IFIP AICT 326

Peter Bernus
Guy Doumeingts
Mark Fox
(Eds.)

Enterprise Architecture, Integration and Interoperability

IFIP TC 5 International Conference, EAI2N 2010
Held as Part of WCC 2010
Brisbane, Australia, September 2010
Proceedings

Springer

World Computer Congress
Brisbane 2010
International Federation for Information Processing

IFIP Advances in Information and Communication Technology 326

IFIP – The International Federation for Information Processing

IFIP was founded in 1960 under the auspices of UNESCO, following the First World Computer Congress held in Paris the previous year. An umbrella organization for societies working in information processing, IFIP's aim is two-fold: to support information processing within its member countries and to encourage technology transfer to developing nations. As its mission statement clearly states,

> *IFIP's mission is to be the leading, truly international, apolitical organization which encourages and assists in the development, exploitation and application of information technology for the benefit of all people.*

IFIP is a non-profitmaking organization, run almost solely by 2500 volunteers. It operates through a number of technical committees, which organize events and publications. IFIP's events range from an international congress to local seminars, but the most important are:

- The IFIP World Computer Congress, held every second year;
- Open conferences;
- Working conferences.

The flagship event is the IFIP World Computer Congress, at which both invited and contributed papers are presented. Contributed papers are rigorously refereed and the rejection rate is high.

As with the Congress, participation in the open conferences is open to all and papers may be invited or submitted. Again, submitted papers are stringently refereed.

The working conferences are structured differently. They are usually run by a working group and attendance is small and by invitation only. Their purpose is to create an atmosphere conducive to innovation and development. Refereeing is less rigorous and papers are subjected to extensive group discussion.

Publications arising from IFIP events vary. The papers presented at the IFIP World Computer Congress and at open conferences are published as conference proceedings, while the results of the working conferences are often published as collections of selected and edited papers.

Any national society whose primary activity is in information may apply to become a full member of IFIP, although full membership is restricted to one society per country. Full members are entitled to vote at the annual General Assembly, National societies preferring a less committed involvement may apply for associate or corresponding membership. Associate members enjoy the same benefits as full members, but without voting rights. Corresponding members are not represented in IFIP bodies. Affiliated membership is open to non-national societies, and individual and honorary membership schemes are also offered.

Peter Bernus Guy Doumeingts Mark Fox (Eds.)

Enterprise Architecture, Integration and Interoperability

IFIP TC 5 International Conference, EAI2N 2010
Held as Part of WCC 2010
Brisbane, Australia, September 20-23, 2010
Proceedings

Springer

Volume Editors

Peter Bernus
Griffith University
Nathan, QLD 4111, Australia
E-mail: p.bernus@griffith.edu.au

Guy Doumeingts
University of Bordeaux 1, LAPS
33405 Talence, France
and INTEROP-VLab, Belgium
E-mail: gdoumeingts@gfi.fr

Mark Fox
Novator Systems Ltd.
Toronto, ON M5V 3P8, Canada
E-mail: mfox@novator.com

Library of Congress Control Number: 2010933124

CR Subject Classification (1998): C.2, H.3, H.4, H.2.8, H.2, D.2

ISSN 1868-4238
ISBN-10 3-642-15508-1 Springer Berlin Heidelberg New York
ISBN-13 978-3-642-15508-6 Springer Berlin Heidelberg New York

springer.com

Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India
Printed on acid-free paper 06/3180

IFIP World Computer Congress 2010 (WCC 2010)

Message from the Chairs

Every two years, the International Federation for Information Processing (IFIP) hosts a major event which showcases the scientific endeavors of its over one hundred technical committees and working groups. On the occasion of IFIP's 50th anniversary, 2010 saw the 21st IFIP World Computer Congress (WCC 2010) take place in Australia for the third time, at the Brisbane Convention and Exhibition Centre, Brisbane, Queensland, September 20–23, 2010.

The congress was hosted by the Australian Computer Society, ACS. It was run as a federation of co-located conferences offered by the different IFIP technical committees, working groups and special interest groups, under the coordination of the International Program Committee.

The event was larger than ever before, consisting of 17 parallel conferences, focusing on topics ranging from artificial intelligence to entertainment computing, human choice and computers, security, networks of the future and theoretical computer science. The conference History of Computing was a valuable contribution to IFIPs 50th anniversary, as it specifically addressed IT developments during those years. The conference e-Health was organized jointly with the International Medical Informatics Association (IMIA), which evolved from IFIP Technical Committee TC-4 "Medical Informatics".

Some of these were established conferences that run at regular intervals, e.g., annually, and some represented new, groundbreaking areas of computing. Each conference had a call for papers, an International Program Committee of experts and a thorough peer reviewing process of full papers. The congress received 642 papers for the 17 conferences, and selected 319 from those, representing an acceptance rate of 49.69% (averaged over all conferences). To support interoperation between events, conferences were grouped into 8 areas: Deliver IT, Govern IT, Learn IT, Play IT, Sustain IT, Treat IT, Trust IT, and Value IT.

This volume is one of 13 volumes associated with the 17 scientific conferences. Each volume covers a specific topic and separately or together they form a valuable record of the state of computing research in the world in 2010. Each volume was prepared for publication in the Springer IFIP Advances in Information and Communication Technology series by the conference's volume editors. The overall Publications Chair for all volumes published for this congress is Mike Hinchey.

For full details of the World Computer Congress, please refer to the webpage at http://www.ifip.org.

June 2010

Augusto Casaca, Portugal, Chair, International Program Committee
Phillip Nyssen, Australia, Co-chair, International Program Committee
Nick Tate, Australia, Chair, Organizing Committee
Mike Hinchey, Ireland, Publications Chair
Klaus Brunnstein, Germany, General Congress Chair

Preface

Enterprise Architecture, Integration, and Interoperability and the Networked enterprise have become the theme of many conferences in the past few years. These conferences were organised by IFIP TC5 with the support of its two working groups: WG 5.12 (Architectures for Enterprise Integration) and WG 5.8 (Enterprise Interoperability), both concerned with aspects of the topic: how is it possible to architect and implement businesses that are flexible and able to change, to interact, and use one another's services in a dynamic manner for the purpose of (joint) value creation. The original question of enterprise integration in the 1980s was: how can we achieve and integrate information and material flow in the enterprise? Various methods and reference models were developed or proposed – ranging from tightly integrated monolithic system architectures, through cell-based manufacturing to on-demand interconnection of businesses to form virtual enterprises in response to market opportunities.

Two camps have emerged in the endeavour to achieve the same goal, namely, to achieve interoperability between businesses (whereupon interoperability is the ability to exchange information in order to use one another's services or to jointly implement a service).

One school of researchers addresses the technical aspects of creating dynamic (and static) interconnections between disparate businesses (or parts thereof). Techniques and underlying theories include the use of information and process modelling, artificial intelligence methods, such as semantic modelling (ontological theories, Semantic Web technologies), intelligent agents for implementing service brokering, Web service technologies to create (supposedly) simple ways of exposing and using services, but also low-level implementation standards (such as XML as a standard syntax for data exchange), etc.

While the above techniques have been maturing, it has also been realised that the solution to the dynamic creation of businesses needs more than just technical elements, and this realisation created another school of thought. Technology provides the opportunity for businesses to work together and to produce value in ways not previously possible, but another necessary condition of success is the creation of economic environments that foster the development of the readiness in enterprises to cooperate and collaborate. These non-technical requirements range from the necessity to develop legislations, industry policies and standards, the creation of an organisational backdrop, such as inclusive industry groups that can help companies to engage with the opportunities brought about by technology. Furthermore, it is not obvious how the interest of the economy as a whole and the interest of powerful companies can be reconciled in this respect. The requirement to create an economic environment that fosters cooperative and collaborative enterprising is most acute in the realm of small and medium-sized enterprises.

Another view of the split in viewpoints and approaches is as follows:

1. Systems that are highly integrated where one can take a holistic approach to system design, e.g., manufacturing and supply chain, where EA methods can be more readily applied, and systems where the holistic approach cannot be applied, e.g., where the motivation to be tightly integrated does not exist.

2. Systems where sharing of data is very important, hence the adoption of interoperability standards is necessitated in order to survive—probably true of many aspects of engineering: CAD, CAE, etc., versus other domains where standards, e.g., ontologies, have not adopted and there is no catalyst to do so, e.g., eCommerce.

While these two major thrusts of interoperability research developed, Enterprise Architecture (EA), which can be considered an applied systems engineering field where the enterprise (or a network of enterprises) is the 'system,' developed methods to address the complexity of enterprise engineering. These methods, however, are usually only used by large companies and government agencies, and in addition have only been utilised extensively in two areas: the creation of manufacturing enterprises (but much less frequently for the dynamic creation of virtual manufacturing enterprises), and for the creation (or change) of the IT architecture that supports conventional enterprises (in private business and in government).

Possibly, treating enterprises as being at one end or the other of a spectrum between self-designing and self-evolving systems (from deliberate to spontaneous) is a way to reconcile (and combine) the methods developed by various segments of this research community.

Furthermore, while the practice of EA has become commonplace in the portfolio of IT management, and in some industrial cultures in the portfolio of manufacturing management, EA practice has not spread much to other portfolios, nor has it been extended to higher levels of management, such as to the CEO or the Board.

Today, there is a growing feeling among EA researchers and practitioners that EA methods would be able to close the still existing gap between strategy making and the implementation of the strategy, and that the next generation of EA methods and tools should ensure that they are well understood by top-level management as well as are demonstrably able to respond to their concerns. The problem is similar to the one faced by interoperability researchers: there are technical as well as cultural barriers to overcome.

In conclusion of this debate we underline the philosophy of the Network of Excellence, INTEROP-NoE (Interoperability Research for Networked Enterprise Applications and Software, a Network of Excellence supported by European Commission 2004-2007, FP6 508011, 42 months, 50 partners, 6,5 M€ EC funds), INTEROP NoE try to reconciliate the two previous schools by defining interoperability as the ability of an Enterprise to interact with other Enterprises not only from an information technology point of view but also from an organisational and semantic point of view. This interaction must be flexible and developed at an acceptably low cost. Interoperability is considered as significant if the interactions can take place at least on four different levels: Data, Services, Processes and Systems, with a semantics defined in a given business context.

Papers in this volume address several of the problems listed above and have been organised into two parts: papers in Part 1 are about the future of enterprise architecture and papers in Part 2 address questions of interoperability.

Papers were double blind refereed by members of the International Program Committee and we are grateful for all who helped in this process.

July 2010

Peter Bernus
Guy Doumeingts
Mark Fox

Organization

Program Committee Chairs

Asia-Pacific

Peter Bernus	Griffith University, Australia

Europe

Guy Doumeingts	INTEROP Vlab, B, and University of Bordeaux, France

Americas

Mark Fox	University of Toronto, Canada

International Steering Committee

Peter Bernus	Griffith University, Australia
Guy Doumeingts	INTEROP-VLab, B and University of Bordeaux, France
Yves Ducq	University of Bordeaux France
Nenad Filipovic	IEDC, SI
Mark Fox	Novator and University of Toronto, Canada
Ted Goranson	Earl Research, USA
John Gotze	CPH Bus School, Demark
Michael Gruninger	University Toronto, Canada
Roland Jochem	IIS, University of Kassel, Germany
Pontus Johnson	KTH, S
Brane Kalpic	ATK and IEDC, SI
Stephan Kassel	University of Zwickau, Germany
Bernhard Katzy Cetim	University Munich, Germany
Kurt Kosanke	CIMOSA, Germany
Gyorgy Kovacs Sztaki	Hungary
Lea Kutvonen	University of Helsinki, Finland
Richard Martin	Tinwistle, USA
Kai Mertins	IPK, Germany
Arturo Molina	TEC Monterrey, Mexico
Laszlo Nemes	Nemes Cons, Australia
Ovidiu Noran	Griffith University, Australia
Hervé Panetto	University of Nancy, France
David Romero	Tec Monterrey, Mexico

Pallab Saha	NUS, Singapore
Gunter Schmidt	University Saarland, Germany
Pat Turner	ASPL, Australia
Marten van Sinderen	University of Twente, The Netherlands
Francois Vernadat	ECA, EU (LX)
Jakob Vlietsrta	USA
Georg Weichhart	University of Linz, Austria
Robert Weisman	Buildthevision, Canada
Richard Weston	Loughborough University, UK
Xu Xiaofei	HIT, PRC
Djamal Zeghlache	Telecom SudParis, France
Martin Zelm	CIMOSA, Germany

Local Organizing Committee

Peter Bernus	Griffith University, Australia
Patrick Turner	ASPL, Australia (Chair)
Ovidiu Noran	Griffith University, Australia
Mark Hudson	CITEC, Australia
Jane Baldock	QLD Health, Australia

Program Committee Members

(Members of IFIP WG5.12 and 5.8)

P. Assogna, Italy
A. D'Atri, Italy
M. Avram, Romania
S. Banerjee, UK
S. Bansal, SG
L. Basanez, Spain
P. Bernus, Australia
J. Brosvic, USA
J. Browne, Ireland
C.J. Bussler, USA
R. Chalmeta, Spain
V. Chapurlat, France
Y. Chen, China
D. Chen, France
I. Cruz, USA
P. Davidsson, Sweden
P. De Sabbata, Italy
Z. Deng, Norway
T. Dimitrakos, UK
A. Dolgui, France
G. Doumeingts, France
N. Dowler, UK
Y. Ducq, France
J. Edwards, UK
F.G. Fadel, Canada
I. Fan, UK
F. Farinha, Portugal
J. Favrel, France
L. Fernandez, Spain
C. Fichtenbauer, Austria
F. Filip, Romania
T. Fischer, Germany
M. Fox, Canada
Y. Fukuda, Japan
M. Garetti, Italy
P. Ghodous, France
R. Goncalves , Portugal
T. Goranson, USA
M. Gruninger, USA
B. Guthridge, USA

Table of Contents

Architecting the Firm – Coherency and Consistency in Managing the Enterprise*

Patrick Turner, John Gøtze, and Peter Bernus

ASPL, Brisbane & CEARM, Griffith University, AU
Patrick.Turner@aspl.net.au, P.Turner@griffith.edu.au
Copenhagen Business School & IT-Univ Copenhagen, DK
john@gotzespace.dk
CEARM, Griffth University, AU
P.Bernus@griffith.edu.au

Abstract. Traditional Enterprise Architecture (EA) practice lacks a clear and effective governance and management layer that is easily understandable and intuitive to senior decision makers with the modern organisation. This paper uses three case studies to demonstrate the relative maturity of different EA practice groups within these organisations to demonstrate the strengths and weaknesses of a traditional ICT management approach versus those that include EA practice in all levels and domains of management. Concepts of Coherency Management and Pervasiveness will be used to explain the idea of a next Generation of EA practice that permeates all layers of the organisation and no longer remains the domain of technologists but instead influences and informs decision-making at all levels (operational, tactical, managerial / strategic) of the organisation. Conditions of such future EA practices are also discussed.

Keywords: Next Generation Enterprise Architecture, Coherency Management, Enterprise Architecture Maturity, Interoperability.

1 Introduction

Enterprise Architecture (EA) as a discipline was originally developed to support the full gamut of management in organisations [1, p23] [6]. However, historically, the architecture function has only been implemented to various extents within organisations, predominantly in technology support roles or as an ICT management framework. This paper presents three case studies (with the identities of the involved organisations removed) to demonstrate different levels of maturity at which enterprise architecture and enterprise architects function in the modern organisation.

Whilst the case studies are not exhaustive, all three authors have repeatedly experienced similar patterns in other Organisations and, as such, argue that the cases can be considered archetypes of the way in which EA practice evolves The paper argues that

* A previous version of this paper appeared in R. Meersman, P. Herrero, and T. Dillon (Eds.): OTM 2009 Workshops, LNCS 5872, pp. 162–171.

P. Bernus, G. Doumeingts, and M. Fox (Eds.): EAI2N 2010, IFIP AICT 326, pp. 1–10, 2010.

this evolution eventually leads to a new approach where the Architecture function is directly responsible to the senior management team and accountable for the quality, consistency and timeliness of the information flow to that group. The direction of the evolution of EA practice (and of its components) points to a future where this practice becomes pervasive across the organisation, is supported by adequate decision support tools, and is the platform underlying the coherency of management decisions [5].

2 Case Study Organisation #1 (Local Government Department) Architecture as a Liability (Cost)

Organisation #1 is a classic Government Department. All Information and Communication Technology (ICT) related matters reside with the Manager of the Information Services Branch (ISB). The ISB Manager represented his employees and IT for that matter at the weekly and monthly management team meetings and dealt with all related issues personally. As serious issues emerged (system upgrades, failure of services, production outages, requests for new functionality, security policy reviews etc) he assigned tasks to his senior engineers as necessary. These senior engineers may or may not have been called architects and were often called system support officers, analysts or engineers. They maintained informal networks across the Organisation, based on their reputation and the quality of their work on previous tasks. They had no formal linkages or relationships with operational staff and certainly had no visibility or relationship with other Branch Managers or Department Heads apart from that of an employee delivering a service.

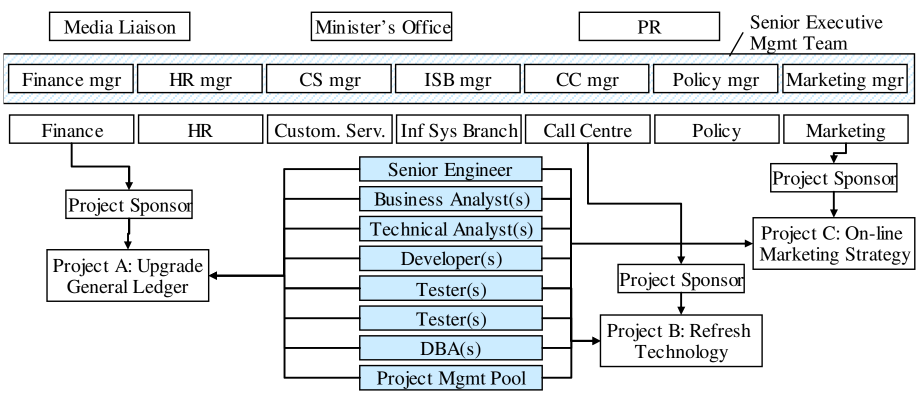

Fig. 1. Architecture as a Cost Centre

The lesson from this case is that the stage of EA practice in such an organisation is characterised by a ‘struggle for existence’. Engineers or Managers trying to establish Architecture practice within an Organisation at this level of EA maturity can find themselves under attack or viewed with deep suspicion or accused of ‘empire building’ by their colleagues. The level of engagement by non-technical personnel will often be effectively nil and individuals not used to communicating in a non technical way may find the going too tough and give up. This will often reflect their relatively low standing within the Organisation and lack of real political and cultural power which impacts upon their ability to drive home real and lasting change. Successful individuals working at this level of maturity within the Organisation will often have to adopt a 'crash or crash through' approach to the use of EA and success will largely be localised in the first instance and more a factor of the strength of their personal convictions rather than any commitment to EA at an Organisational level.

Given the above, it can be said that EA within this environment often emerges in the form of a champion or a senior engineer frustrated with the ad-hoc nature of things or someone who has external reading, study or work experience which demonstrates to them that there is a better way of organising and managing an ICT environment. Often this individual goes to extraordinary lengths, with some personal and professional risk involved, to get the ISB Manager to make the first faltering steps towards the development of an EA framework. The EA framework itself will always be seen here as an IT controlled asset, run by 'techies' for 'techies' with limited use and value by other personnel in the organisation apart from operational and program level reporting, specifically for technology driven initiatives or programs of work.

Within this model there is no thought to exposing others outside of the IT Branch to the potential value or utility of an EA framework. Line Managers 'procure' technical resources via discussions with the ISB Manager and expect that they come equipped with their own approach and frameworks that will deliver the required outcomes.

3 Study Organisation #2 (Large Mining Company) – Architecture as an Asset

Within this model, the Organisation from the beginning has recognised the existence of Architecture and the potential role it can play in managing and coordinating the delivery of technology aligned programs of work. In this case the CIO has created specific Architect roles (Chief Architect, Solution, Information, Infrastructure architect, etc) with the express purpose of achieving productivity improvements in the management and coordination of large enterprise ICT assets (ERP, billing, invoices, customer and vendor management, payroll, management and operational reporting, manufacturing, logistics, supply chain). In this type of Organisation, there is recognition at least of the potential for EA to help manage ICT assets across the Organisation and the understanding that other Departmental Heads and personnel need to understand and be involved in EA activities within the Organisation.

