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EDITORIAL

Challenges and solutions in enterprise computing

Introduction

The emergence of the networked enterprise has a profound effect on enterprise computing. The trend towards networked enterprise solutions entails autonomous enterprises joining networks of business-driven alliances, called virtual enterprises, with the objective of achieving added value and more business opportunities. This development was enabled and accelerated by advances in networking and computing technologies. It has significant implications for enterprises, vendors, and the market in general. At the same time, it led to new demands with respect to technology and infrastructure support, as a consequence of the increasingly cross-organisational, cross-jurisdictional and cross-domain nature of business collaborations. Enterprise computing continues to evolve, driven by the interacting forces of business and technology developments. This editorial discusses five important and mutually related challenges in enterprise computing, and positions the articles of this special issue as specific solutions and approaches with respect to these challenges.

Interoperability

The networked enterprise trend implies the availability of interoperable solutions, which support seamless collaborations among enterprises. However, enterprise systems in many cases are not designed to interoperate with other systems. Legacy enterprise applications often hinder cooperative endeavours. Most of the problems emerge from proprietary development or extensions, unavailability or oversupply of standards, and heterogeneous hardware and software platforms. The need for interoperability is even more pressing in the case of new business models such as extended enterprise and on-demand business that require enterprises to align business processes and optimise interoperability to achieve further benefits.

Despite the efforts already spent to overcome interoperability problems, it is still a major concern and solving these problems represents a considerable portion (over 30%) of IT costs of enterprises (Grilo *et al*. 2007). In order to improve upon this situation, enterprise interoperability problems should be addressed coherently at business and technical levels as a whole (Kutvonen 2007). The need for further work in this direction has also been recognised by the International Federation of Information Processing (IFIP) Technical Committee for Information Technology Applications (TC5) and recently led to the establishment of a separate working group (WG5.8).

Flexibility and adaptability

Enterprises have to flexibly and continuously react to (imminent) changes in markets and trading partners. Such changes in the inter- and intra-organisational environment will persist and may even occur at higher frequencies in the future. In addition, enterprises may

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want to be very dynamic and opportunistic in setting up collaborations with partners, pursuing specific business goals with temporary partnerships. This requires great flexibility, with proper technology support.

The technology level itself is also subject to constant change. Many recent advances in IT technologies, such as wireless communication, mobile computing and context-awareness, have opened up possibilities for business innovation and new patterns of use. Enterprises should be able to flexibly and timely adapt to and exploit technological changes without the need for substantial redesign and re-engineering.

Enterprise systems should therefore be designed for change, and be able to agilely respond to emerging business opportunities (Izza *et al.* 2008). Technology level solutions should support this and realise better re-use and maintainability. Enterprise computing is facing various challenges to push limits further, since guiding principles, converging architectures and standard solutions are still largely lacking. An interesting (so far mainly technology-driven) development is that of context-awareness, where a (software application) system uses sensor data to determine relevant aspects of its user context, and then adapts and personalises the service provided to each user such that it better suits the situation at hand (van Sinderen *et al.* 2006a).

Design frameworks, architectures and standards

The benefits of enterprise architectures are widely accepted, and reference architectures are available that identify the scope of architectural concerns and how these concerns can be decomposed and separated (Shah and El Kourdi 2007). Nonetheless, challenges remain in this area, especially since new requirements with respect to interoperability and flexibility have to be addressed, which leads to increased complexity of enterprise systems.

The lack of enterprise interoperability is a problem that has to be addressed both from business and technological points of view. Interoperability implies support of information and communication technologies between different enterprises that must be based on shared business. To achieve interoperability between enterprises, the integrated vision of a reference architecture is needed, and associated standards must be agreed upon and take into account the cooperation needs of the organisations.

Without standards there is no open interoperability (Chen and Vernadat 2002), and without open interoperability the claimed benefits of networked enterprises cannot be achieved. Standards not only deal with interoperability issues, but also with prerequisite and support knowledge such as concepts, methodologies, languages, and reference architectures. Indeed, a reference architecture may be used to coordinate standardisation efforts and deliver a set of consistent and composable standards.

Two complementary paradigms increasingly influence architectures and standards in enterprise computing, as well as technology, and are often proposed as a basis for integrated design frameworks. These paradigms are service-oriented computing (SOA) and model driven architecture (MDA). SOA utilises the service abstraction to decouple business functions from technology, and to allow flexible composition of functions spanning organisations and technology platforms. The SOA principles are (partially) realised by Web services standards and technologies, which in turn are based on XML.

MDA is based on the idea that models are not temporary aids in the development of a system, but are valuable assets because of the role they can play in system development and maintenance, migration to new technology platforms, and addressing new business requirements. Various modelling viewpoints to bridge between computational-independent business concerns and technology-dependent software solutions have been

proposed and meta-modelling is used to facilitate consistency of models and to support model transformation including code generation. MDA is supported by standards such as UML, MOF and QVT, and by a growing set of increasingly powerful tools.

It should be clear that SOA and MDA represent ongoing paradigm shifts. They should not be considered as alternatives, but rather as approaches that complement each other. Combined, they appear to present a suitable framework (Jardim-Goncalves *et al*. 2006, van Sinderen *et al*. 2006b) for addressing many of the challenges mentioned here.

