instances. A sub-instance is similar to a WS-BPEL scope, except that it can be dynamically frozen during a session and stored as a process in a variable. When frozen in a variable, the process instance can be sent to remote services as any other content of variables and dynamically re-instantiated as a local sub-instance continuing its execution. This conceptually relatively simple idea results in a very powerful higher-order business process language allowing to express a nested hierarchy of processes and business process management processes.

We exemplify the use of HomeBPEL by an example of pervasive healthcare, where instances of treatment workflows are moved between and executed locally on mobile devices belonging to either the doctor or the patient, depending on whether the treatment workflow requires actions by the doctor or it prescribes actions carried out as self-treatment by the patient.

The investigation is part of the Computer Supported Mobile Adaptive Business Processes (CosmoBiz) project [10], which aims to provide a fully formalized runtime engine for a business process language extended to allow for flexible mobile and disconnected operation of Enterprise Resource Planning (ERP) systems as developed by Microsoft Development Center Copenhagen [12].

A key concern is to limit the gap between the source language, its formalization, and the implementation. To this end we currently work within the model of bigraphical reactive systems on proving operational correspondence between the concrete bigraphical semantics of WS-BPEL (which is close to the concrete WS-BPEL syntax) and a more abstract semantics given by a second bigraphical reactive system closer to process calculi. Another key concern is to use the formalizations as basis for the development of type systems that can be used to statically guarantee safe and reliable behavior. To this end we plan to examine the approaches done for Boxed Ambients [6] and for the higher-order π-calculus [13] on the safe integration of higher-order mobility and sessions.

Another interesting path for future research will be to examine different primitives for management and manipulation of processes, such as sub-process reflection and general manipulation, e.g. editing or joining of frozen sub-processes. This relates to the work on Higher-Order (Petri) Nets and applications to workflow studied in [11].

3 Trustworthy Pervasive Healthcare Services

The Trustworthy Pervasive Healthcare Services (TrustCare) project [8] is a strategic interdisciplinary research collaboration between IT University of Copenhagen, Department of Computer Science, Copenhagen University and Resultmaker[1], a Copenhagen based software company developing workflow management systems for e.g. the public sector. The project combines experiences in developing workflow management systems with research in programming languages technology, concurrency theory, logical frameworks, pervasive computing and human computer interaction. The aim of the project is to contribute to the foundations of IT-systems able to support trustworthy pervasive workflows and services within the healthcare sector. This is an extremely challenging application domain, since by nature, healthcare services involve coordination of a heterogeneous set of professionals and patients, across different locations, organizations, and sectors. Moreover, healthcare services are highly safety critical; deal with sensitive medical data; and must be able to support dynamic changes to adapt to inevitable evolution of treatment processes and unforeseen events.

One path being explored in the project is the use of *declarative* process descriptions and *shared storage* architectures as opposed to *imperative* process descriptions and *message passing/communication-centric* architectures such as WS-BPEL. The current process model employed in the Resultmaker Online Consultant workflow management system is indeed based on a patented declarative process model based on the specification of dynamically evaluated conditions for inclusion of activities in workflows (e.g. different kinds of predecessor constraints between activities) and a shared storage architecture.

This is in line with a recent proposal by Van der Aalst and Pesic in [15] to use LTL as the foundation for flexible declarative process languages. Van der Aalst and Pesic argue that the use of imperative process languages often leads to *over-specification*, which imposes too many constraints on the flows and consequently amplifies the need for changes to the specified process. Based on this, the authors propose a paradigm shift replacing the imperative process languages with *declarative* process languages, in which one specifies only the required constraints between work activities rather than a receipt for how the constraints are resolved. (This is in fact a rebirth of 20 year old proposal by Gabbay described in [5].)

So far, we have described in [14] how to formalize the key primitives of the Online Consultant process model as Linear time Temporal Logic (LTL) formulas. A workflow process is then described as the conjunction of temporal constraints, e.g. specifying that an activity A must happen before another activity B or that some activity B must be re-executed every time the activity A has been executed. A concrete example of the latter is when B is the activity of signing a contract and activity A is the activity of changing the content of the contract.

Van der Aalst and Pesic [15] and our work in [14] focus on the *temporal* constraints. However, we would like to stress that this approach could equally well be applied to the *spatial* aspects, that is, the specification of distribution and uses of resources. Part of our future work will thus be to investigate the use of declarative models, e.g. adding spatial [4] and so-called independence (or

[1] See ⟨http://www.resultmaker.com⟩

true concurrency) modalities [7] to the specification logics, to describe flexible distributed workflow processes that may be seamlessly dynamically distributed, changed or re-distributed.

Related to this we are investigating the development and use of (timed) concurrent constraint programming for workflow and business process management, which to our surprise is as yet almost unexplored.

As a possible architecture for a distributed declarative process engine we will investigate distributed shared storages. A key point here is that the interaction happens through a (possibly transparently) distributed storage and not as explicit communications between localities. However, at some level one has to consider the communication between different localities. This raises the natural question of how to map from a global description to a distributed end-point description, in particular to specify and implement reliable and secure interfaces between end-points. In addressing the former question we plan to investigate the research on communication-centric computation and translations between global descriptions to local end-point descriptions in [2, 3] and in general the use of behavioral types.

A related question is how to support reliable and trustworthy interfaces between services and *human* actors/end-points. We plan to address this question by investigating extensions of pervasive user interfaces based on the paradigm of activity-based computing, e.g. to include dynamically generated user interface components based on behavioral types and end-point projections.

An interesting challenge to the existing methods is to be able to deal with dynamic changes in behavioral interfaces, i.e. by dynamic end-point projections, which may be needed to cope with the fact that workflow processes may need to be dynamically changed. We intend to investigate the use of proof carrying code techniques and (concurrent) logical frameworks as a foundation for trustworthy dynamic changes of interfaces.

4 Conclusions

To summarize, the two projects CosmoBiz and TrustCare outlined above both address the challenge to provide flexible process languages and models that allow seamless, trustworthy distribution and mobility of workflows and business process. But so far from two different sides. The former project so far considers *imperative* process languages extended with primitives for higher order mobile embedded processes and formalized as bigraphical reactive systems. This has resulted in a proposal and formalization of HomeBPEL, forming the foundation for further studies of type systems for higher order processes. On the other hand, the latter project focus on *declarative* process languages formalized in temporal logics and implemented using logical frameworks. While declarative process languages has been proposed as a means to achieve more flexible process descriptions with respect to the *logical* ordering of actions, we point out that it may well also be used to achieve more flexible process descriptions with respect to the *spatial* distribution and truly concurrent execution of actions. The two projects will of course not run in isolation — in particular, we intend to study the use of (declarative) higher order primitives in the latter and the use of declarative languages and distributed shared storage in the former. (Research on the use of bigraphical reactive systems as the foundation for an XML-centric distributed shared storage coordination middleware has in fact already been initiated in [9].)

Finally, we expect to contribute to the study of projections from global descriptions to local end-points and interfaces, in particular in researching how to support changes to processes, dynamic generation and verification of interfaces, and the generation of human user interfaces.

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