This stage of EA practice evolution can often be 'evangelical', whereby a defined sub-group or community within the Organisation seeks to spread or extend its influence using whatever means possible. There is a religiosity about 'spreading the word' in that practitioners seek new converts wherever they may find them. The founding of this new faith can only occur because at least one of the senior Managers, often the CIO, is already a convert and the community has at last found some protection within one individual at a senior management level to defend and protect their flock. Architecture is now a recognised practice within the Organisation with published position descriptions and with proscribed review and over-watch responsibilities within the design and delivery of any large program of work. Figure 1 illustrates how large programs of work, with dedicated long term program resources and responsibility for delivering Organisational artefacts spanning several operational areas (Departments) have emerged.

The locus of control for the EA framework still firmly resides with the CIO and the traditional IT Department aided by an evolved structure hierarchy of chief- or principal architect and then senior and junior architects perhaps also managed by functional layers – i.e. data, integration, system, application etc. Certifications, training and experience with various EA frameworks have now become highly valued and the Architectural community that has emerged is often characterised by religious 'wars' between competing ideologies or camps supporting one EA framework or tool-set over another. These often occur within the IT Department itself and can result in significant personal and professional loss of face to the protagonists who often begin to use external materials, vendor publications, industry surveys, reports, consultants, academic or commercial journals to state their case or overcome their opponents.

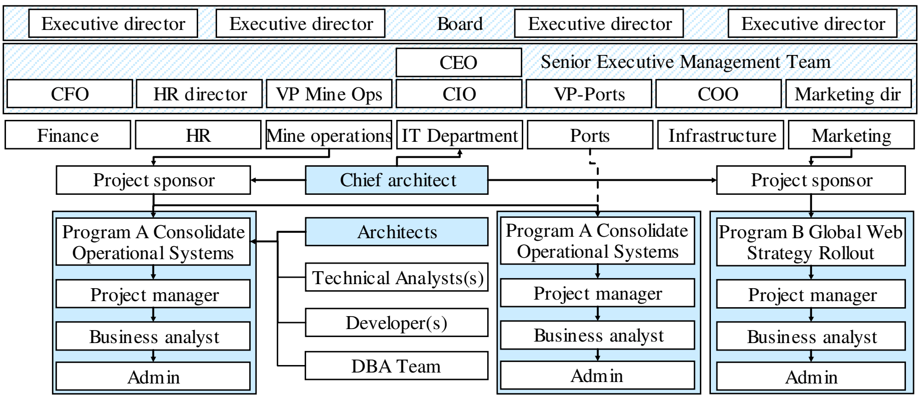

Fig. 2. Architecture as an Asset

In this stage EA practice is seen as an enabler for the organisation to define and to deliver ICT services to best support business needs, and architecture descriptions are to be also seen by non-IT people – although traditional models which satisfy IT stakeholder concerns may not be of interest to the non-IT stakeholder [7]. New communication and modelling skills (and tools) become necessary for this more extended architecture practice to be successful. Ross *et al* [9] describe roadmaps and criteria for success for this stage of development with skill extensions and dual role definitions required for Technologists and Managers alike.

4 Case Study Organisation #3 (Global Bank) –Architecture as a Service

On this level of maturity, the EA function is now offered as a core Service provided by a de-centralised Enterprise Architecture team. Not all members of the team are physically co-located, with the delivery and maintenance of core EA assets across multiple geographic locations. Many architect- and analyst roles now reside permanently within business units themselves outside of this core EA team. The core EA team 'own' the dissemination and communication of corporate standards, governance and procurement of new system domains and de-commissioning of old core platforms, whole of Enterprise initiatives and upgrades to the core operating systems within the Organisation as a whole but in an increasingly "custodial" fashion only. The first elements of self absorbed "coherency" practice with a level of pervasiveness (unconscious adoption) can now be seen. In organisations with this level of EA practice maturity the core EA team ('Global EA Framework and Service Delivery Team' in Fig.3) will focus on strategic initiatives. Also, individual line Departments will now have the delegated authority to design, procure, implement and support their own specialised applications as long as each step in the journey stays within the approved governance procedures and standards and policies.

No longer does the core team 'own' architecture outside of the core EA assets and framework, as applied architecture in the form of application and system level design has now permeated the whole Organisation with dozens if not hundreds of simultaneous programs of work occurring across multiple specialised domains of work. The Core EA team is responsible for the establishment of Meta models and a Meta framework, and for a repository and tool-set used for the creation and dissemination of architecture artefacts (architecture descriptions and models), as well as ensuring broad conformity within a published set of standards and procedures. Pervasiveness or "unconscious adoption" is now vitally important if the EA framework is to have any hope of success given the limited ability of the now vastly reduced core EA team in directly influencing all of the architectural and general business decision making events happening every second and minute of the day at all levels of what is now a significantly complex Organisation with many moving parts and increasingly complex decision making points at all levels of the structure.

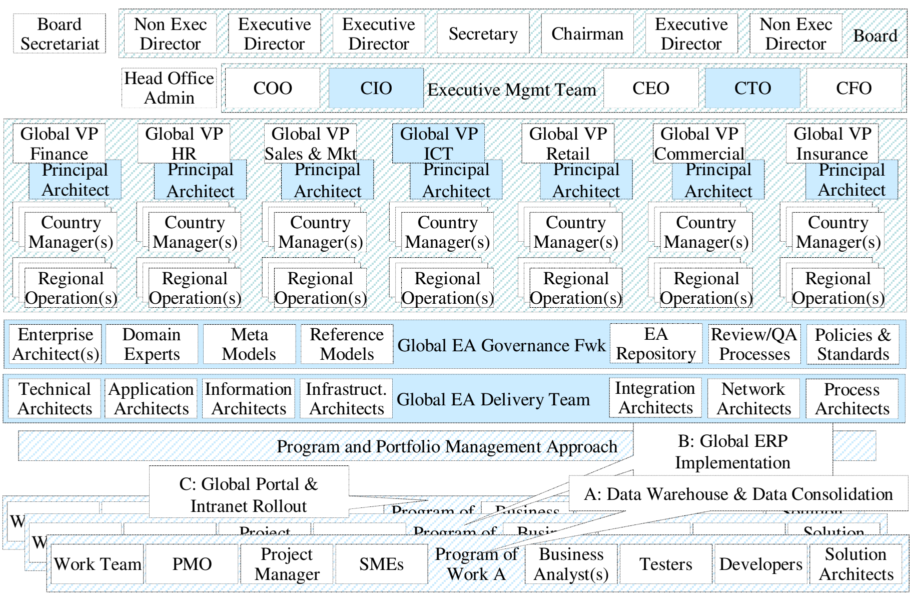

Fig. 3. Architecture as a Service

5 Next Generation EA – Architecture as a Pervasive Management Decision Support Tool

The proposed approach envisages the fully evolved next generation EA practice operating above and beyond the scope covered by the discussed case studies. In this idealised state, the next-gen EA is all pervasive and fully coherent at all levels of the Organisation, a natural and unconscious extension of normal management practice.

Political and cultural divides between technology and business disappear as the management value of EA is realised by all stakeholders and championed by senior managers in making strategic business decisions. A fully pervasive and conformed EA practice and supporting framework across all levels of the Organisation allow for superior and consistent decision-making ability in a fully informed information environment. The underlying framework allows for a fast and truly evolved combination of business and technology metrics and inputs across the organisation. Under this model, the Architecture team is aligned directly with the executive management team and truly accountably for the accuracy, consistency, timeliness and quality of all management and corporate reporting and analysis being conducted.

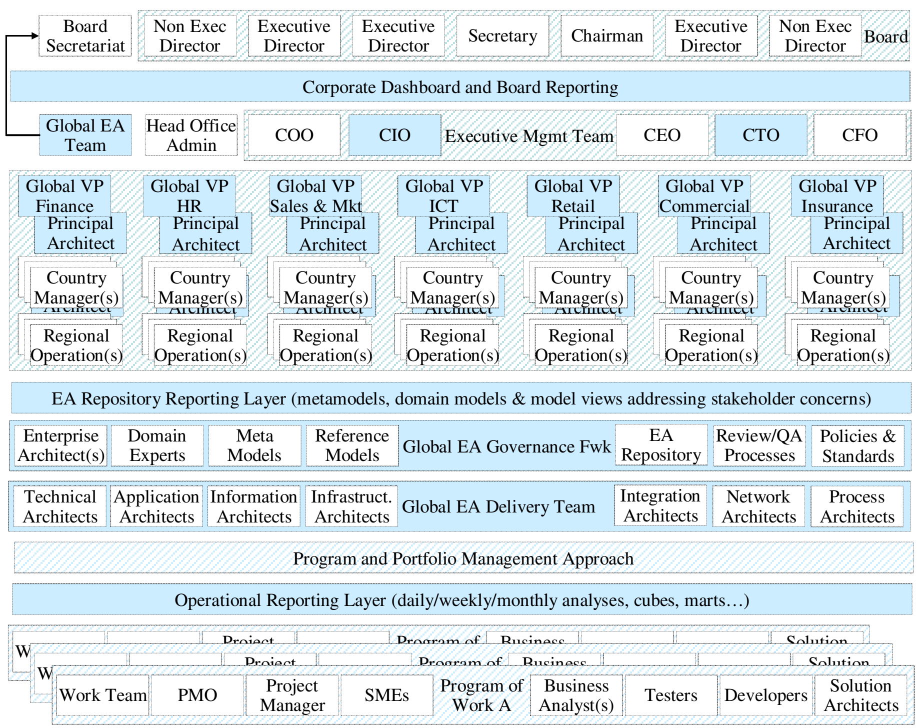

Fig. 4. A pervasive EA practice supporting coherency in management

As Fig.4 illustrates, the EA team is now involved in producing key issues- and strategic briefing papers for Board meetings and quarterly AGMs. All executive, corporate and management reporting uses an organisation-wide management reporting tool with corporate Dashboards and views available for executive managers and Board members. These reports are now also for the first time fully consistent and aligned with all subordinate reporting layers so that a coherent and pervasive view of the Organisation emerges for all levels of operations and at all times.

The EA team is now fully tasked with the responsibility and accountability of ensuring that all of the technical impacts and technological risks associated with any new corporate initiatives (mergers, takeovers, acquisitions, major system upgrades or business transformation projects) are fully understood and have been factored in as part of the full decision making process for the Board. This responsibility then flows down to ensuring that sophisticated analytics and impact assessments (including scenario analysis and portfolio and program management options) are also available in a consistent manner for executive, senior and operational management teams.

In this role, the EA team (as opposed to operational architects such as solution- or process architects embedded in line Departments and project teams) are still responsible for the EA framework and meta models within the Organisation, but now have the additional responsibility (similar now to that of the Finance function) of ensuring that senior business decision-makers are fully informed prior to any strategic business decision is made. This vision for EA however relies on all of the technological advances that are part of the next generation vision. Fully enabled and seamless interoperability across internal business units and external partners, fully maximised and intelligent pro-active optimisation of existing assets (internally and externally), use of virtual resources such as cloud- and grid computing and the creation of virtual enterprises able to react and respond rapidly and quickly to new business opportunities and threats.

The legitimacy of this new vision for EA is dependent upon some significant progress that must occur for EA practice and tools to realize this ambition. Elements needed to implement a fully coherent and understandable framework include:

1. A unifying theory of EA that is acceptable (and accepted) as a common ground by both the business / management and engineering communities. Part of the is technical (need improved tool-sets, metamodels, reference models, demonstrations, prototypes, etc); and part of it is community building to bring together influential thinkers of management and engineering representing both points of view, and to develop trust and acceptance of any technical results;
2. Reliable and effective enterprise layers that seamlessly allow transactional and other information flows through the various domains and sub-domains as well as layers of management. Given today's decision support tools and investment in their deployment, work on the interoperability of such tools is imperative or the above ideas may not be realistic or feasible;
3. Extension of enterprise modelling tools enabling decision optimisation using relevant views for senior management and allowing business prototyping, what-if- and predictive analyses (future state modelling for risk, profitability, cost, resource, productivity and other non financial metrics (e.g. legal));

While the above list addresses several key technical issues and some aspects of discipline development, coherency in management has a number of other conditions as well. The summary of these conditions is provided in Fig.5. [5]

There are a number of important consequences to this condition [5]. Firstly, agreed, consistent and institutionalised EA methods create *alignment* between various lines of business which facilitates communication and agreement. Secondly, coherent and pervasive decision making practices allow the enterprise to identify, and to react to, market opportunities, i.e. act in an *agile* way, because EA practice ensures the swift translation of strategic decisions to tactical and operational levels. Thirdly, the ability of decision makers to access the right information in the right time is an *assurance* that decision making will be based on the best available information.

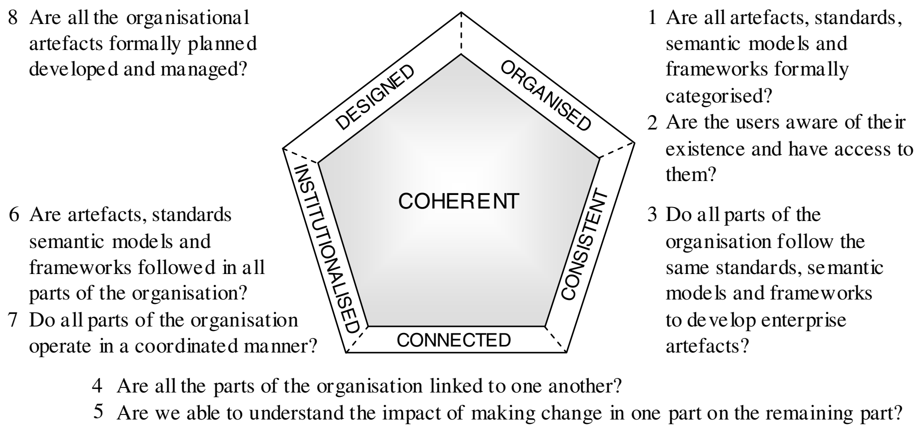

Fig. 5. The meaning of coherency in management [5] (used with permission)

The presented case studies reinforce the findings of others [5] that there exist various maturity levels in EA practice, i.e., even if all the technical conditions were satisfied, for any enterprise the adoption of a pervasive fully mature EA practice needs to go through stages. Doucet *et al* [5] introduce the concept of modes of EA to describe the maturing EA practice. The first mode is called Foundational Architecture corresponds to our Case Study #1 and #2, in which EA is very IT-centric and its tools and methods are used for the optimisation and governance of the enterprise's IT systems, with different degrees of visibility and participation from business. The next mode is Extended Architecture which corresponds to our Case Study #3, where EA is used for the planning of business objectives, processes, etc – not only the IT systems themselves, and with the full participation in an explicit EA process by various business stakeholders. However, on this level the EA process is not pervasive, it is not embedded in the normal processes and as such parts of the enterprise may remain isolated from this practice (such as, for example, senior management). Embedded Architecture) is the third mode, where EA practices are pervasive and cover all levels of management, as illustrated in Fig.4. [5] also defines a fourth mode (fifth maturity level) called Balanced Architecture, where the business is actively using EA tools and methods for the creation or validation of business strategies, e.g. to respond to market opportunities in an agile way, to optimise business plans, to analyse and mitigate risks – in other words this is the level where applied EA theory and management theory become indistinguishable. As the Synopsis of the Handbook on Enterprise Architecture [1] predicts "what earlier seemed to be separate disciplines, such as enterprise engineering, systems and software engineering, project management, and industrial and manufacturing engineering, suddenly become unified into one under one powerful theory of enterprise entities. However, this unification is not overtaking or destroying the individual efforts, it rather allows the significant details of these discipline to fit together".

After more than thirty years of work on the topic, the vision of the right information for the right people at the right time and in the right format has still not been realised, and it appears that the reason is partly the lack of an underlying *commonly accepted* theory, and partly the lack of mature enough tools. The coherency of information flow has always been the original aim of the discipline of Enterprise Integration (EI), "The goal of enterprise integration is to provide timely and accurate exchange of consistent information between business functions to support strategic and tactical business goals in a manner that appears to be seamless" [10], and since the 1980s [12] integration of the information flow has been a major strategic objective – whether integration by design or dynamic integration (interoperation).

6 Future Issues

Future issues that remain un-resolved and open for further investigation in this exciting emerging field include the following:

1. For pervasive and coherent EA practices to achieve more penetration, much more research and development is needed to define feasible pathways for the uptake of EA frameworks and practices and tools, which still have not reached optimum influence and usage within organisations. Current developments in the disciplinary EA-bodies, such as the Open Group, must be supported by academic practice.
2. Traditional management roles, responsibilities and authorities (as well as assumed skills and competencies) may have to change in order for pervasive and coherent EA practice to take a foothold in the armoury of higher management. Demonstration is needed on significant case studies of the benefits of such practice, as successful examples are the best motivators for the adoption of new practices (examples of EA being used in business design include [11, 8, 3] demonstrating virtual enterprise creation, trust, virtual breeding environments, brokering, and other fundamental management problems, although decision support tools are still evolving [14,15]).
3. EA frameworks and practices have to evolve in order to deliver benefits needed for these two audiences. The frameworks need to contain metamodels to define a common terminology to be used by stakeholders, and must also be expressed as ontological theories, so as EA tools can be used to make inferences from architecture descriptions and models for the benefit of such stakeholders. While the requirements have been known for over a decade [2], and are part of the international standard that defines requirements to be satisfied by EA frameworks [6], the metamodels behind today's enterprise modeling tools are often limited to the concepts necessary to deliver the IT function, and not adequate for the full architecture of the firm.

7 Conclusions

This paper attempted to outline various deficiencies in the traditional role of Enterprise Architecture and Architects themselves. It has been argued that a subordinated role of Architecture has led to a failure to provide effective decision support to senior business decision makers. A future model has been proposed in which next generation EA would be positioned to include senior business management providing effective and full information to the right people at the right time. It is suggested that this repositioning of Architecture within the modern Organization can have a significant contribution to the timeliness, effectiveness and accuracy of the decisions made by these senior business decision makers.

References

1. Bernus, P., Nemes, L., Schmidt, G.: Handbook on Enterprise Architecture. Springer, Heidelberg (2003)
2. Bernus, P., Nemes, L.: A Framework to Define a Generic Enterprise Reference Architecture and Methodology. Computer Integrated Manufacturing Systems 9(3), 179–191 (1996)
3. Camarinha-Matos, L.M., Afsarmanesh, H., Ollus, M. (eds.): Methods and Tools for Collaborative Networked Organisations. Springer, Berlin (2008)
4. Information Technology Management Reform Act (40 U.S.C. 1401(3)) (1996)
5. Doucet, G., Gøtze, J., Saha, P., Bernard, S. (eds.): Coherency Management: Architecting the Enterprise for Alignment, Agility, and Assurance. International Enterprise Architecture Institute, Falls Church (2009)
6. ISO 15704:2000 Industrial automation systems – Requirements for enterprise-reference architectures and methodologies. Geneva: ISO (2000)
7. ISO/IEC 42010:2007. Systems and Software Engineering – Recommended practice for architectural description of software-intensive systems. ISO, Geneva (2007)
8. Karvoinen, I., et al. (eds.): Global Engineering and Manufacturing in Enterprise Networks (Globemen). VTT Symposium Series, vol. 224. VTT, Helsinki (2002)
9. Ross, J.W., Weill, P., Robertson, D.: Enterprise Architecture as Strategy: Creating a Foundation for Business Execution. Harvard Business School Press, Cambridge (2006)
10. Smith, D., O'Brien, L., Kontogiannis, K., Barbacci, M.: Enterprise Integration. The Architect 5(4), 1–14 (2002)
11. Uwakato, U.: The Intelligent Manufacturing Systems Program. In: Wessner, C.W. (ed.) International friction and cooperation in high-technology development and trade, pp. 205–215. NAP, Washington (1997)
12. Vernadat, F.: Enterprise Modeling and Integration: Principles and Applications. Springer, Berlin (1996)
13. IFIP-IFAC Task Force GERAM: Generalised Enterprise Reference Architecture and Methodology Version 1.6.3. (1999), `http://www.cit.gu.edu.au/~bernus/taskforce/geram/versions/geram1-6-3/v1.6.3.html` (accessed July 1, 2009)
14. Peñaranda, N., Galeano, N., Romero, D., Mejía, R., Molina, A.: Collaborative Engineering Environments for Virtual Organizations. Int. J. Technology Mgmt. 8(3), 298–320 (2009)
15. Noran, O.: A Decision Support Framework for Collaboratiave Networks. Int. J. of Production Research 47(17), 4813–4832 (2009)

Defining Leadership as Process Reference Model: Translating Organizational Goals into Practice Using a Structured Leadership Approach

David Tuffley

School of ICT, Griffith University
Nathan, Brisbane, Qld. 4111, Australia
d.tuffley@griffith.edu.au

Abstract. Effective leadership in organisations is important to the achievement of organizational objectives. Yet leadership is widely seen as a quality that individuals innately possess, and which cannot be learned. This paper makes two assertions; (a) that leadership is a skill that not only *can* be learned, but which can be formalized into a Process Reference Model that is intelligible from an Enterprise Architecture perspective, and (b) that Process Reference Models in the strict sense can be redefined to include a new category of PRM called provisionally a Reference Model of Organisational Behavior which focuses on organisational behavior in pursuits of goals.