Security and trust

As long as information is stored and used within one autonomous enterprise, security policies and mechanisms can be optimised for internal use by this enterprise, and access by people from outside the organisation can be blocked. Of course, since security budgets are finite, policy specification and implementation always involve a risk analysis to determine against which threats an enterprise has to protect itself.

Networked enterprises, on the other hand, are based on collaboration, and therefore require information exchange between participating enterprises. Security policies and mechanisms must now selectively make information available to other organisations, rather than shield all information from other organisations. At the same time, enterprises must trust that other enterprises have effective internal security policies and mechanisms in place. This places risk and trust management in the centre of information security management (Esper *et al*. 2008).

Risks may be managed by performing an analysis of the business threats and considering different (configurations of) security measures to deal with these threats. In this way, well-informed decisions can be made regarding the deployment, configuration and operation of information services for cooperation between different enterprises.

Quality assurance and differentiation

Inter-enterprise collaborations are governed by electronic contracts which are negotiated and agreed upon between the participating enterprises during a preparation phase preceding the actual collaboration. Besides functional aspects, such contracts also cover non-functional, or quality, aspects, which are captured in a service level agreement (SLA). While the importance of service quality for competition in the new networked enterprise economy is undisputed (Adels *et al*. 1997), it is less clear how a common interpretation of relevant quality properties among enterprises can be established. In addition, the translation from a SLA specification to effective and efficient quality monitoring and assurance mechanisms is very hard. More often than not, such mechanisms are only considered after the functional design has been completed, resulting in integration problems (Jonkers *et al*. 2005).

The trend towards short-term, short-notice business collaborations leads to interesting new challenges with respect to quality assurance and differentiation, as is clearly demonstrated with SOA-based approaches (Liu *et al*. 2005). Dynamic selection and composition of services may require that candidate services are evaluated based on their quality properties. Moreover, the combined performance of composed services should satisfy the specified quality requirements of the end-user. During service execution, constant monitoring is needed to detect quality degradations and take appropriate countermeasures. Therefore, a comprehensive quality model and a consistent management

and monitoring infrastructure are essential to realise quality-based competition in SOA solutions for networked enterprises.

Contents of this special issue

This special issue contains seven articles, which are revisions of selected papers presented at the 11th IEEE EDOC Conference – The Enterprise Computing Conference (EDOC 2007), which was held in October 2007 in Annapolis, Maryland, USA.

The EDOC conference series started in 1997 with a strong focus on enterprise distributed object computing (EDOC). However, with following events the scope broadened to encompass more than just distributed objects, and since 2005 EDOC added 'The Enterprise Computing Conference' to its name to reflect its new scope and focus (Hung and van Sinderen 2005, Hung *et al.* 2006). EDOC recognises that enterprise computing is based on a wide (and ever-growing) range of methods, models, tools and technologies, and that the resulting applications cover a broad spectrum of vertical domains and industry segments. EDOC therefore emphasises the integration and management of enterprise computing research and development results, fostering approaches that can address and relate business, application, middleware and technical levels. The themes of openness and distributed computing, based on objects, components and services, are considered to provide a useful and unifying conceptual thread for this purpose.

The seven articles in this special issue are representative of the topics covered by EDOC. Moreover, they represent specific solutions and approaches that address the challenges presented above.

The interoperability challenge is clearly addressed in the article 'Modelling and analysing interoperability in service compositions using COSMO' by D. Quartel and M.J. van Sinderen. The authors identify different models that play a role in the service composition process. Subsequently, they discuss how these models are used to assess whether two or more services can meaningfully interoperate, and whether interoperability is correctly refined in the design process.

Two articles touch the flexibility challenge. A.T. Tao and J. Yang propose in their article 'Towards policy driven context aware differentiated services design and development' a design method that allows different service interfaces to be generated for the same abstract business process, based on the existence of different usage contexts. This type of service differentiation is claimed to be more suitable for today's dynamic e-business environments with diverging requirements of different users. Another perspective is taken by T. Graml *et al.* in their article 'Patterns of business rules to enable agile business processes'. They propose an approach which considers business rules during business process modelling, in order to make business processes agile and adaptive during run-time.

J. Mendling *et al.* consider a design framework in their article 'Getting rid of OR-joins and multiple start events in business process models'. More specifically, they address two translation challenges that are often encountered when mapping a conceptual process model onto an executable model.

A particular security issue is addressed in F. Kerschbaum's article 'Building a privacy-preserving benchmarking enterprise system'. He describes the challenges faced when building a privacy-preserving benchmarking enterprise system, and proposes an algorithm to determine sensible groupings of companies in benchmarking processes.

The two remaining articles consider the quality challenge. T. Wang *et al.* address the problem of transaction support for contract-driven service-oriented processes in their

article 'Towards a contractual approach for transaction management'. They propose an approach to include transactional quality properties in service contracts, thus guaranteeing reliability of service execution both technically and legally. Finally, the article 'Top-down business process development and execution using quality of service aspects' by F. Rosenberg *et al*. considers service level agreements (SLAs) among partners in cross-organisational cooperation. They outline a top-down modelling approach for Web-services-based business processes, including automated derivation of policies from SLAs which can be enforced during execution.

In conclusion, this special issue provides a broad perspective on enterprise computing by touching on a number of areas in which serious challenges remain. These challenges were highlighted in the context of the developments regarding networked enterprises. We would like to thank all the authors who submitted articles, and the reviewers for their conscientious and helpful comments. We hope that readers will find the articles of this special issue interesting, informative, and useful.

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