Keywords: leadership, complex teams, virtual teams, process reference model, process assessment model.

1 Introduction

Enterprise Architecture can be thought of as an *informing principle* that enables the translation of an organisation's high-level aspirations into the structures and processes that are designed to realise these aspirations [1]. This includes the technological infrastructure and associated data that allows the enterprise to function. No less important to the realisation of the enterprises' goals is the exercise of leadership at various levels within the organisation.

Indispensable as leadership is to high-performance enterprises, there is still no commonly agreed definition of leadership [2], much less a meaningful definition of leadership in process terms that can be used to facilitate more effective leadership in a process-driven enterprise. This paper describes a Process Reference Model for the leadership of complex virtual teams with which an enterprise might better facilitate the translation of those high-level aspirations into concrete reality.

A Leadership Process Reference Model is arguably consistent with the generalized view of Enterprise Architecture as concerning itself with describing in a formal, structured way the relationships between the elements (including people and technology) of an organisation in such a way that they can manage on-going change and achieve their goals [3].

P. Bernus, G. Doumeingts, and M. Fox (Eds.): EAI2N 2010, IFIP AICT 326, pp. 11–20, 2010.

Process Reference Models in the software engineering sense must conform to certain prescribed criteria (that they be developed in conformance with ISO/IEC 15504 and ISO/IEC 24774). The leadership model discussed in this paper conforms to these standards. A second issue is that of whether leadership is something that can even be described in a Process Reference Model. Both of these issues will be discussed below.

2 Process Reference Models in Organisations

Process models developed in conformance with ISO/IEC 15504 and ISO/IEC 24774 can arguably be called a Process Reference Model (PRM), particularly when the draft model has had all of its outcomes validated by the existence of artefacts and/or activities identified during multiple review iterations involving practitioners and process model experts. In addition, the model may be used by an external observer to describe the behavior of an effective leader. Combine these factors and a strong argument exists for this position.

But the orthodox view in software engineering sees PRMs as high-level descriptions of what tasks to perform and in what order to perform them in order to achieve desired project outcomes. The focus is on external entities that can be observed and assessed against an objective assessment model.

A difficulty arises though when trying to reconcile the orthodox view of PRMs with a specific PRM focused on the elusive qualities of Leadership. Despite thousands of books and papers written on the topic of leadership over centuries, no commonly agreed definition yet exists [2]. Leadership qualities derive partly from a set of personality factors residing *in* the leader and partly from explicit actions performed *by* the leader at the team and organisational level. While the explicit actions can be directly observed, the implicit qualities cannot be observed, only their effects (as manifested by the attitudes and activities displayed by the leader).

A PRM for the leadership of complex virtual teams describes aspects of desired *organisational* behavior that if performed repeatedly will become institutionalised and which will result in consistently achieving the prescribed purpose (i.e. working towards the achievement of organisational goals). This approach re-focuses attention from conformance to prescribed activities and tasks, to a focus on the *demonstration of desired organisational behavior*, taking us away from the traditional role of a PRM. And leadership is potentially just one of many desirable organisational behaviors that might be facilitated by a PRM.

How then to reconcile these differences? A logical answer is to conclude that the Leadership PRM is in fact a new category of process reference model, described provisionally as a *Reference Model for Organisational Behavior* (RMOB).

The creation of this new category of PRM and its associated assessment model opens up the field across a diversity of disciplines for others to develop models of organisational behavior covering a range of activities (for example IT governance), giving them the means to assess and improve organisational behavior.

Reference Models for Organisational Behavior (RMOB) therefore represent a significant new application of Process Reference Models and Process Assessment Models in domains outside software, systems engineering and service management.

RMOBs have relevance to Enterprise Architecture since they are concerned with formal, structured descriptions of the relationships between the elements (including people and technology) of an organisation, and how these can be used to manage on-going change and achieve organisational goals [3].

3 Can Leadership Be Described as a Process?

Leadership is not alone in the broad category of behaviors engaged in by organisations as they pursue their objectives. If leadership can be described in a Process Reference Model (PRM) and supported by a PAM, then theoretically so too might these other behaviors not yet serviced by a PRM. For example, ISO/IEC 15504 offers organizations the means to develop and assess their integrated teaming capability against the measurement framework prescribed by ISO/IEC 15504 [4].

We begin by examining whether there are grounds to believe that PRMs are applicable in addressing leadership in a software engineering environment? It will be seen from the discussion that PRMs and Model Based Process Improvement (MBPI) can arguably be applied to a range of software engineering challenges, including the challenge of project leadership

As seen in Figure 1, there are two broad justifying reasons; first that Leadership can be taught and learned by those who would practice it [5] [6] [7]. Second that the defining of processes is necessary for organisational effectiveness [8]. As Deming said, *if you cannot describe what you are doing as a process, then you don't know what you are doing* [9].

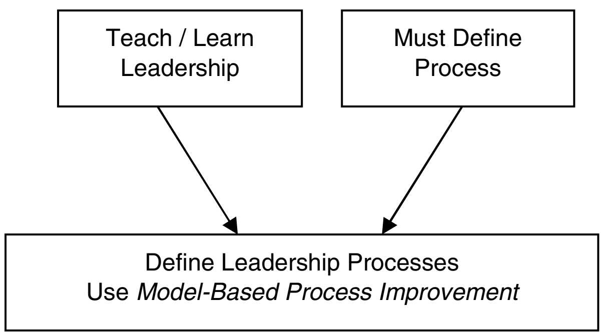

Fig. 1. Model-Based Process Improvement enables definition of leadership processes

The conceptual overview diagram in Figure 2 illustrates the evolution of the question *how can the challenge of more effective virtual team leadership be met?* Assuming that the leadership factors could be identified from a broad literature review, then a Process Reference Model is a logical way for these factors to be formalised and applied in real situations.

The basic topic of team functioning was examined first, which led to the identification of what characteristics are likely to create a successful team. Arising from this work on successful teams, leadership is clearly identified as being of critical importance.

The conceptual overview acknowledges the basic distinction between co-located and virtual teams, and that integrated teams can be either. Virtual teams do not have to be integrated but commonly are. Integrated teams do not have to be distributed, but commonly are. Therefore, the characteristics of successful teams and successful leaders are considered for both co-located and virtual teams, culminating in the characteristics of successful leaders of integrated teams operating in virtual environments.

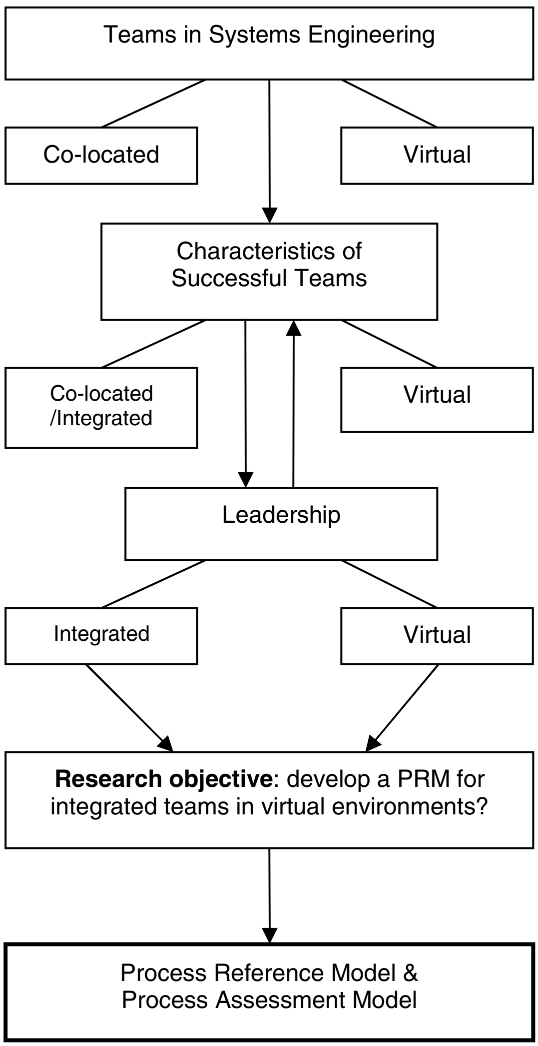

Fig. 2. Conceptual overview of how Leadership PRM & PAM evolved

4 Model-Based Process Improvement as a Solution to Rising Organizational Complexity

The business of managing complex projects across dispersed geographical locations has never been more difficult, given the rising complexity of the global economic environment and the multi-national corporate entities that now inhabit this world. There is a clear need to find improved ways of managing this often difficult process now and into the future [10].

Model Based Process Improvement (MBPI) potentially offers the means by which organisational challenges such as the leadership of complex virtual teams can be met. MBPI has not (to the knowledge of the author) been used to address leadership, though there is arguably a sound basis for thinking that it can be used in this way.

MBPI aims generally to improve the performance and maturity of an organisation's processes. It combines the discipline of process improvement with the several international standards and frameworks now in use (i.e. ISO/IEC 15504, CMMI). Combining this awareness of process performance with internationally recognised standards is advantageous to organisations. It affords a structured and comprehensive framework as a way forward and prescribes in general terms the scope of activities required to systematically improve their process maturity.

Heston and Phifer [11] ascribe the following organisational benefits to MBPI:

- *Improving consistency and repeatability:* consistency and repeatability assist with minimising process variation, a major source of product defects. It also allows project staff to move into and out of projects more easily by having clearly defined roles and responsibilities.
- *Improving communication:* achieved through the adoption of a common vocabulary with clearly prescribed meanings that allows project staff, clients and business partners to communicate with less ambiguity.
- *Enabling more improvement*: process improvement programs create an environment which is conducive to further improvement. Beyond consistency and repeatability comes the ability to measure and record process performance. This performance data can then be used to plan further improvements and to benchmark against best practice.
- *Providing motivation*: objective targets, for example being assessed at a certain level of maturity, become a visible motivator for project staff to maintain their efforts to improve process performance.

5 Leadership PRM in Practice

The Leadership PRM was developed using a Design Research approach in which an initial prototype was developed based on the broad literature and reviewed in a series of design iterations over an 18 month period (a total of six reviews). The reviews included the standard PRM-developer's method of practitioner and expert reviewers, plus an ISO/IEC 24774 conformance review to ensure the model met the requirements of that standard. The PRM was also validated with Dromey's Behavior Engineering [12], a formal method for checking content and syntax for errors and ambiguities that was developed initially for validating software requirements for complex systems, but which has proven a highly effective method for validating PRMs [13].

Having passed through these six reviews, the V1.0 PRM was released and reviewed again by a focus group over a full day. The group comprised two practitioner project managers and two experts on process models in software engineering. The terms of reference of this post-release review was to *evaluate the efficacy of the leadership PRM, particularly in relation to (a) fitness for purpose, (b) organisation of and content of elements, and (c) what would make it more usable from a practitioner's point of view?*

Table 1. Structure and content of Leadership Process Assessment Model

Leadership Process Assessment Model	
Individual Process Group (IND)	
IND.1	Vision
IND.2	Objective(s)
IND.3	Integrity
IND.4	Action-orientation
IND.5	Intelligence
IND.6	Individualized consideration
IND.7	Management-by-exception
Team Process Group (TEM)	
TEM.1	Team structure
TEM.2	Team requirements
TEM.3	Team recruitment
TEM.4	Team environment
TEM.5	Team formation
TEM.6	Team roles
TEM.7	Team rules
TEM.8	Team authority
TEM.9	Team performance management
TEM.10	Team development
Organisation Process Group (ORG)	
ORG.1	Team boundaries
ORG.2	Team collaboration
ORG.3	Team & home organization balance

As a result of the review, V1.1 PRM was produced. This version incorporated the accumulated feedback from the focus group and resulted in substantial changes by (a) consolidating and merging several processes, (b) reordering the processes to reflect a sequence more naturally performed in projects, and (c) adding additional informative material relevant to virtual and/or integrated project environments. All of these changes were consistent with the review's terms of reference.

Importantly for the purposes of this paper, the consensus opinion of the focus group was that the *Leadership PRM is a usable model*. They each wanted a copy of the update V1.1 PRM for use in their own projects. This feedback lends support to the argument that a Reference Model of Organisational Behavior that conforms to the requirements of a PRM in a software engineering sense can be a useful and usable artefact.

Also emerging from this first post-release review was a *Process Assessment Model* (PAM) based on the Leadership PRM. This PAM was developed in accordance with ISO/IEC 15504-1:2004 Parts 1 and 2.

Table 2. Structure and content of PAM Example 1

Process ID	**IND.1**
Process Name:	**Vision**
Process Purpose:	The purpose of the vision process is to create and communicate a shared vision in ways that inspires people to realise that vision.
Process Outcomes:	As a result of successful implementation of the vision process: 1) A vision of the goal(s) is created. 2) The vision of the goal(s) is communicated to the team 3) Commitment by team to the shared vision is gained
Base Practices:	**IND.1.BP1: Create the vision**. The leader envisions a desirable future condition [Outcome 1]
	IND.1.BP2: Communicate the vision. The leader communicates the vision in a way that creates positive expectation in the team members [Outcome 2].
	IND.1.BP3: Commitment to vision by team. The leader obtains commitment from the team members for the realisation of the vision, making it a shared vision [3].

Work Products / Activities / Conditions	
Inputs	**Outputs**
Business goals [Outcome 1]	Team Charter [Outcome 1]
	Imperative Objectives [Outcome 1]
Customer requirements [Outcome 1]	Project Plan [Outcome 1]

An example process from the PAM (*Vision)* is shown in Table 2 below. It and the other 15 processes have now been elaborated into a draft PAM. The first review established that a PAM which embodies at least the Process dimension is viable.

The second and subsequent reviews (V1.2 onwards) will investigate the feasibility of including the Capability dimension in the Leadership PAM. While it has been established during the validation of the PRM that each of the outcomes can be

Table 3. Structure and content of PAM Example 2

Process ID	**IND.2**
Process Name:	**Objectives**
Process Purpose:	The purpose of the objectives process is create and communicate objective(s) based on the vision and derived goals.
Process Outcomes:	As a result of successful implementation of the objectives process: 1) Practical objective(s) for goal(s) achievement are developed. 2) Positive expectation for achieving objective(s) is encouraged.
Base Practices:	**IND.2.BP1: Develop objectives**. The leader derives a set of practically worded objectives from the shared vision and subsequent goals that give the team a concrete set of outcomes to achieve. [Outcome 1]
	IND.2.BP2: Encourage positive expectation. The leader generates an optimistic mind-set and outlook in the team towards the achievement of the objectives [Outcome 2]

Work Products / Activities / Conditions

Inputs	**Outputs**
Vision statement [Outcome 1]	Goals [Outcome 1]
	Objectives [Outcome 1]
Project plan [Outcome 1]	Goals [Outcome 1]
	Objectives [Outcome 1]
Project launch [Outcome 2]	Positive expectation re vision [Outcome 2]
Team briefing [Outcome 2]	Commitment to vision [Outcome 2]
Yearly kick-off [Outcome 2]	Positive expectation re vision [Outcome 2]
Quarterly review [Outcome 2]	Commitment to vision [Outcome 2]

substantiated by the presence of artefacts and/or activities, it is not yet clear whether the discernable process indicators can be distinguished with sufficient clarity to establish the capability dimension. Only by performing a number of assessments using the draft PAM and accumulating data in the *Work Products / Activities / Conditions* section will we know whether a capability dimension is feasible. This work is on-going.

Note that the PAM can be used in three possible ways, (a) by project managers to evaluate their own practice, and engage in self-improvement by benchmarking against best-practice, and (b) by organisations wishing to improve their internal management capability, and (c) theoretically by external agencies wishing to evaluate a potential supplier's management capability (though this would be some distance away since the capability dimension has not been established).

6 Conclusion

This paper discusses the issue of effective leadership in organisations and argues the case that (a) leadership is a skill that can be learned, and which can be formalized into a Process Reference Model that is intelligible from an Enterprise Architecture perspective, and (b) Process Reference Models in the strict sense can be redefined to include a new category of PRM called provisionally a Reference Model of Organisational Behavior which focuses on organisational behavior in pursuits of goals.

In support of the case that leadership can be learned is the extensive body of work by influential researchers on leadership like Warren Bennis [5] and Peter Drucker [6]. This does not ignore the innate charisma of so-called 'born leaders', but makes the case that leadership can be understood and applied more effectively in a practical sense.

In support of the case that leadership can be described as a process reference model is the work of process pioneer W. Edwards Deming who observed that if you cannot describe what you are doing as a process, you don't really know what you are doing [9]. While the Leadership Process Reference Model conforms to the normative reference, qualifying it to be called a PRM, the broader, more organizationally-focused nature of this model suggests it might be best described as a new category of PRM, provisionally called a *Reference Model for Organisational Behavior*.

A Leadership PRM developed by a rigorous Design Research process and tested in preliminary trials and found to be useful by practitioners and experts is arguably a viable model. Strengthening this position is the draft Process Assessment Model that considers initially the process performance dimension, but which will be elaborated in on-going trials for the inclusion of the capability dimension.

The results so far have been encouraging. Not only is a Leadership PRM & PAM useful its own right, but it also points to the possibility of developing other *Reference Models for Organisational Behavior* and PAMs covering a range of organisational behaviors in a range of disciplines including but not limited to financial institutions and banks, automotive systems and software, aerospace systems and software, medical device systems and software, IT service management, test process improvement, small and very small enterprises. This would significantly extend the breadth of application of the standardised approach to process assessment.

From an Enterprise Architecture perspective, a Leadership Process Reference Model and its derived Assessment Model are arguably consistent with a generalized view of Enterprise Architecture as optimized formal descriptions of the elements and relationships (including people and technology) of an organisation in order to achieve their goals [3]. As such they make a worthwhile contribution to the EA domain.

References

1. Institute for Enterprise Architecture and Developments Enterprise Architecture Standards Overview, `http://www.enterprise-architecture.info/EA_Standards.htm` (accessed January 22, 2010)
2. Yukl, G.: Leadership in Organisations. Prentice-Hall, Englewood Cliffs (1994)
3. Bernus, P., Mertins, K., Schmidt, G. (eds.): Handbook on Architectures of Information Systems. 2nd Revised and extended edn., pp. 2–6. Springer, Berlin (2006)
4. Tuffley, D.: Implementing Integrated Teaming According to ISO15504. In: Proceedings of the 6th International SPICE Conference on Process Assessment & Improvement, Centre de Recherche Public Henri Tudor, Luxembourg (2006)
5. Drucker, P.: Managing in a Time of Great Change. Butterworth Heinemann, London (1996)
6. Bennis, W.: On Becoming a Leader, What Leaders Read 1, p. 2. Perseus Publishing (1994)
7. Humphrey, W.S.: Winning with Software. Addison Wesley Longman, Reading (2002)
8. Repenning, N.P., Sterman, J.D.: Getting Quality the Old-Fashioned Way: Self-Confirming Attributions in the Dynamics of Process Improvement. Sloan School of Management. MIT, Cambridge, `http://web.mit.edu/jsterman/www/SDG/Attrib.pdf`
9. Deming, W.E.: Out of the Crisis. MIT Press, Cambridge (1997)
10. Herbsleb, J., Moitra, D.: Global Software Development. IEEE Software 18(2), 16–20 (2001)
11. Heston, K.M., Phifer, W.: The Multiple Quality Models Paradox: How Much 'Best Practice' is Just Enough? Software Process Improvement and Practice. Wiley InterScience, Hoboken (2009)
12. Dromey, R.G.: Climbing Over the 'No Silver Bullet' Brick Wall. IEEE Software 23(2), 118–120 (2006)
13. Tuffley, D., Rout, T.: Applying Behavior Engineering To Process Modelling. In: Proceedings of the 1st Improving Systems and Software Engineering Conference (ISSEC), National Convention Centre, Canberra, Australia, August 10-12 (2009)

Valuation of Procurement Flexibility in the Machinery and Equipment Industry Using the Real Option Approach

Alexander Kleinert and Volker Stich

Forschungsinstitut für Rationalisierung, Pontdriesch 14-16, 52062 Aachen, Germany
{Alexander.Kleinert,Volker.Stich}@fir.rwth-aachen.de

Abstract. The increasingly uncertain business environment requires the necessity to implement more flexibility in companies. Unfortunately, companies being specialized in engineer-to-order production cannot use safety stocks which are generally used in make-to-stock productions to secure flexibility. Therefore, an alternative approach has to be developed to facilitate procurement flexibility for these companies. In this paper, firstly the current situation of production networks of machine tool and equipment manufacturers will be described. Secondly, the shortcomings of current approaches for inter-company coordination will be discussed. Finally, the real option approach will be examined as a mean to evaluate the benefits of procurement flexibility.

Keywords: Delivery reliability, flexibility, procurement, real options.

1 Introduction

Besides the general market fluctuations, the impact of the financial and economic crisis illustrated the complexity and volatility which today's European machinery and equipment industry has to deal with [1,2]. In addition to challenges like international competition, increasing customer demand, cost pressure, shortened product life cycles and a rising number of variants, manufacturers have to face increased financial problems and even higher fluctuations in demand [3,4,5,6].

While formerly only programmes for reducing stocks were used to minimize the financial needs, nowadays alternative flexibility potentials, such as the introduction of short-time work, have to be used. [7]. Nevertheless, in increasing non-centralised and temporary production networks, it is not enough to focus only on own resources [8]. With the high amount of outsourcing of complete modules the potential of time and capacity flexibility in the order process has to be used in order to keep the potential sales volume. By using delivery time flexibility within the order process many problems that effect especially modules could be reduced. In particular, the increased delivery time flexibility reduces the negative effects of early or late deliveries that lead to high fluctuations in the whole production network and cause a substantial economic expense [9]. Possible penalties, insufficient ability to plan, high safety stocks, raised lead times and lower service levels are often the result [10]. In a global industry survey, the “suppliers’ reliability” was evaluated as the third biggest cause of

P. Bernus, G. Doumeingts, and M. Fox (Eds.): EAI2N 2010, IFIP AICT 326, pp. 21–31, 2010.

potential risks [11]. However, up to now the expenses which are generated by the insufficient delivery reliability in the machinery and equipment industry cannot be quantified in a satisfactory measure [12].

In order to find solutions for these challenges in procurement, research is conducted. Since September 2009, the Research Institute of Operations Management (FIR) and the Laboratory for Machine Tools and Production Engineering (WZL) at the RWTH Aachen, Germany, analyse in cooperation with ten European partner institutions from industry and research various approaches to improve the interplant communication, transparency and coordination within the research project "InTime – in time delivery in non-hierarchical manufacturing networks" (http://www.fp7-intime.eu/)

2 Scientific Approaches on Procurement and Logistics in Production Networks

The machinery and equipment industry differs by heterogeneous and constantly changing production networks substantially from other industries like the automotive and trading industry (Fig. 1) [13]. On the one hand, intensive relationships exist only for a small share of active suppliers. On the other hand, the production network in the machinery and equipment industry is not as highly dominated by a single company as in the automotive or trading industry.

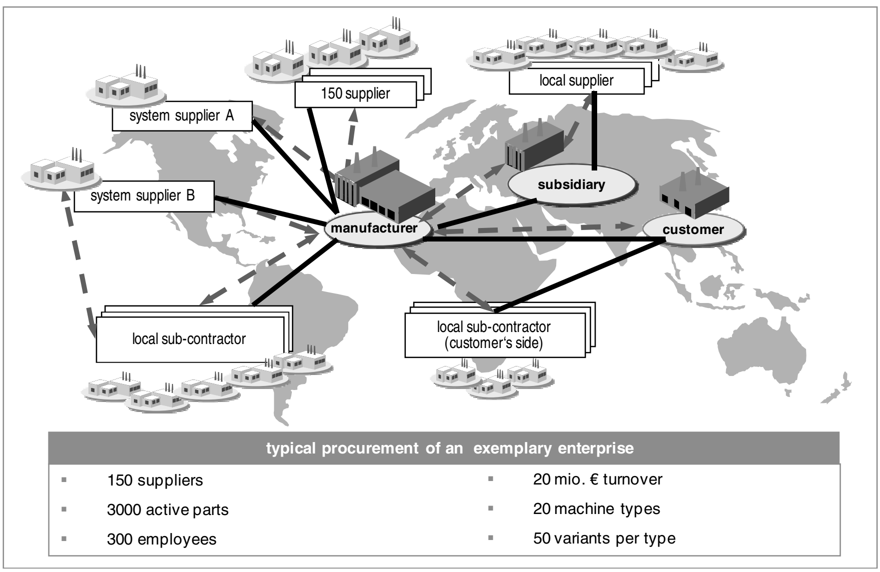

Fig. 1. Non-centralised production network in the machinery and equipment industry

In an industry like this a continuous IT integration can hardly be accomplished by existing data standards such as EDIFACT which is used via sub-standards like Odette in the automotive industry or EANCOM in the trading industry [14]. Hence, many proven approaches for streamlining the value chain, which are based on a continuous IT integration without interfaces, cannot be used either [15]. One of these approaches is the "Just in Time" concept (JIT). This production-synchronous delivery on demand pursues the objective to reduce stocks and thereby costs of procurement logistics [16]. Therefore, requirements are careful supplier selection, nearness to supplier, IT-supported integration of the supplier as well as a production targeting mass manufacturing [17]. Besides the missing IT integration, mass production rarely exists in the machinery and equipment industry. Another approach is “Quick Response” (QR) which is based on “process shaping”, enabling suppliers to react rapidly on fluctuation in demand [18,19]. The start of production is only triggered by short term demand requirements [20]. In machinery and equipment industries short reaction times are rarely in focus, as the make-to-order production requires an extended manufacturing time. Another approach, the Continuous Replenishment (CR) focuses on a high level of shelf availability with low stocks at the same time [19]. Its focus is the automatic delivery of goods as soon as the requirement is set. Regarding the project and order specific requirements, this approach cannot be applied for the machinery and equipment industry either. While the delivery reliability in the automotive or trading industry was increased by these approaches by up to 95%, this rate constitutes only 60% in the machinery and equipment industry [21].

Nowadays in the machinery and equipment industry, either one uses Andler’s formula minimizing the sum of stock and procurement costs or one orders from the supplier who offers the minimal component costs [22]. This static method based on costs and quantities, includes neither uncertainties of the dynamic business environment nor the value of delivery accuracy. Since outsourced components might make up to one fifth of the overall project value, component orders that appear more an investment than a typical order must be treated differently.

Furthermore, the arrangement of divergent target systems of a company becomes continuously an additional challenge for the overall company’s performance. While employees in purchasing have usually the incentive to reduce purchase costs, the production department strives for a high degree of utilisation and short lead times and the sales department is urged to generate high turnovers. In addition, differing inter-company target systems exist. Thus, situations often occur in which the customer’s purchasing department and the supplier’s distribution departments negotiate without considering the consequences for their production departments [23]. This can lead to insufficient capacities on the supplier’s site intending to keep the delivery date and to high expenses on customer’s site due to earlier or late deliveries. For many years, management science on human resources has been claiming that incentive schemes lead to improved employees’ performance. Although such incentives are still not established company-wide, a current study of the FIR and WZL shows that demand in new concepts exists [12]. For the improvement of the situation, consistent and company-wide performance indicators are necessary to calculate incentives. Various performance evaluation systems already exist like the SCOR model or the Balanced Scorecard model. These models offer general performance indicators but do not fit sufficiently enough to the challenge of delivery reliability. Concepts like the "Kennlinienmodell" by Nyhuis and Wiendahl, regard delivery reliability but mainly focus on make-to-stock productions [24].

The investigation of relevant approaches for procurement logistics shows that various concepts already exist for company-wide synchronisation, determination of procurement costs and motivation of employees. Nevertheless, these concepts provide few instructions how the procurement in machinery and equipment industry should operate flexible and value-oriented with rising outsourcing of high-quality modules in times of uncertainty.

3 The Real Option Approach as an Instrument to Increase Flexibility for Uncertain Situations

The analysis of the present situation showed that an instrument is necessary to assess and control the procurement process of make-to-order components more dynamically and proactively. Due to the high uncertainty in manufacturing processes, a method to increase the flexibility has to be used. One method increasing companies' flexibility that has been used within the last years is the real option approach [25]. So far, this method proved to be a possible approach to evaluate investments and innovative projects (Fig. 2).

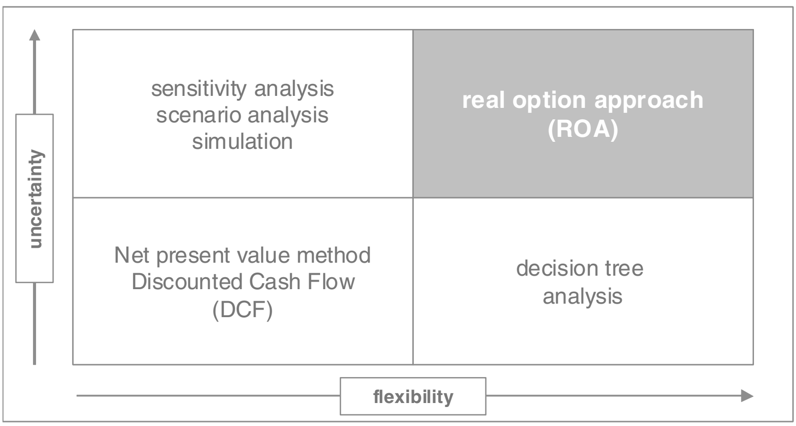

Fig. 2. Valuation methods in regard to flexibility and uncertainty ([26,27])

After a short introduction to the theory of this approach, it will be illustrated to what extent options can be used in the order process of high-quality components. Furthermore, the required conditions of the approach will be analysed and a possible methodology to calculate the real option for capacity flexibility will be described.

3.1 Fundamentals of the Real Option Approach

Originally, the real option approach was developed in the disciplines of financial and decision-making sciences to adapt the assessment of financial options on the assessment of investments in “real” assets [28,29]. The basic idea was established by MYERS which states that investment possibilities should be evaluated according to the changes of project-value through possible follow-up investments in the future [30]. Like ordinary financial options, real options offer the right, but not the commitment to accomplish an investment in the future. Therefore, real options create the possibility to adapt investments and its scopes to changing environmental conditions [31]. Hence, the value of a real option increases with an increasing uncertainty about future developments [32]. In case of unpredictable events an essential scope for action can be established using the real option approach [33]. Instead to make an investment decision on a certain date, an option allows to postponing the decision in favour or against the investment (fig. 3).

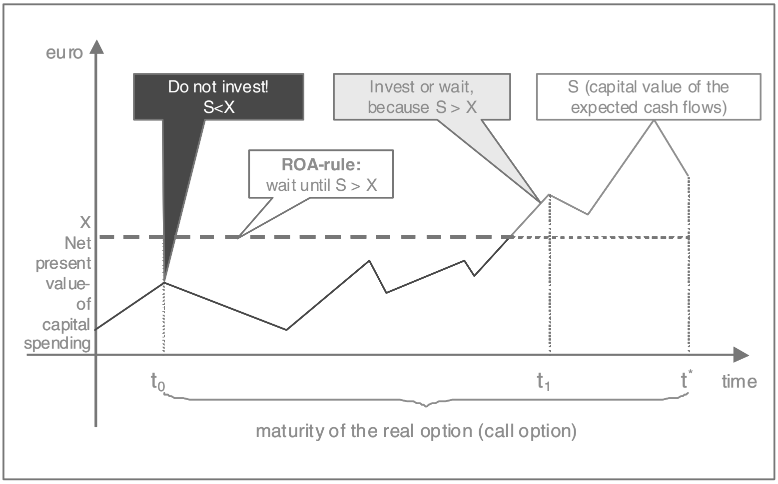

Fig. 3. Scope for decision-making with the real option approach [32]

Since people from industry are usually quite sceptical about the application of the real option approach due to the high mathematical complexity and many restrictions, a methodology has to be developed facilitating the application of the intuitive character of the option approach on the topic of the flexibility of orders. Additionally, it ought to assist the user’s comprehension through an adequate level of complexity. Not only is the real option approach meant to be used as an instrument for identification, evaluation and control of options but should also augment the understanding of the decision makers concerning their scope of action [34].

3.2 Introduction of Options in the Procurement Order Process

Purchasing processes in the machinery and equipment industry usually have uncertainties and alterations implied, especially when considerable modules are to be manufactured externally. Generally, at the beginning of a contract, a delivery date is set with the supplier to which the external service is to be completed. In case that during the production time new requirements are set on the part of the manufacturer or the customer, it would be an advantage if the possibility existed to access additional capacities of the supplier (fig. 4). Such a capacity option is to be considered as a guarantee for the manufacturer when the contract is concluded. The supplier ensures to provide additional capacities in order to maintain the delivery date.

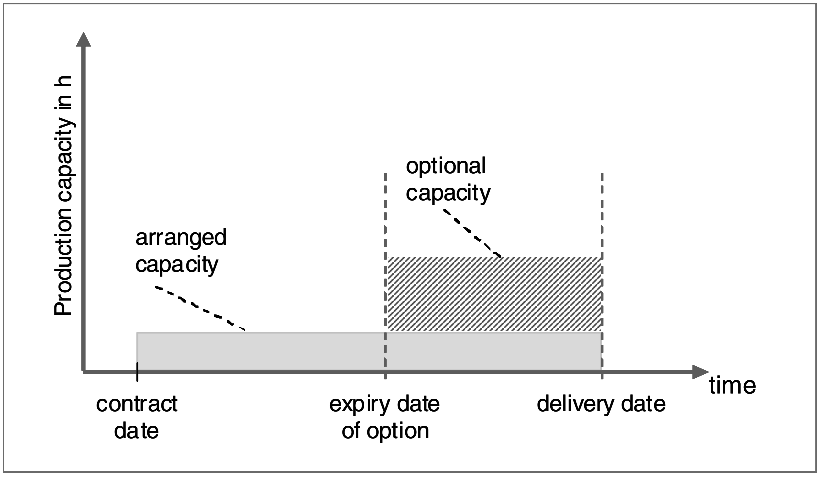

Fig. 4. Option on capacity extension

3.3 Conditions for the Application of the Real Option Approach on the Assessment of Procurement Order Flexibility

A precondition for the application of the real option approach on a new problem is the existence of exclusivity, flexibility, uncertainty, irreversibility and an investment (fig. 5) [29,35]. The reservation of capacities can be seen as an exclusive or at least advantageous initial situation for the utilization of capacities insofar the contractor the guarantees the reservation. As on reservation of capacities, no obligation but the right exists to access the additional capacities if a requirement on additional flexibility is needed. Uncertainties exist because the benefit of delivery reliability is unpredictable in the setup phase of the contract. The once paid reservation fee is irreversible and must be recorded as "sunk cost". The attribute of an investment can be verified if cash flows exist that begin with outgoing payments and result in incoming payments [36]. The investment in a timely delivery of a module in form of capacity reservation constitutes an investment in an intangible. It starts with a payment to the supplier for the capacity reservation and might result in an additive delivery reliability representing an advantage in terms of reduced setup time, rescheduling or delay costs, as well as possible follow-up orders.

Attributes	Financial option	Option on capacity extension
exclusiveness	Sole right of the owner to buy (Call) or sell (Put) a finacial title within a period for a predetermined price.	Exclusive reservation of production capacities, which can be used to guarantee the scheduled delivery date.
flexibility	Right but not an obligation to excercise an option.	The reservation must not be exercised
uncertainty & resolution	Excercise is depending on the ex ante uncertain performance of the financial title in the future. The uncertainty disappears over time.	The value of an scheduled delivery is not precise predictable at conclusion of the contract. But many uncertainties disappear over time.
irreversibility	The option expires with excercise or break-up (sunk costs).	An once paid option price has to be recorded as sunk costs.
gradual investement	The excercice price is typically a multiple of the option price.	The usage of development and production capacities requires further investment.

Fig. 5. Analogy between financial options and options on capacity extension for delivery reliability

3.4 Evaluation of the Option on Delivery Reliability

As the real option approach bases on various value drivers, these value drivers have to be adapted to the assessment of the specific circumstances (fig. 6) [32]. The monetary value of the expected efficiency gain of reduced setup time, rescheduling and delay costs as well as possible follow-up orders is equivalent to the *market price* of a financial asset. The *exercise price* can be interpreted as expenses for the supplier's capacity extension. The *volatility* can be understood as the uncertainty influencing the market price and exercise price. Beside demand fluctuations, uncertainties come from unspecified processes, uncertain events influencing the progress of internal activities or difficulties within the coordination with other suppliers. The *dividend* can be seen as loss of cash flow by waiting. In this connection, especially performance related expenses like monitoring costs or increased prices of supplier parts are to be mentioned. Increased prices can be caused by extra demand of competitors, general scarcity of raw materials or inflation. The parameters *period* and *risk free interest rate* are related to the parameters of financial options. The time period describes when the option on capacity extension expires. The risk free interest rate is usually gathered from the interest rate for short-term federal bonds.

Financial option	Parameter	Option on capacity extension
market price	**S**	**value of the scheduled delivery** costs that occur if the delivery time is not accurate
excercise price	**X**	**costs of scheduled delivery** costs of extra capacity on supplier site
volatility of the stock price	**σ**	**process stability in production** fluctuation in demand and production
option period	**t**	**option period** period in which the capacity option is executable
dividends	**D**	**running costs for monitoring of the procurement situation** increase of storage fee of the supplier
riskless rate	**i**	**riskless rate**

Fig. 6. Value drivers for the option on capacity extension

Regarding the evaluation of option prices the investigation focuses on proven assessment models that explain the complicated structures and connections in a relatively simple way. As such a procedure, the Lattice method offers the possibility to illustrate the benefit of an extended scope of action with the help of a tree structure analysis (fig. 7) [32]. In the first step, different scenarios are established that start on a negotiation date and show the various outcomes on the delivery date. Depending on the events occurring in this time period, different costs emerge due to the supplier's delay on the date of delivery. The discounting of these negative cash flows to the negotiation date results in the net present value of the delay costs. Secondly, another lattice tree is established taking the capacity extension into account. Assuming that the additional supplier’s capacities reduce the probability of a delayed delivery, this Lattice tree leads to a lower net present value of the emerging costs. Finally, the option price is calculated by subtracting the net present values from one another. The result is the option price for the reservation fee that has to be paid by the manufacturer to the supplier in order to receive the right to access the supplier's capacity in case of uncertain events. The manufacturer will only access this option if the time accuracy is worth more than the price of the capacity extension.

This monetary valuation of the option price for capacity extension together with the cause-effect analysis of the main impact factors influencing the delivery reliability are the main focus areas of the project InTime. In order to examine the adaptability of the methodology in practice, the approach will be validated in diverse case studies.

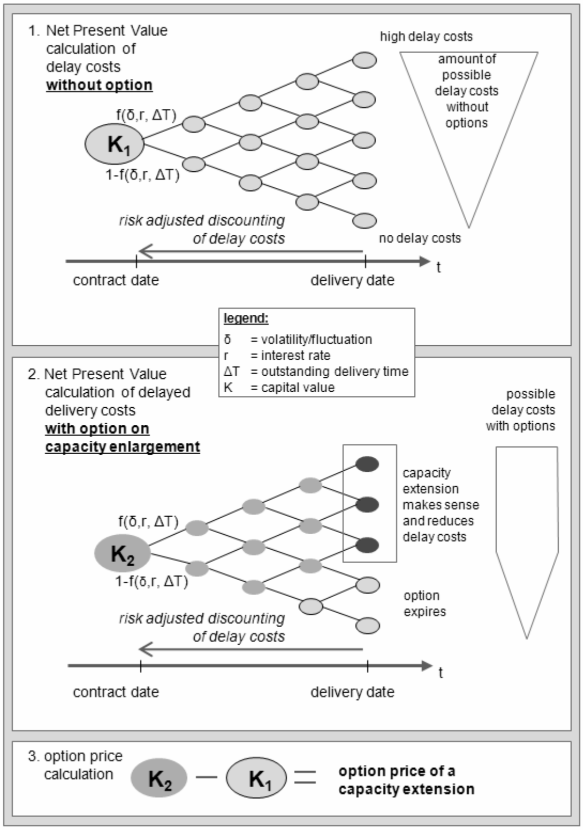

Fig. 7. Evaluation of purchasing flexibility using a lattice tree

4 Summary and Outlook

The situation with which producing companies are currently threatened due to the credit and real estate crisis clearly shows that the success of machine and equipment manufacturers does not only result from their technical excellence but also from strict value orientation [37]. Especially the coordination of external manufacturing of components requires new ways of thinking. Innovative methods have to be applied to evaluate, control and optimise logistical objectives like the delivery reliability. Due to its advantage to map the factors uncertainty and flexibility which cannot be represented by conventional evaluation procedures, the real option approach, founded in financial science, gains increasing interest and application within the decision making processes for real assets [33].

The essential advantage of the application of this approach from the point of view of the procurement logistics consists in realising the typical characteristics of deliveries with an option on capacity extension and in showing the effects of value adding. The additional benefit of the flexibility in purchasing can be understood easier by decision makers and, hence, can be included easier in their decision-making.

Within the framework of the European research project InTime the application of the above mentioned real option approach will be further investigated for the delivery adherence. The objectives are both the determination of the monetary value for timely deliveries as well as an internet-based application facilitating the negotiation of prices between suppliers and customers on such a platform. Finally, the developed models are validated by industrial project partners on the basis of a case study approach.

References

1. O.V.: Maschinenbau-Aufträge sinken um 42 Prozent, http://www.welt.de/wirtschaft/article3314855/Maschinenbau-Auftraege-sinken-um-42-Prozent.html (02.12.2009)
2. Becker, S.: Deutsche Werkzeugmaschinenindustrie hat Talsohle im Auftragseingang erreicht, http://www.vdma.org/wps/portal/Home/de/Branchen/W/WZM/Wirtschaft_und_Recht/Int_Maerkte_und_Konjunktur/Wzm_A_20091105_AE?WCM_GLOBAL_CONTEXT=/vdma/Home/de/Branchen/W/WZM/Wirtschaft_und_Recht/Int_Maerkte_und_Konjunktur/Wzm_A_20091105_AE (02.12.2009)
3. Schuh, G., Schweicher, B., Schmidt, C.: Globale Produktion mit flexiblem Quasi-Standard. wt Werkstatttechnik online 96(4), 226–232 (2006)
4. Geimer, H., Kühn, H., Salje, R.: Komplexitätsmanagement: Basis für erfolgreiches Supply Chain Management. Supply Chain Management 3, 43–48 (2005)
5. Dierig, C.: Talfahrt im Maschinenbau verlangsamt sich deutlich, http://www.welt.de/die-welt/wirtschaft/article5024420/Talfahrt-im-Maschinenbau-verlangsamt-sich-deutlich.html (02.12.2009)
6. Knoll, A.: Finanzkrise kommt im Maschinenbau an, http://www.elektroniknet.de/home/automation/news/n/d/finanzkrise-kommt-im-maschinenbau-an/ (02.12.2009)
7. Crimmann, A., Wießner, F.: Verschnaufpause dank Kurzarbeit. Bertelsmann Verlag, Nürnberg (2009)
8. Schmidt, C., Schweicher, B., Walber, B., Wienhold, H.: Referenzmodell überbetrieblicher Koordinationsprozesse: Effiziente Auftragsabwicklung mit myOpenFactory, pp. 73–88. Carl Hanser Verlag, Wien (2008)
9. Grasedyck, O.: Liefertermintreue als Schlüssel zu mehr Wettbewerbsfähigkeit, http://www.dieeinkaufsexperten.de/content/e7494/e7579/e8836/publication8839/LogistikfrUnternehmen5-6-2008-LiefertermintreuealsSchlsselzumehrWettbewerbsfhigkeit_ger.pdf (03.02.2010)
10. VDMA: Maschinenbau in Zahl und Bild (2008), http://www.ixpos.de/nn_1183434/DE/07Publikationen/00__Downloads/VDMA__Maschinenbau2008,templateId=raw,property=publicationFile.pdf/VDMA_Maschinenbau2008.pdf (03.02.2010)
11. McKinsey Quarterly: Understanding Supply chain Risk. No. 09, pp. 1--9 (2006)
12. Schuh, G., Kampker, A., Narr, C., Jasinski, T., Sander, S., Vogel, C.: Beschaffungslogistik im Maschinen- und Anlagenbau. Apprimus Verlag, Aachen (2009)
13. Stich, V., Kleinert, A., Brosze, T.: A networked business model improving inter-organizational processes. In: Helsinki University of Technology (ed.): APMS 2008 Innovations in Networks, pp. 331–335 (2008)

14. Schuh, G.: MyOpenFactory: In: International Journal of Computer Integrated Manufacturing 21(2), 215 (2006)
15. Pochard, S.: Managing Risks of Supply-Chain Disruptions. Massachusetts Institute of Technology Verlag, Boston (2003)
16. Fandel, G., Francois, P.: Just-in-Time-Produktion und -Beschaffung: ZfB - Zeitschrift für Betriebswirtschaft, pp. 531–544 (1989)
17. Zibell, R.: Just-in-time: Philosophie. Huss Verlag, München (1990)
18. Stölzle, W.: Industrial relationships. Oldenbourg Verlag, Wien (1999)
19. Corsten, D., Gabriel, C.: Supply-Chain-Management erfolgreich umsetzen, 2nd edn. Springer, Tokio (2004)
20. Brehm, L., Ferencak, R.: Potenziale von SCM-Software für das Management unternehmensübergreifender Prozesse, `http://www.wiso.boku.ac.at/uploads/media/scm-software2_01.pdf` (03.02.2010)
21. Fuchs, S.: Der Weg aus dem Rückstand über Synchronisierung der PPS. Industrieanzeiger 8, 70 (2008)
22. Vahrenkamp, R.: Produktionsmanagement, 6th edn. Oldenbourg Verlag, München (2008)
23. Keller, M., Hellingrath, B.: Kennzahlenbasierte Wirtschaftlichkeitsbewertung in Produktions- und Logistiknetzwerken. In: Otto, A., Obermaier, R. (eds.) Logisitkmanagement, pp. 51–75. Deutscher Universitätsverlag, Wiesbaden (2007)
24. Otto, A., Obermaier, R.: Logistikmanagement, 1st edn. Dt. Univ.-Verlag, Wiesbaden (2007)
25. Lander, D., Pinches, G.: Challenges to the practical implementation of modelling and valuing real options. The Quarterly Review of Economics and Finance 38(Special issue), 537–567 (1998)
26. Hommel, U., Lehmann, H.: Die Bewertung von Investitionsobjekten mit dem Realoptionsansatz. In: Hommel, U., Scholich, M., Vollrath, R. (eds.) Realoptionen in der Unternehmenspraxis, pp. 113–129. Springer, Heidelberg (2001)
27. Copeland, T., Keenan, P.: How much is Flexibility worth? The McKinsey Quarterly 2, 38–49 (1998)
28. Trigerorgis, L.: Real Options and Interactions with Financial Flexibility. Financial Management 22(3), 202–224 (1993)
29. Pritsch, G.: Realoptionen als Controlling-Instrument, 1st edn. Dt. Univ.-Verlag, Wiesbaden (2000)
30. Myers, S.: Determinants of corporate Borrowing. Journal of Financial Economics 5(2), 147–176 (1977)
31. Hommel, U., Pritsch, G.: Marktorientierte Investitionsbewertung mit dem Realoptionsansatz. Finanzmarkt und Portfolio Management 13(2), 121–144 (1999)
32. Trigeorgis, L.: Real Options. MIT Press, Cambridge (1996)
33. Batran, A.: Realoptionen in der Lieferantenentwicklung, 1st edn. Betriebswirtschaftlicher Verlag Dr. Th. Gabler, Wiesbaden (2008)
34. Pritsch, G., Weber, J.: Die Bedeutung des Realoptionsansatzes aus Controlling-Sicht. In: Hommel, U., Scholich, M., Vollrath, R. (eds.) Realoptionen in der Unternehmenspraxis, pp. 13–43. Springer, Berlin (2001)
35. Hommel, U., Pritsch, G.: Investitionsbewertung und Unternehmensführung mit dem Realoptionsansatz. In: Achleitner, A., Thoma, G. (eds.) Handbuch Corporate Finance, pp. 1–67. Deutscher Wirtschaftsdienst Verlag, Köln (1999)
36. Götze, U.: Investitionsrechnung, 6th edn. Springer, Berlin (2008)
37. Schuh, G.: Lean Innovation Capability. In: Schuh, G., Wiegand, B. (eds.) Tagungsband/ 5. Aachener Management Tage, pp. 1–18. Apprimus-Verlag, Aachen (2008)

Business Capabilities Centric Enterprise Architecture

Thiago Barroero, Gianmario Motta, and Giovanni Pignatelli

University of Pavia, Department of Computer Engineering and Systems Science,
via Ferrata 1, 27100 Pavia, Italy
{thiago.barroero,gianmario.motta,giovanni.pignatelli}@unipv.it

Abstract. In the field of Enterprise Architecture, The Open Group Architecture Framework (TOGAF) is a well known framework, that links Business Architecture, Data Architecture, Application Architecture, Technology. A key concept within Business Architecture domain is Business Capabilities, that are delivered by Business Component (BC). A BC is a business unit that encompasses a coherent set of activities, supported by assets including people, processes and technology. Current TOGAF version recognizes the BC requirements but misses how to bridge those requirements with a data, application and technology architecture. Defining the bridge is specifically the purpose of our extension called Business Capabilities Centric Enterprise Architecture (BCCE), where we adapt some TOGAF phases, extend the core TOGAF meta-model and add architectural contents. We have validated our approach on a telecommunication example taken from literature. A major benefit of the proposed extension is to link changes of business to data, application and technology architectures.

Keywords: Enterprise Architecture, TOGAF, Business Capabilities.

1 Introduction

1.1 Enterprise Architecture and Business Capabilities Modeling

Nowadays scenario of Enterprise Architecture (EA) testifies a plethora of frameworks [1] from which it is hard to determine which one is *better* than another, for they differ in goal and in approach. The point is that each framework has specific characteristics and has been developed for a specific purpose. Still, The Open Group Architecture Framework (TOGAF) is the result of best practice [7] and the second framework most used overall [2]. TOGAF is specifically conceived as cross-industry open standard for enterprise architecture. Across the board the principle that EA is critical to business survival and success, and is an indispensable means to achieve competitive advantage through IT. Inspecting IBM CEO survey 2008 [3], it is plain that the enterprise of the future requires EA for responsiveness and innovation are achievable only if an integrated and responsive IT environment is supportive of the delivery of business strategy. In order to overcome today's imperatives of growth and profitability, firms must focus on responsiveness, innovation, differentiation and efficiency [3], and should embrace the concepts of Business Capabilities through *Componentization of Business* [4].

P. Bernus, G. Doumeingts, and M. Fox (Eds.): EAI2N 2010, IFIP AICT 326, pp. 32–43, 2010.

Componentization breaks down each enterprise capability into business component (BC). Each BC is an individual business model that encompasses a coherent set of activities, supported by assets including people, processes and technology. A component serves a unique purpose within the organization but could also, in principle, operate as an independent entity [5]. A BC is characterized by a distinctive high-level capability that it offers to the Enterprise. This possessed ability is used to achieve a specific purpose or outcome. In other words, BCs are the modular building blocks that compose an enterprise.

1.2 Business Capabilities Models

A Business Capability model includes the description of capabilities and connections, how services are provided, their performance metrics, the people responsible for the service, and the systems that provide support for them. In general, business component may be modeled in two very different ways [6] that lead to diverse patterns described in Table 1.

Table 1. Modeling Business Capabilities Description

	Strategic Modeling	Functional Modeling
Objective	To produce a model that enables the identification of business challenges and business opportunities.	To produce a model of each business component that enables its implementation, either on a business view (i.e. organizational structure, accountability, processes and activities, business services etc.) or on a IT view (i.e. design of systems, applications, software artifacts etc.).
Outcome	A business model, usually a paper or a tool-based model, that focuses on sensitive components.	A detailed design of all dimensions of each component
Primary Audience	Business executives	Business and IT managers

A BC is orthogonal to the overall domains of an EA. A generic EA divides the architecture in four domains [7], namely Business, Data, Application and Technology Architecture shortly summarized inTable 2.

Table 2. Enterprise Architecture Domains

Architecture Type	Description
Business Architecture	The business strategy, governance, organization, and key business process.
Data Architecture	The structure of an organization's logical and physical data assets and data management resources
Application Architecture	A blueprint for the individual application systems to be deployed, their interactions, and their relationships to the core business processes of the organization
Technology	The software and hardware capabilities required to support the deployment of business, data and application services. This includes IT infrastructure, middleware, networks, communications, processing, and standards.

BC modeling is incorporated in methodologies, including those by IBM and Microsoft. Let us consider their profile and position our approach.

IBM CBM Approach

IBM Component Business Modeling (CBM) [4][5][15] focuses on business change and transformation of enterprises. CBM identifies business challenges and business opportunities and analyzes the role of each BC in terms of specialization and differentiation. In other words, CBM enables to determine building blocks for the future business in different areas and across operational functions. The approach guides the architect in identifying gaps between current and future state showing requirements to be met (fit-gap analysis), but, alas, does not guide the analyst in defining how to bridge requirements with a data, application and technology architecture design.

Microsoft Motion

In [7] [9] Homann and Tobey describe a Microsoft approach to “model a business architecture as a network of capabilities, and then transform the business architecture into a service-oriented architecture.” The Microsoft Motion methodology provides an approach to link a business modeling to an IT implementation related to Web Service technology. Motion is a top-down approach, from business to IT requirements. The methodology addresses architectural issues like capabilities view, people view, process view, technology view and Service Level Expectations (SLE), but does not describe how steps are performed, e.g. how components should be selected or decomposed, nor links BC to the information systems.

Other Approaches

Business Capability Mapping and Analysis (BCMA) by Helix Commerce International Inc. [10] focuses on capabilities and its alignment with business processes. It is based on customers’ needs and priorities. The approach may be considered as an EA Framework as it bridges the chasm between Strategy, Process, Architecture, and Technology and brings greater clarity to the as-is state and capabilities of a organization, and its alignment to the to-be vision of the business.

Capgemini reports an approach adopted to support insurance companies that uses a business component architecture [11]. The methodology divides the business into functions called components and analyzes each aspect of the business that impact on the performance of a business component. The Business Component Architecture models the business architecture by identifying components and their relationship, it designs a target solution based on the component map in a manner that covers all functions that must be supported with no overlap and finally design and implement a insurance enterprise system to support the business functions.

Finally, enhanced Telecom Operation Map (eTOM) [12] is a detailed description of the business processes of a generic telecommunication company, decomposed to a deep level of detailed. If we observe the eTOM map decomposed down to the third level, we may consider those “processes” as components for they represent business functions.

1.3 Summary and Positioning

After this short review, we position the BC models in terms of their orientation (functional or strategic), their target (industry, cross industry) as in Table.

Table 3. Comparative profile of business components models

Model Name	Orientation	Target	EA Integration
IBM - CBM	Strategic	Cross Industry	Missing
MS - Motion	Functional	Cross Industry	Missing
Helix - BCMA	Strategic	Cross Industry	????
Cap Gemini	Functional	Insurance	OK
eTOM	Functional	Telecom	OK

Apparently, a well-established and mature business capability centric approach that grants EA design, implementation and governs is still missing. The main purpose of this paper is to fill this gap. As a host methodology we have chosen TOGAF since [2]:

- Is supported by an open strong committee
- Is a proven method and result of long term practice
- Uses a standard taxonomy for business, information, and technology modeling.
- Has a business focus in the architecture development
- Is supported by many tools.

On the other side, Zachman is the most used framework, but it is a taxonomy rather than a methodology [2].

2 TOGAF Extension

"TOGAF provides the methods and tools for assisting in the acceptance, production, use and maintenance of an enterprise architecture. It is based on an iterative process model supported by best practices and a re-usable set of existing architecture assets." [7] and includes several parts. The TOGAF structure includes a core and a certain number of extensions. Extensions add method steps, meta-model entities and artifacts. BCCE is one of the possible TOGAF extensions. Specifically Business Capabilities Centric Extension (BCCE) introduces the BC concept in the TOGAF core structure and changes it in some parts as shown in Table 4.

2.1 Changes in TOGAF Part II - Architecture Development Model (ADM)

The main changes in Part II - Architecture Development Model include

- Integration of the Componentization of Business principle as a constraints of the Enterprise Architecture structure

Table 4. Impact of BCCE on TOGAF

TOGAF Part	Comments	Impact of BCCE
Part I Introduction		
Part II Architecture Development Model (ADM)	Describes a process for deriving an organization-specific enterprise architecture that addresses business requirements	Additions to the method steps to include BC concepts
Part III ADM Guidelines & Techniques	Supports ADM	• Added the principle "Componentization of Business" • Added Architectural Artifacts
Part IV Architecture Content Framework	Provides a detailed model of architectural work products, including deliverables, artifacts within deliverables	Changes to the core meta-model entities
Part V Enterprise Continuum	A model for structuring a virtual repository and provides methods for classifying architecture and solution artifacts.	---------------
Part VI Architectural Reference Models	TOGAF provides two reference models for inclusion in an Enterprise Continuum	---------------
Part VII Architectural Capability Framework	A set of resources, guidelines, templates and background information	---------------

Table 5. The principle of Componentization of Business

Name of principle	Componentization of Business
Statement	Well-defined business units called Business Components (BC) compose the Business Architecture. Each BC encompasses a distinctive set of capabilities, activities and resources, and interacts with other components through services. Each BC has to be considered as a "centre of services".
Rationale	Componentization of business delivers a modular enterprise architecture that that potentially is more responsive to business changes.
Implications	- Componentization of business brings a revolutionary change to enterprise organization for it divides the business into separated business units. - Componentization places a big constraint on business inter-component communication, because every exchange of value or information should be conducted through business services. - Componentization generates an environment where every unit of an enterprise acts like a producer of services; thus, every part could be managed as a single independent organization itself. The whole organization should be fully componentized in order to benefit from componentization.

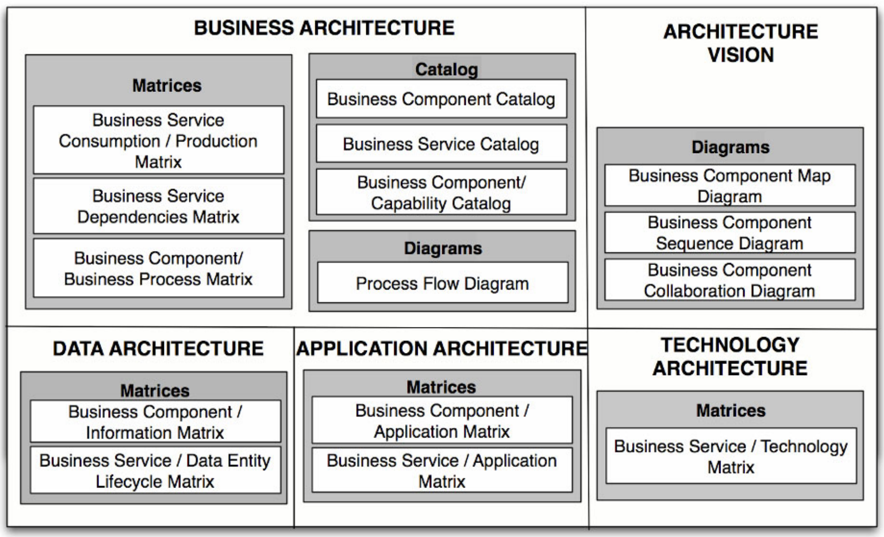

Fig. 1. TOGAF viewpoints taxonomy of BCCE

Table 6. BCCE Diagrams and Matrices Description

Entity	Description
Business Component Map Diagram	A business component map diagram provides an overview of the enterprise as a whole illustrating high-level capabilities of the enterprise.
Business Component Collaboration Diagram	A business component collaboration diagram provides a static description of the interaction between components on a specific business scenario. It shows main business services exchanged by components.
Business Component Sequence Diagram	A business component sequence diagram provides a time sequence high-level workflow for the specific business scenario. It provides information on timing and dependencies of business services
Process Flow Diagram	A process flow diagram describes the workflow on a level of detail that shows activities, business rules and information flow.
Business Service Consumption/Production Matrix	The matrix shows which business component produces business services and which one consumes it.
Business Component/ Business Process Matrix	The matrix shows which business component is involved in which business process.
Business Service Dependencies Matrix	The matrix shows the dependencies between business services.
Business Component/ Information Matrix	This matrix shows for each component what source of information is required.
Business Service /Data Entity Lifecycle Matrix	This matrix shows the data lifecycle (CRUD) used by business services.

- Description of the Architecture Vision in terms of business capabilities trough Business Component Map Diagram and Business Component Collaboration Diagram;
- Introduces in Capability Assessment the strategic value added by BC.

2.2 Changes in TOGAF Part III – ADM Guidelines and Techniques

The first change is the Componentization of Business as a new principle for Enterprise Architecture (Table 5).

Part III also contains new architectural artifacts that are required by method steps described in Part II. Figure 1 shows BCCE added artifacts and describes their respective content.

2.3 Changes in TOGAF Part IV - Architecture Content Framework

We have extended the TOGAF core meta-model by introducing or redefining concepts of the BC approach. Figure 2 shows the changes to core TOGAF meta-model and Table 7 describes them. The foundations of our contents extensions are available in [13] [14] [15].

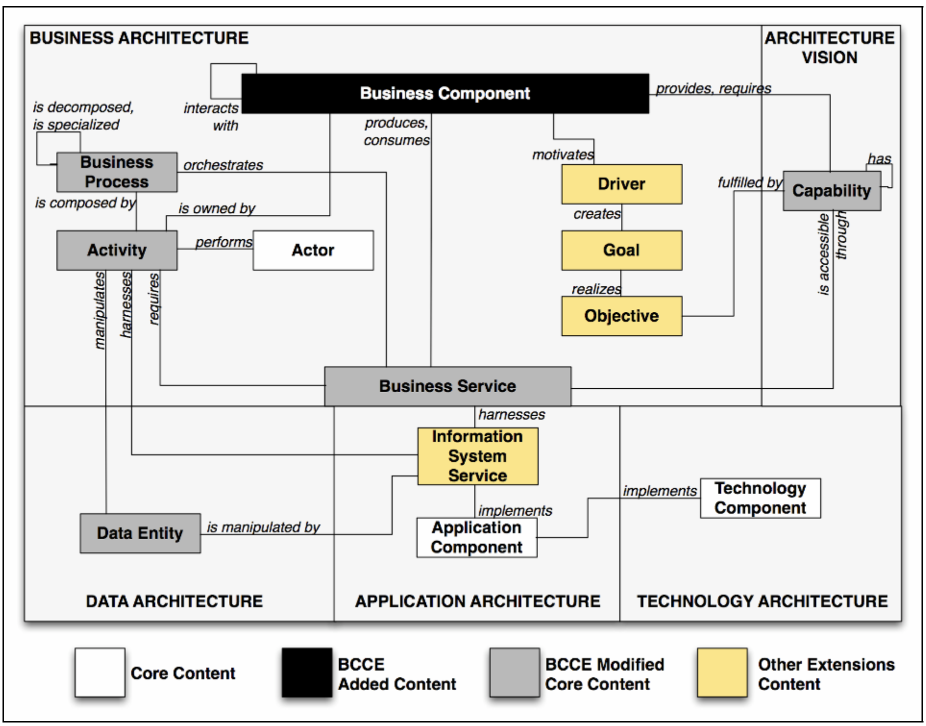

Fig. 2. Business Capabilities Centric Extension (BCCE): Changes to Metamodel

Table 7. BCCE Changes to TOGAF meta-model description

Entity	Description	Change Type	Notes
Business Component	A business component encompasses a coherent set of activities, supported by assets including people, processes and technology. It interacts with other business components through business services.	New	
Capability	A capability is the "power or the ability to do something". It is an idealized conceptual structure that describes what a BC can do to creates value for customers. It is accessible through business services and identifies what is required to accomplish a business objective.	Modified	Each capability can be associated to one and only one BC
Business Service	A business service is an interface through which other components requires or provides a capability. It is standardized and hides its implementation from other components.	Modified	BCs can exchange value only trough business services.
Activity	An activity is an atomic operation performed within a BC and belongs exclusively to a single component. It represents an operation performed to provide low-level capability.	Modified	Each Activity can be associated to one and only one BC
Business Process	A business process represents the procedures required to provide a capability, i.e. the governance required to orchestrate business services, activities, resources and technology.	Modified	Business Process is a composition of Business Services
Data Entity	A data entity is a major source of data that must be understandable, consistent, complete and stable. It is used by and activity through an information system service.	Modified	Data Entity can be handled only by Business Services and Information Systems Services.
Information System Service	An information system service represents an IT functionality implemented as a service that may encompasses a set of activities or even represent a fully automated business service.	Modified	Each system function can be implemented only by Information System Services

3 Validation

Let's consider a telecommunication organization that whishes to capitalize the emerging of new opportunities such as DSL demand in his country. Due to processes inefficiency and the complexity of a DSL offer, the intervention requires a re-design of business processes and organization in order to govern and manage demand planning, network planning and order management. The case is taken from NGOSS Framework for it is a best practice on the Telecommunication industry adopted in the world by major Telco companies.

In order to assess enterprise capabilities we built a Business Component Map diagram based on eTOM level 3 processes. In Figure 3 we identified the direct and indirect impacted components in order to deliver a DSL service. The map quickly

Table 8. Resource Provisioning BC capabilities decomposition

Goal	Guarantee that resource orders are issued correctly and complete.	
Capability	Ability to issue correct and complete resource orders.	
Ability to initiate a resource order assessing the information contained on a service order.	State	*Specified*
Ability issue resource orders that require a feasibility assessment, new provisioning activities, change to a previous resource order, or require the deletion/recovery of previously delivered resource orders.	State	*Specified*
Ability to manage specific or unusual requirements.	State	*Specified*

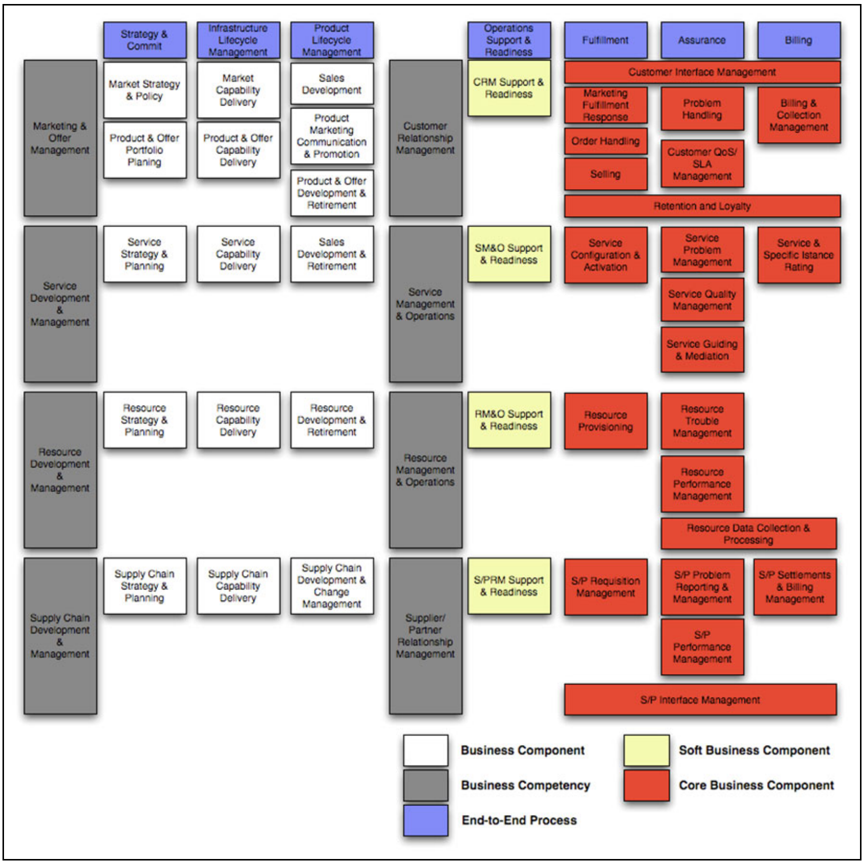

Fig. 3. Business Component Map Diagram for a telecommunication enterprise

shows what components of the enterprise are required for the desired service and become a requirement for further modeling. For each business component a catalog of sub-capabilities is created to identify what ability should have each BC. Table 8 shows a catalog of capabilities for the Resource Provisioning BC aligned to the BC goals.

Then, we defined a business scenario for each process that composes a DSL Service, namely DSL Fulfillment, DSL Assurance and DSL Billing. For each one of them we designed a Business Component Collaboration diagram to identify main business services exchanged between components. Figure 4 shows the Collaboration Diagram referred to a DSL Fulfillment sub-process, i.e. DSL Pre-sales sub process. Those viewpoints together with the dynamic collaboration viewpoint addressed with UML Sequence Diagrams represent a high-level vision of the desired behavior and structure of our target enterprise architecture.

Hereafter we start a functional modeling of each component. For each Business Component Collaboration View, a process flow is drawn in order to identify activities and information flows and to validate business services.

When the business architecture phase is over, an analysis of main source of data was conducted. For each business service we identified how data entity was manipulated building the Business Service / Data entity Lifecycle Matrix showing CRUD (Create, Read, Update, Delete) relations. Furthermore, we identified source of data for each activity described during the process flow analysis.

Finally, we identified system services by analyzing data manipulation. Our goal was not to provide a system design but describe system as group of low-level capabilities that manage data of the data architecture and support activities on business architecture. At last, we related application components to technology components.

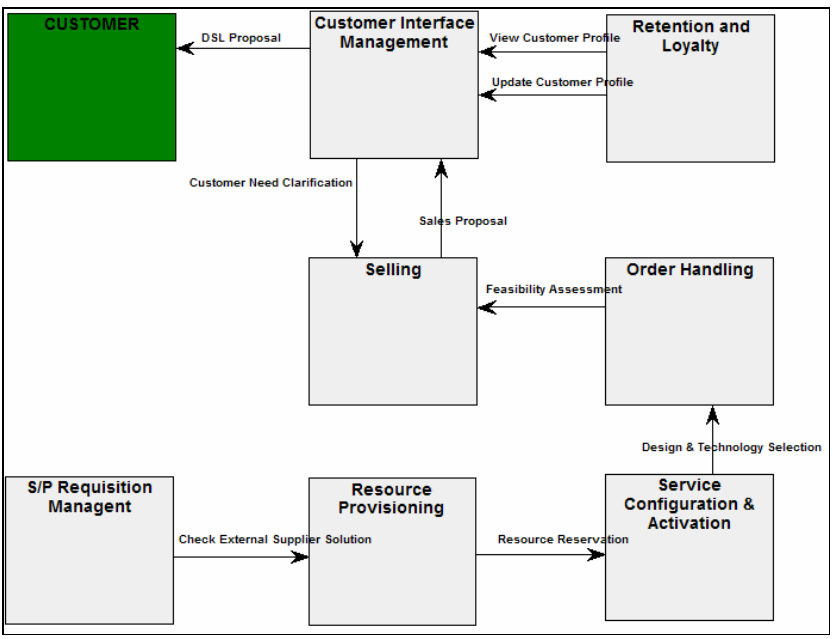

Fig. 4. Business Component Collaboration Diagram. DSL Fulfillment. Pre-sales sub-process.

4 Conclusions

We have illustrated the integration of a the Business Component approach into the TOGAF framework. This integration implies multiple potential benefits.

First it links business strategy and IT strategy by a very convincing model. For Business Component approach is a very popular method among enterprise consultants to identify a modularization of the enterprise in the perspectives of business development, sourcing and out-sourcing.

Second the link between the business component concept and related information architecture is clear and easy to understand. In fact from a business strategic viewpoint Business Component is a Business Unit and from IT viewpoint it is a cluster that receives and delivers services.

Third Business Component allows by its very nature a modularization of IT architecture, that potentially enhancing its responsiveness to sudden business and environmental changes. Moreover the alignment of IT to Business comes almost as a byproduct of mating Business Component into Information Architecture.

Next steps include a formal field validation and a subsequent step its formal integration in the TOGAF framework body.

Business Component Approach is a strategic modeling procedure that is taking place over last years. It focuses mainly on decision-making steps for it defines scopes, required capabilities and strategic evaluations. We used TOGAF 9 to fill the gap between the outcome of the business component approach and an EA framework. Next step would require a detailed description of EA with a service oriented architecture supporting business component approach.

References

1. Schekkerman, J.: Institute for Enterprise Architecture Developments (IFEAD). Trends in Enterprise Architecture. Reports of the Thirds Measurement, Edition 1.0, Suikerpeergaarde 4, 3824BC Amersfoort, The Netherlands (December 2005)
2. Minoli, D.: Enterprise Architecture A to Z. Frameworks, Business Process Modeling, SOA, and Infrastructure Technology. Auerbach Publications. Taylor & Francis Group (2008) (Hardcover), ISBN 978-0-8493-8517-9
3. IBM Global CEO Study. The Enterprise of the Future. Executive Summary. GBE03044-uSEn-01 (2008)
4. Cherbakov, L., et al.: Impact of Service Orientation at the Business Level. IBM Systems Journal 44(4) (2005)
5. Pohle, G., Korsten, P., Ramamurthy, S., Foecking, S.: The Specialized Enterprise. A Fundamental Redesign of Firms And Industries. IBM Business Consulting Services (2005)
6. Herzum, P., Sims, O.: Business Component Factory: A Comprehensive Overview of Component-Based Development for the Enterprise. Wiley Press, Hoboken (2000)
7. The Open Group. TOGAF Version 9. The Open Group Architecture Framework. Document Number G091. Published by The Open Group (2009), ISBN 978-90-8753-230-7
8. Homann, U., Tobey, J.: Building Distributed Applications. From Capabilities to Services: Moving from a Business Architecture to an IT Implementation. MSDN Library (2006)
9. Homann, U.: Building Distributed Applications. A Business-Oriented Foundation for Service Orientation. MSDN Library (2006)

10. Helix. Business Capabilities Mapping and Analysis (BCMA). Helix Commerce International Inc. (2006)
11. Linan, R.: The Smart Insurance Enterprise System (SIES). Capgemini Financial Services (September 2007)
12. Enhanced Telecom Operations Map (eTOM). The Business Process Framework. For the Information and Communication Industry. Release 6.0. TeleManagement Forum (2005)
13. Ackermann, J., Turowski, K.: Specification of Customizable Business Components. In: Euromicro, 29th Euromicro Conference (EUROMICRO 2003), p. 391 (2003)
14. McDavid, D.W.: A Standard for Business Architecture Description. IBM Systems Journal 38(1) (1999)
15. Ernest, M., Nisavic, J.M.: Adding Value to the IT organization with the Component Business Model. IBM System Journal 46(3) (2007)
16. Pohle, G., Korsten, P., Ramamurthy, S., Foecking, S.: The Specialized Enterprise. A Fundamental Redesign of Firms And Industries. IBM Business Consulting Services (2005)

An Enterprise Architecture Approach towards Environmental Management

Ovidiu Noran

Griffith University Australia, School of ICT
O.Noran@griffith.edu.au

Abstract. Environmental responsibility is fast becoming an important aspect of strategic management as the reality of climate change settles in and relevant regulations are expected to tighten significantly in the near future. Many businesses react to this challenge by implementing environmental reporting and management systems. However, the environmental initiative is often not properly integrated in the overall business strategy and as a result the management does not have timely access to appropriate environmental information. This paper argues for the benefit of integrating the environmental management (EM) project into the continuous enterprise architecture (EA) initiative present in all successful companies. This is done by demonstrating how a reference architecture framework and a meta-methodology using EA artefacts can be used to co-design the EM system and the organisation in order to achieve an appropriate synergy.

Keywords: Environmental management, enterprise architecture.

1 Introduction

The existence and success of businesses depends not only on their economic sustainability but also on their impact on the natural environment and the way they treat their workers. This basic truth was emphasized by Elkington's (1998) Triple Bottom Line (TBL) approach to business sustainability: one must achieve economic bottom-line performance but also environmental and social accomplishment. Thus, Blackburn (2007) compares economic sustainability to air and environmental and social sustainability to food: the first is more urgent but not more important than the second. The '2Rs' (Respect for humans and judicious Resource management) are another essential component of overall sustainability of the business. Hence, a successful enterprise must take a whole-system approach to *sustainable development* (UN World Commission on Environment and Development 1987). This paper focuses on the challenges presented by the proper integration of the environmental sustainability aspect in the business and proposes a solution addressing these challenges based on an EA approach.

2 Tackling Environmental Management Integration

To date most EM efforts within an enterprise are rather disjointed, i.e. specific to business units and not properly supported by the ICT infrastructure. This means that

P. Bernus, G. Doumeingts, and M. Fox (Eds.): EAI2N 2010, IFIP AICT 326, pp. 44–55, 2010.

a) different units approach environmental sustainability in different levels of detail and at a different pace, b) there is a possible loss of aggregate capabilities due to the various departments not 'understanding' each other's approach to sustainability and c) top management cannot effectively use the information generated by the environmental reporting functions due to language, format, level of aggregation etc.

Strategic integration of EM is only achievable if the necessary information is at the fingertips of managers in the form and level of aggregation they need (Molloy 2007). Therefore the EM initiative must be accompanied by and integrated with changes in the enterprise's information system (IS), necessary to provide effective access to environmental information facilitating the decision-making process (Nilsson 2001; Molloy 2007). For the EM project to succeed in the long term, i.e. to determine *permanent* changes in the way people act, there will be a need for:

a) top-management support for the project champion(s);
b) sufficient authority and appropriate human / infrastructure resources;
c) a suitable strategy integrated in the general company strategic direction;
d) a cross-departmental approach.

The above-mentioned requirements match to a good extent the scope of typical enterprise architecture (EA) projects; it is therefore proposed here that EA could provide a solution to an integrated approach to the introduction of environmental aspects in the management and operation of all business units. This is desirable because a company whose architecture includes EM competencies and responsibilities in an integrated fashion will have the necessary *agility* and *preparedness* to cope with the challenges brought about by climate change, thus turning a potential weakness into strength. The EM project would involve some of the steps below:

a) identifying the business processes and their environmental impact (AS-IS);
b) defining a vision and concept(s) for the future state (the TO-BE),
c) eliciting and specifying requirements to reach the selected TO-BE state,
d) (re)designing the processes and policies according to these requirements
e) implementing the processes and policies previously designed;
f) continually monitoring the effects and
g) applying some of the previous steps for correction and enhancement.

These phases reflect the continuous improvement Plan-Do-Check-Act cycle (Shewhart 1986).

3 Environmental Management Artefacts: A Brief Analysis

Companies typically address the requirement to introduce environmental responsibility in their business units by attempting to implement some type of environmental reporting and environmental management system (EMS).

While an EMS is a step in the right direction, when implemented in isolation it may not trigger the cultural change necessary to achieve permanent environmental responsibility. Some authors (Coglianese and Nash 2001) argue that the implementation of an EMS alone is irrelevant in the absence of a *real* commitment to environmental improvements. Relevant regulation, for example ISO 14001:2004 (ISO 2004) only requires that an EMS be designed in such a way that companies can work toward the goal of regulatory compliance and seek to make improvements, not that the company actually achieves compliance with existing law.

Various reference models (frameworks, methods etc) and alternatives to EMS design have emerged. For example, Blackburn (2007) proposes a 'Sustainability Operating System' - in fact, a management method to achieve sustainability based on the Brundtland report (UN World Commission on Environment and Development 1987), the '2R's and the TBL approach applied to sustainability. Willard (2002) also recommends a TBL-based approach encompassing economy / profit, environment / planet and equity / people with seven benefits: easier hiring and retention, increased productivity, reduced manufacturing / commercial sites expenses, increased revenue / market share and reduced risk. Clayton and Redcliffe (1998) propose a systems approach to integration of sustainability aspects into the business and define the concept of environmental quality as capital (and thus the feasibility of 'tradable pollution').

EM frameworks aim to provide a structured set of artefacts (methods, aspects, reference models, etc) specialised for the EM area. Some examples are The Natural Step (TNS) Framework, using a systems-based approach to organisational planning for sustainability (Upham 2000), The Natural Edge Project (TNEP 2007) which proposes a holistic approach ('Whole System') taking into account system life cycle and the Life Cycle Management Framework for continuous environmental improvement (Hunkeler 2004).

Assessment and reporting frameworks aim to assist the measurement and reporting functions of the EMS. For example, the Life Cycle Assessment (LCA) method measures the environmental impacts of products or services relative to each other during their life cycles (EPA 2008). The Global Reporting Initiative's sustainability reporting framework (GRI 2002) contains reporting principles, guidance and standard disclosures potentially applicable to all types of businesses.

International Standards also cover the EM issue. ISO 14000:2004 is a set of reference models for EMS setup, life-cycle assessment, environmental auditing of processes, environmental labelling and environmental performance evaluation. ISO 14001:2004 deals specifically with EMS-s, aiming to provide a framework for a holistic and strategic approach to the organization's environmental policy, plans and actions (ISO 2004). Standards provide a good starting and reference point for design and assessment; however, as mentioned current EM standards do not define EM performance levels that the company should meet.

Many of the above-mentioned artefacts recognize the need to analyse the life cycle of the products. However, in reality it is often required to also take into account other life cycles – such as those of the host company, of its IS, of the projects set up to (re)design the IS and create the EMS and especially of the EMS itself. It is also necessary to analyse the interactions between these entities in that context. This approach provides a holistic perspective, allowing to represent and understand the business, the relevant projects, the target EMS, its impact on the IS and to identify potential problems and aspects that may not be otherwise obvious. Frameworks describing systems during their entire life (not just at particular points in time), also called *life cycle architectures* are commonly used in EA.

4 Enterprise Architecture Frameworks, GERAM and GERA

Enterprises are highly complex systems. Therefore, sets of models (sometimes aggregated in *architectural descriptions* corresponding to *viewpoints* representing stakeholders (ISO/IEC 2007)) are produced using various languages in order to control this complexity and allow the enterprise architect and other stakeholders to focus on various aspects of the business. Other types of artefacts commonly used to structure knowledge in EA practice are modelling frameworks (MFs), methods, reference models, ontologies, metamodels, glossaries, etc; they are typically organised in architecture frameworks (AFs), some of which have underlying metamodels formally describing their structure. Currently there are several mainstream AFs, generic (e.g. PERA (Williams 1994), TOGAF (The Open Group 2006)) or aimed at various domains such as manufacturing (CIMOSA (CIMOSA Association 1996), ARIS (Scheer 1999)), defence (DoDAF (DoD Architecture Framework Working Group 2004), information systems (Zachman 1987), etc.

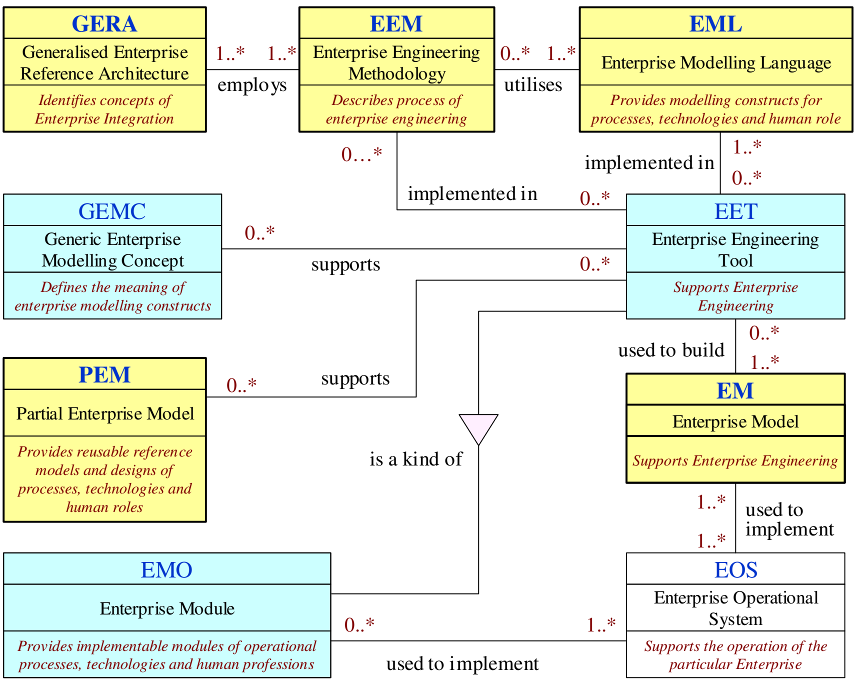

Fig. 1. A high-level meta-model of GERAM (based on (ISO/IEC 2005))

In this research we have selected a reference framework obtained by generalising other AFs and thus potentially expressive enough to contain all the elements necessary to achieve environmental management integration using EA artefacts. This AF is GERAM (Generalised Enterprise Reference Architecture and Methodology), described in ISO 15704:2000. GERAM has been used in practice to guide EA projects (Bernus, Noran et al. 2002), to assess other enterprise AFs (Noran 2003b; Noran 2003a; Noran 2005a; Saha 2007) and to build a structured repository of AF elements for a project management decision support system (Noran 2007a). For more details on GERAM see (ISO/IEC 2005).

The main component of the Reference Architecture of GERAM (called GERA, see Figure 1) is a MF containing an extensive set of aspects including life cycle, management, organisation, human and decision, corresponding to various stakeholder concerns (ISO/IEC 2007). A subset of GERA has been used as a modelling formalism in the creation of a life cycle-based business model as subsequently shown in this paper.

5 A Meta-methodology for Enterprise Architecture Projects

The paper argues that EA can provide an overarching and life cycle-based approach in setting up and operating an EM project aiming to produce an EMS in an integrated and coherent manner in relation to the host organisation and other relevant external entities. To illustrate this approach, the researcher has used a *meta-methodology*, or a 'method to build methods' applicable for specific types of EA tasks (projects), based on an original approach abiding by EA principles. The meta-methodology, first defined in (Noran 2004; Noran 2005b) and tested in several case studies (Noran 2006; Noran 2007b; Noran 2008), employs a set of steps and sub-steps as shown in Figure2.

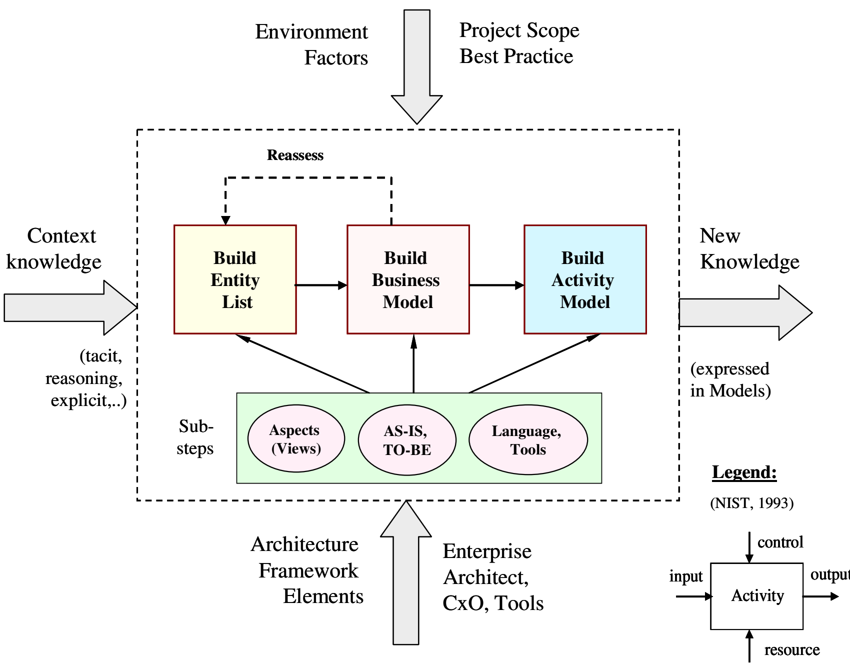

Fig. 2. Meta-methodology concept (Noran 2009a)

In the first step, the user is prompted to create a list containing entities of interest to the project in question, including project participants, target entities (organisations, other projects) and importantly, the project itself. The second step comprises the creation of business models showing the relations between the previously listed entities *in the context of their lifecycles*, i.e. illustrating how entities influence each other within each life cycle phase (several aspects can be represented, see sub-step one). The third step assists the user in inferring the set of project activities by reading and interpreting the previously represented relations for each life cycle phase of the project and other target entities. The resulting activities are then decomposed (using aspects selected according to sub-step one) to a level deemed suitable for the intended audience.

The first meta-methodology sub-step calls for the selection of suitable aspects (or views) to be modelled in each stage. The life cycle aspect must be present since it is essential to the meta-methodology. The selection of a MF is also recommended, as MFs typically feature structured collections of views that can be used as checklists of candidate aspects and their intended coverage. This sub-step also calls for the identification and reconciliation of any aspect/view dependencies. The second sub-step asks the user to determine if the present (AS-IS) state of the views previously adopted needs to be shown and whether the AS-IS and future (TO-BE) states should be represented in separate or combined models. Typically, the AS-IS state needs to be modelled when it is not properly understood by the stakeholders or when the TO-BE state is to be evolved from the AS-IS (no radical re-engineering is likely). The third sub-step requires the selection of suitable modelling formalisms and modelling tools for the chosen aspects according to the target audience and competencies and tools available in the organisation at present or in the future. Best-practice modelling principles such as formalism re-use and minimal number of languages are also underlying the formalism selection criteria.

Due to its scope and to space limitations, the paper will cover only the first and second meta-methodology steps, focusing in particular on the benefits of creating a business model in the context of the life cycles of all relevant participant entities.

6 Application to the Environmental Management Project

In this case, the meta-methodology deliverables are various models of the EM project and the EMS taking into consideration the internal and external business life cycle context. Since the management of the organisation and all other entities (business units, other organisations, agencies, laws etc) that need to be involved in the EM project and the EMS are to be included in the entity list (first step in Figure 2, left), their influence will be taken into account throughout the life cycle of the EM project and the EMS. An important prerequisite for EM integration into the organisation is thus fulfilled. As shown in Figure 2, the meta-methodology assists in creating new knowledge (in this case, how to go about setting up and operating the EM project and the EMS) based on *context knowledge*, i.e. the know-how of running the business including corporate culture, relations with suppliers, clients, authorities etc, typically available at middle and top management level. The involvement of these roles in the methodology creation process establishes the conditions for management buy-in and support for the upcoming EM project and for the early involvement of the EA department in the EM project. This will create the best conditions for the integrated development of the EMS and the supporting functions of the IS.

Proposed members in the entity list are the company as a whole, business units, the EM project, the IS project, the EMS, the IS, environmental reports, NGOs, the government, Environmental Protection Agency (EPA), EM principles (e.g. 2R, TBL), EM laws, EM standards, EM frameworks, assessment and reporting frameworks, social responsibility standards, Quality Standards and EM consultants. The MF of GERA (see Figure 1) is adopted here as the most suitable to provide a formalism for the (mandatory) life cycle and other selected aspects.

In this case, the TO-BE state is incremental and based on the AS-IS (no radical redesign recommended when setting up an EMS). Therefore, in sub-step two, it the AS-IS state should be represented for all aspects. While there is no tangible advantage in showing separate AS-IS and TO-BE states in the business model, it is very useful to do so in the decisional / organisational structure. This is because here it is imperative to clearly show where and how the functions of the EMS interact with the existing system so as to ascertain the degree of integration and effects of the EMS on the decisional and organisational structure of the host company. Separate AS-IS / TO-BE decisional / organisational models also help define several TO-BE scenarios.

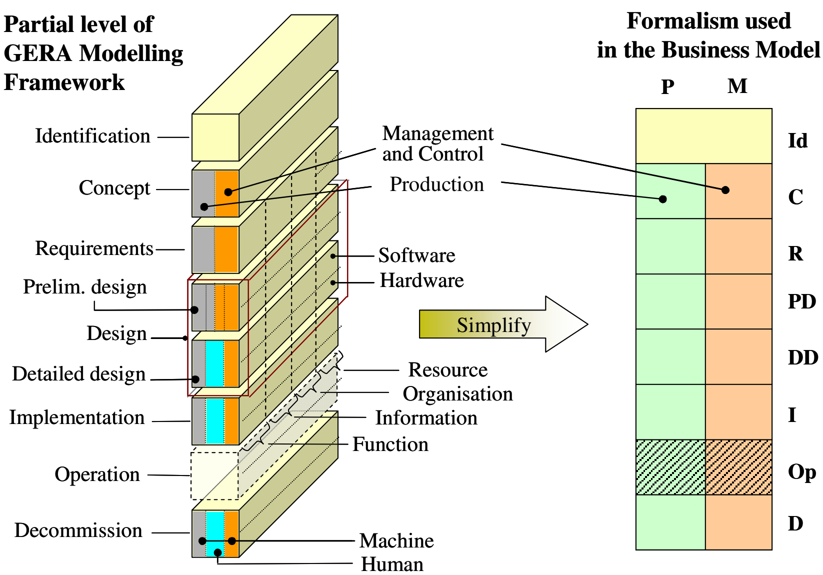

Fig. 3. Formalism used for the business model: simplified GERA MF

A modelling formalism based on the GERA MF was chosen for the business model (see Figure 3). GRAI–Grid (Doumeingts, Vallespir et al. 1998) was selected to represent decisional and organisational aspects (see Figure 5), together with a plain graphical editor as a modelling tool. GRAI-Grid was optimal in this case due to its ability to represent both the decisional and organisational aspects.

As shown in Figure 1, the business model is constructed in the second step based on context knowledge (often tacit and requiring eliciting by the meta-methodology facilitator) owned by stakeholders, i.e. CxO, enterprise architect, top management, etc.

A possible result is shown in Figure 4. As can be seen, the relations between the relevant entities can be explicitly represented for each life cycle phase. Note that some entities' life cycle representation has been reduced to the phase(s) relevant for the EM project and the EMS. For example, we are only interested in the Operation life cycle phase of Auditors, EM assessment / reporting frameworks, EM consultants, etc since they are not being designed / built as part of the EM project. The figure shows the relations between the company, the EM project, the EMS and the IS, thus facilitating a common understanding, building consensus and representing what needs to be done, step by step, at a high level.

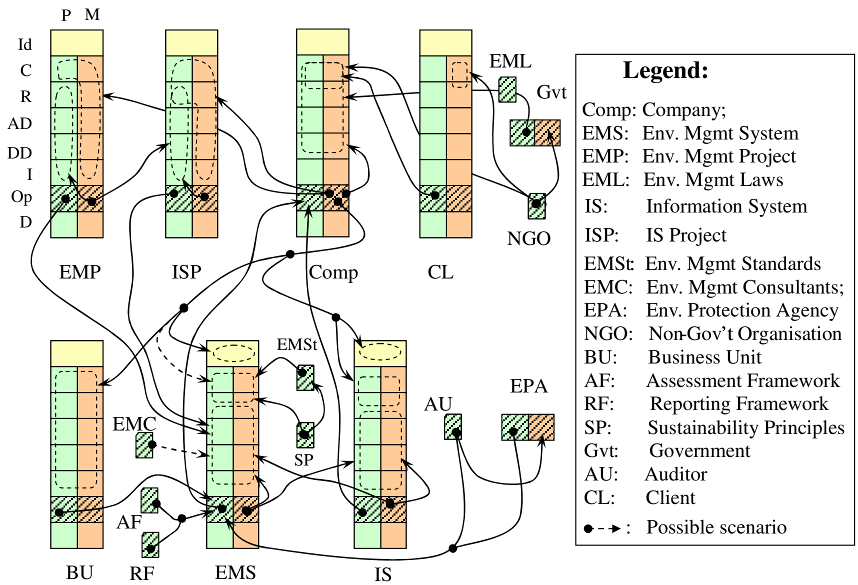

Fig. 4. Business model showing relations of relevant entities in the context of their life cycles

For example, the EMS is built by the EM project, with the possible involvement of consultants (EMC). The company is lobbied by NGOs and must abide by EM laws (EML). Auditors (AU) may perform certification audits (during the design of the EMS) or surveillance audits (to check if the EMS is still compliant). The EPA will look into the EMS operation and receive information from external auditors. Importantly, the EMS should be able to *redesign itself* (arrow from its Mgmt operation to its other EMS life cycles) to a certain extent and thus remain *agile* in the face of moderate EM regulation and market changes. Reaction to major changes will however be delegated to the upper company management via an EM project (EMP) (arrows from company (Comp) management operation to EMP and from EMP operation to EMS life cycles).

The arrow from the operation management side of the EMS to IS life cycles reflects the requirement to partially re-design the IS management and operation to integrate the EMS functions. On the other hand the IS is also influencing the design of EMS. Such inter-relations are detailed in the next meta-methodology steps as controls, inputs, decision frameworks, etc.

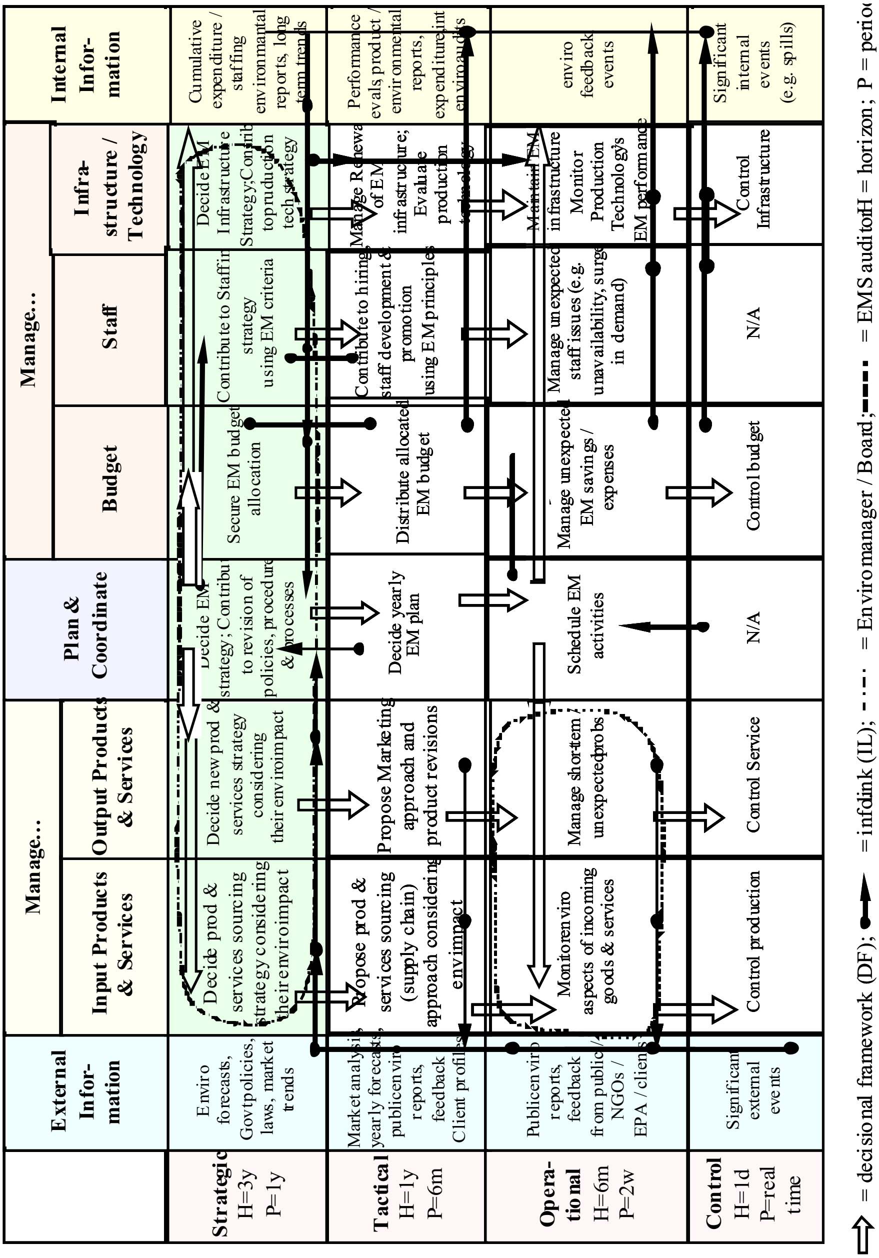

Fig. 5. Sample GRAI Grid for EM integration

The influences of other entities on the EMS and on the EM project EMP can also be interpreted as stakeholder concerns that translate in particular areas of interest being modelled and addressed. For example, the client may want to know how the mission and vision of the Company (the Concept area of Comp entity in Figure 4) addresses its environmental concerns, and the government (Gvt) will want to ensure that the Company abides by the public environmental concerns expressed in EM laws.

Models of the AS-IS and several potential TO-BE decisional and organisational aspects have also been constructed. For example, Figure 5 shows in a simplified form (using the GRAI-Grid formalism) a possible TO-BE decisional / organisational structure of an EMS as an add-on enabling the organisation to manage, benchmark and improve its environmental performance in an integrated manner (i.e. taking into account all relevant areas in a cross-departmental manner).

Detailed models including activity models of the third meta-methodology step are available in (Noran 2009b).

7 Conclusions and Further Work

Currently, businesses do not appear to achieve the maximum benefits from implementing and operating an EM project and an EMS. Firstly, there seems to be a lack of integration of the EM initiative with the business and its IS, especially at the strategic level. Thus, the management cannot take full advantage of the knowledge present in the environmental reporting mainly due to wrong format and/or level of aggregation. Secondly, an EMS needs to be driven internally and permeate all business areas in a consistent manner in order to produce organisational culture change, hence lasting effects. This paper has argued that such needs are best addressed by integrating EM in the ongoing EA initiative present in some form in every successful enterprise. EA can provide the necessary artefacts and the prerequisites for a coherent, cross-departmental and culture-changing approach ensuring business sustainability and profitability in the long term.

References

Bernus, P., Noran, O., et al.: Using the Globemen Reference Model for Virtual Enterprise Design in After Sales Service. Global Engineering and Manufacturing in Enterprise Networks (Globemen). In: Karvoinen, I., van den Berg, R., Bernuset, P., et al. (eds.) VTT Symposium 224, Helsinki / Finland, pp. 71–90 (2002)

Blackburn, W.R.: The Sustainability Handbook. EarthScan Publishers, Cornwall (2007)

CIMOSA Association, CIMOSA - Open System Architecture for CIM, Technical Baseline, ver 3.2. Private Publication (1996)

Clayton, A., Redcliffe, N.: Sustainability - A Systems Approach. Earthscan Publications, Ltd., Edinburgh (1998)

Coglianese, C., Nash, J. (eds.): Regulating from the Inside: Can Environmental Management Systems Achieve Policy Goals? RFF Press (2001)

DoD Architecture Framework Working Group (2004); DoD Architecture Framework Ver 1.0 (2007)

Doumeingts, G., Vallespir, B., et al.: GRAI Grid Decisional Modelling. In: Bernus, P., Mertins, K., Schmidt, G. (eds.) Handbook on Architectures of Information Systems, pp. 313–339. Springer, Heidelberg (1998)

Elkington, J.: Cannibals with Forks: The Triple Bottom Line of 21st Century Business (1998)

EPA. Management Tools, Environmental Protection Agency, South Australia (2008)

GRI, Sustainability Reporting Guidelines. Sustainability Reporting Framework. Global Reporting Initiative (2002)

Hunkeler, D. (ed.): Life-cycle Management. Society of Environmental Toxicology & Chemist (2004)

ISO, ISO 14001:Environmental management systems - Requirements with guidance for use. International Standards Organisation (2004)

ISO/IEC, Annex C: GERAM. ISO/IS 15704:2000/Amd1:2005: Industrial automation systems - Requirements for enterprise-reference architectures and methodologies (2005)

ISO/IEC, ISO/IEC 42010:2007: Recommended Practice for Architecture Description of Software-Intensive Systems (2007)

Mo, J.: The use of GERAM for Design of a Virtual Enterprise for a Ship Maintenance Consortium. In: Saha, P. (ed.) Handbook of Enterprise Systems Architecture in Practice, pp. 351–366. IDEA Group, Hershey (2007)

Molloy, I.: Environmental Management Systems and Information Management – Strategic- Systematical Integration of Green Value Added. In: Gómez, J.M., Sonnenschein, M., Müller, M., Welsch, H., Rautenstrauchm, C. (eds.) Information Technologies in Environmental Engineering ITEE 2007 - (Porceedings of the 3rd International ICSC Symposium) (2007)

Nilsson, I.: Integrating Environmental Management to Improve Strategic Decision-Making. Chalmers University of Technology, Götteborg (2001)

Noran, O.: An Analysis of the Zachman Framework for Enterprise Architecture from the GERAM perspective. IFAC Annual Reviews in Control, Special Edition on Enterprise Integration and Networking (27), 163–183 (2003a)

Noran, O.: A Mapping of Individual Architecture Frameworks (GRAI, PERA, C4ISR, CIMOSA, Zachman, ARIS) onto GERAM. In: Bernus, P., Nemes, L., Schmidt, G. (eds.) Handbook of Enterprise Architecture, pp. 65–210. Springer, Heidelberg (2003b)

Noran, O.: A Meta-methodology for Collaborative Networked Organisations, School of Computers and Information Technology. Griffith University (2004)

Noran, O.: An Analytical Mapping of the C4ISR Architecture Framework onto ISO15704 Annex A (GERAM). Computers in Industry 56(5), 407–427 (2005a)

Noran, O.: A Meta-methodology Prototype for Collaborative Networked Organisations. In: Camarinha-Matos, L. (ed.) Collaborative Networks and Breeding Environments, Proceedings of the 6th IFIP Working Conference on Virtual Enterprises - PROVE 2005, pp. 339–346. Springer, Valencia (2005b)

Noran, O.: Refining a meta-methodology for collaborative networked organisations: a case study. Int. J. Networking and Virtual Organisations 3(4), 359–377 (2006)

Noran, O.: A Decision Support Framework for Collaborative Networks. In: Camarinha-Matos, L., Afsarmanesh, H., Novais, P., Analide, C. (eds.) Establishing the Foundation of Collaborative Networks, Proceedings of the 8th IFIP Working Conference on Virtual Enterprises - PROVE 2007, Guimaraes / Portugal, pp. 83–90. Kluwer Academic Publishers, Dordrecht (2007a)

Noran, O.: Discovering and modelling Enterprise Engineering Project Processes. In: Saha, P. (ed.) Enterprise Systems Architecture in Practice, pp. 39–61. IDEA Group, Hershey (2007b)

Noran, O.: A Meta-methodology for Collaborative Networked Organisations: Creating Directly Applicable Methods for Enterprise Engineering projects. Saarbrücken, VDM Verlag Dr. Müller (2008)

Noran, O.: A Decision Support Framework for Collaborative Networks. International Journal of Production Research 47(17), 4813–4832 (2009a)

Noran, O.: Engineering the Sustainable Business: An Enterprise Architecture Approach. In: Doucet, G., Gotze, J., Saha, P. (eds.) Coherency Management: Architecting the Enterprise for Alignment, Agility, and Assurance, pp. 179–210. International Enterprise Architecture Institute (2009b)

Saha, P.: A Synergistic Assessment of the Federal Enterprise Architecture Framework against GERAM (ISO15704:2000 Annex A). In: Saha, P. (ed.) Enterprise Systems Architecture in Practice, pp. 1–17. IDEA Group, Hershey (2007)

Scheer, A.-W.: ARIS-Business Process Frameworks. Springer, Berlin (1999)

Shewhart, W.A.: Statistical Method from the Viewpoint of Quality Control. Dover Publications (1986)

The Open Group, The Open Group Architecture Framework (TOGAF 8.1.1 'The Book') v8.1.1 (2006)

TNEP, The Natural Edge Project, TNEP (2007)

UN World Commission on Environment and Development. Our Common Future (Brundtland Report). Oxford University Press, Oxford (1987)

Upham, P.: An assessment of The Natural Step theory of sustainability. Journal of Cleaner Production 8(6), 445–454 (2000)

Willard, B.: The Sustainability Advantage: Seven Business Case benefits of a Triple Bottom Line. New Society Publishers, Gabriola Island (2002)

Williams, T.J.: The Purdue Enterprise Reference Architecture. Computers in Industry 24(2-3), 141–158 (1994)

Zachman, J.A.: A Framework for Information Systems Architecture. IBM Systems Journal 26(3), 276–292 (1987)

A Metamodel for Enterprise Architecture

Peter Bernus and Ovidiu Noran

Griffith University, Nathan (Brisbane)
Queensland 4111, Australia
P.Bernus@griffith.edu.au, O.Noran@griffith.edu.au

Abstract. The paper presents an evolved metamodel that has its origins in GERAM 1.6.3 but takes into considerations the needs of evolution of EA standards, including ISO 15704:2000 and ISO 42010:2000 – both currently under review.

Keywords: Enterprise Architecture Framework, metamodelling, GERAM.

1 Introduction

This paper aims to present an evolved metamodel of GERAM. The original GERAM document that formed the basis of ISO 15704:2000 had an informally expressed metamodel (IFIP-IFAC, 1999; Fig 1) but recent trends in standards development require that the metamodel be expressed in a formal way. Such formalisation, as can be expected, brings out previously unclarified details, including the details of the difference between life cycle phases and life history stages, milestones etc. Also a more formal definition of modelling frameworks is given. In addition, the attempt to harmonise with ISO 42010:2000 brings a new insight into the relationship between enterprise models and stakeholders who are users of these models. As a side-effect of this clarified terminology, the paper also presents a new understanding of EA frameworks that are based on the life cycles of enterprise entities and the Zachman framework.

2 History

Real-world enterprises are inherently complex systems. To tackle this complexity a variety of proposals were developed in the 1980s and 1990s, and these proposals fell into two categories: (a) proposals that created generally applicable 'blueprints' (later to be called reference models, partial models, or 'architectures of type 1') so that the activities involved in the creation (or the change) of the enterprise could refer to such a common model (or set of models); (b) proposals which claimed that to be able to organise the creation, and later the change, of enterprises one needs to understand the life cycle of the enterprise and of its parts. These latter were the proposed 'architectures of type 2', or more intuitively 'life cycle architectures' (cf IFIP-IFAC Task Force, 1999). This second type of architecture was at the time called an

P. Bernus, G. Doumeingts, and M. Fox (Eds.): EAI2N 2010, IFIP AICT 326, pp. 56–65, 2010.

'Enterprise Reference Architecture'. Several proposals emerged in those two decades – e.g. PERA (Williams 1994), CIMOSA (CIMOSA Association 1996), ARIS (Scheer 1999), GRAI-GIM (Doumeingts, 1987), and the IFIP-IFAC Task Force, based on a thorough review of these as well as their proposed generalisation (Bernus and Nemes, 1994) developed GERAM (IFIP-IFAC Task Force, 1999) which then became the basis of ISO15704:2000 "Industrial automation systems – Requirements for enterprise-reference architectures and methodologies". While the name suggests that this standard is about 'industrial automation', this standard is in fact applicable to any man-made system (enterprise, product, project, etc). Curiously, independently from this, John Zachman developed his Information Systems Framework (Zachman 1987), which later was realised to be applicable to any enterprise (product, project, etc) as well.

While neither GERAM (and its inceptors) not the Zachman Framework were originally called an 'Enterprise Architecture Framework (AF)', this is the current term used to describe the metamodel that defines the terminology of EA. Note that as (Noran, 2003) shows, the Zachman Framework is not exactly what we would call a 'life cycle architecture', there is a clear connection between a life cycle architecture and the Zachman Framework, which makes either of these qualify as Architecture Frameworks. The 'technical trick' of ISO15704:2000 is that it is actually Framework agnostic: while it incorporates GERAM as an appendix, the normative part of the standard only lists the *requirements* that any architecture framework should satisfy. This is very important because it would be unreasonable to expect that investments into adopting a framework will be abandoned by organisations just because a new standard appeared. However, at the same time, the developers of frameworks can use the standard to evolve their own frameworks and therefore the standard has a harmonising effect on the language / terminology of enterprise architecture, as well as can be used to make EA frameworks more complete than they would be without such definition.

Later developments in the EA domain saw the inception of C4ISR – now DoDAF (DoD Architecture Framework Working Group, 2004), and TOGAF (The Open Group, 2006) to name only a few of the popular ones. Mappings of most on GERAM / ISO 15704:2000 are available (although perhaps not popularised enough) and it is clear that neiter of these are complete yet in terms of satisfying *all* ISO 15704:2000 requirements, however, there does not seem to exist an obstacle to their future evolution.

Architecture Frameworks have been used in many industries, including the domains of industrial automation / manufacturing / production management, business information systems (of various kinds), telecommunications and defence.

Part of the Enterprise Architecture practice is 'enterprise engineering' and the practice of 'enterprise modelling' (or just modelling) and complete AFs describe the scope of modelling (which later can be summaised as a Modelling Framework that is part of the AF). Note that (quite independently from the above), IEEE developed a standard in 2000 (IEEE 1471, 2000) that documents some important requirements that models describing the architecture of a 'software intensive system' should satisfy, and a recent deveopment in ISO is the adoption of this latter IEEE standard as ISO42010 (currently [2010] under review). It should not be surprising to the reader that this standard is also applicable to a much wider domain than originally thought (i.e., not only sofware systems).

In the past there have been various attempts to map the existing AFs and their associated artefacts against one another (e.g. (Williams, Zoetekouw et al. 1996)); such attempts have highlighted the difficulties encountered in the mapping process such as meaning, gaps, overlapping, etc.

Subsequently, efforts were made to map the AFs against a neutral reference, able to accommodate all possible types of artefacts contained in the mapped architectures. This reference has been constructed by essentially combining all the features of the main existing architectures, filtering out coverage overlaps and adding missing (and thought to be necessary) aspects. Typically, some areas are well covered and understood in all frameworks, while others are not, for reasons relating to framework history, purpose, intended audiences, underlying framework ontologies, etc. For example, function and information are fairly well understood in all frameworks, while human and decisional aspects are not.

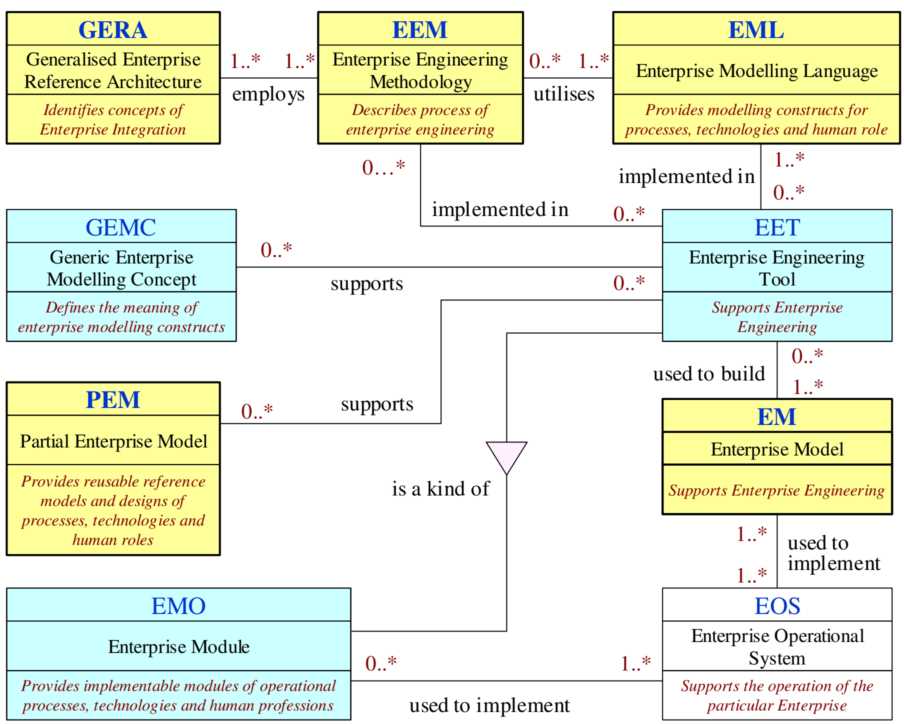

Fig. 1. A possible metamodel of GERAM (Noran, 2003) based on (GERAM 1.6.3)

The result of the mappings was a matrix-like structure of requirements (Bernus and Nemes, 1994 and 1996), which has further improved understanding of the frameworks and their problems; however, the result was rather complex and difficult to follow.

A more space-efficient and user-friendly, three-dimensional structure was then proposed in order to improve and simplify the previous flat and tabular MF. Subsequently, the new MF was supplemented with specific concepts such as entity type, recursion, life history, etc. to create a true AF.

The AF was obtained by putting together the generalised MF and all essential generic concepts of enterprise engineering, such as enterprise models, modelling languages, generic enterprise modelling concepts, partial models, etc. The current outcome of these efforts is the generalised reference AF described in Annex A of ISO15704:2000 and 2005, as an example of a framework compliant with that standard.

Among others, GERAM has been used in practice to guide Enterprise Architecture (EA) projects (Bernus, Noran et al. 2002; Noran 2004; Mo 2007; Noran 2007), harmonize international standards, assess other enterprise AFs (Noran 2003; Noran 2005; Saha 2007) and to build structured repositories of AF elements for a project management decision support system (Noran, 2009). For a complete description of GERAM see ISO15704:2005 (ISO/IEC 2005).

3 The Need for Change

Enterprises are highly complex and dynamic entities. The continuous maturing and evolution of the EA domain reflects this; thus, existing AFs are adapted and enriched and new AFs are being created to reflect the new business environment's challenges. Zachman, TOGAF, etc. are just a few examples.

In addition to mandatory reviews, international standards in this domain go through similar change processes. For example, ISO42010 (ISO/IEC 2007) evolved from IEEE1417 in order to set updated guidelines for architecture descriptions of software-intensive systems.

The AF domain understandably displays signs of competition between the various AFs. This unfortunately translates in the difficulty for the typical user to achieve a clear understanding of the main purpose and domain covered by each AF, and problems in employing a combination of AFs (or parts thereof) for specific projects. In the past GERAM has been used to try to classify some of the above-mentioned AFs and thus facilitate their use for specific tasks. However, for this endeavour to succeed there is a need for GERAM and ISO15704 themselves to be updated to keep up with the changes in the AF domain.

In the standards area, harmonisation rather than competition is (and has been) the main issue. Ongoing efforts attempt to reconcile and eliminate gaps and overlaps between various related standards (such as e.g. ISO15288 – systems life cycle processes and ISO12207 – software life cycle processes) using different terminology and levels of abstraction due to historic and other reasons. As part of the standardisation effort and a possible tool for reconciliation, ISO15704 and its Annexes (eg GERAM) must also go through a process of harmonisation with other relevant standards – a prominent example being ISO42010 (ISO/IEC 2007).

This paper attempts to describe a possible way forward in the evolution of GERAM and ISO15704 by proposing an enhanced and more formal description of the artefacts involved and their relationships, including some extension to show the relationship to ISO 42010.

4 The Proposed Metamodel

It has been considered that due to the amount and significance of changes involved, the next version of GERAM should be designated as 'GERAM 2.0'. The proposed changes encompass:

- a clarification of several ambiguous terms;
- more formal representation of the relations between fundamental components of GERAM;
- the introduction of several concepts and terminological equivalences in order to harmonise GERAM and ISO15704 with efforts in other areas, notably ISO42010.

Fig. 2 attempts to present the above changes in a metamodel created using a UML (OMG, 2005) class diagram. The figure presents in effect a combined AS-IS / TO-BE (present / future) state of affairs. Therefore, the notes attached to elements are crucial to the understanding of the metamodel as they show whether an element exists in the current version of GERAM 1.6.3 and whether that element is to be added / removed / kept in the next version (GERAM 2.0). The use of UML and specification of all multiplicities assists the formal representation of the relation between artefacts.

4.1 A More Formal Representation of the Metamodel

4.2 New and Changed Artefacts

The new metamodel proposed to introduce several new artefacts and changes the designation and/or *meaning* for others in order to achieve better stakeholder understanding and terminological harmony with other relevant standards. For example the term view in GERAM 1.6.3 was equivalent to the term 'viewpoint' in ISO42010. Therefore it is proposed to be changed to viewpoint while view as a term will remain with the meaning of architectural view corresponding the to terminology of ISO 42010.

The concept of life history has been present in the version 1.6.3 of GERAM. However, it now has been considered beneficial to explicitly specify that while the past life history is unique (cannot be changed), the future life history is a matter of choice between several scenarios (and of course, a proportion of chance).

ISO 15704 and GERAM has used the term life cycle phase to denote life cycle activities. The term life history *stage* is used to denote a time interval on the life history of an entity (or the time interval within a sequence of events in the life history) as the case may be. Thus the occasional miuse of the term 'phase' in the temporal context is eliminated.

4.3 Clarification of Relations between Artefacts

The new metamodel allows the enrichment of relationship representation by using aggregation, interface and specialisation / abstraction. Thus, it is now possible for example to represent the fact that a life history event, an enterprise model or an enterprise entity can be decomposed. It is also possible to represent the fact that a collection of viewpoints can be contained in an MF or that the life cycle of an

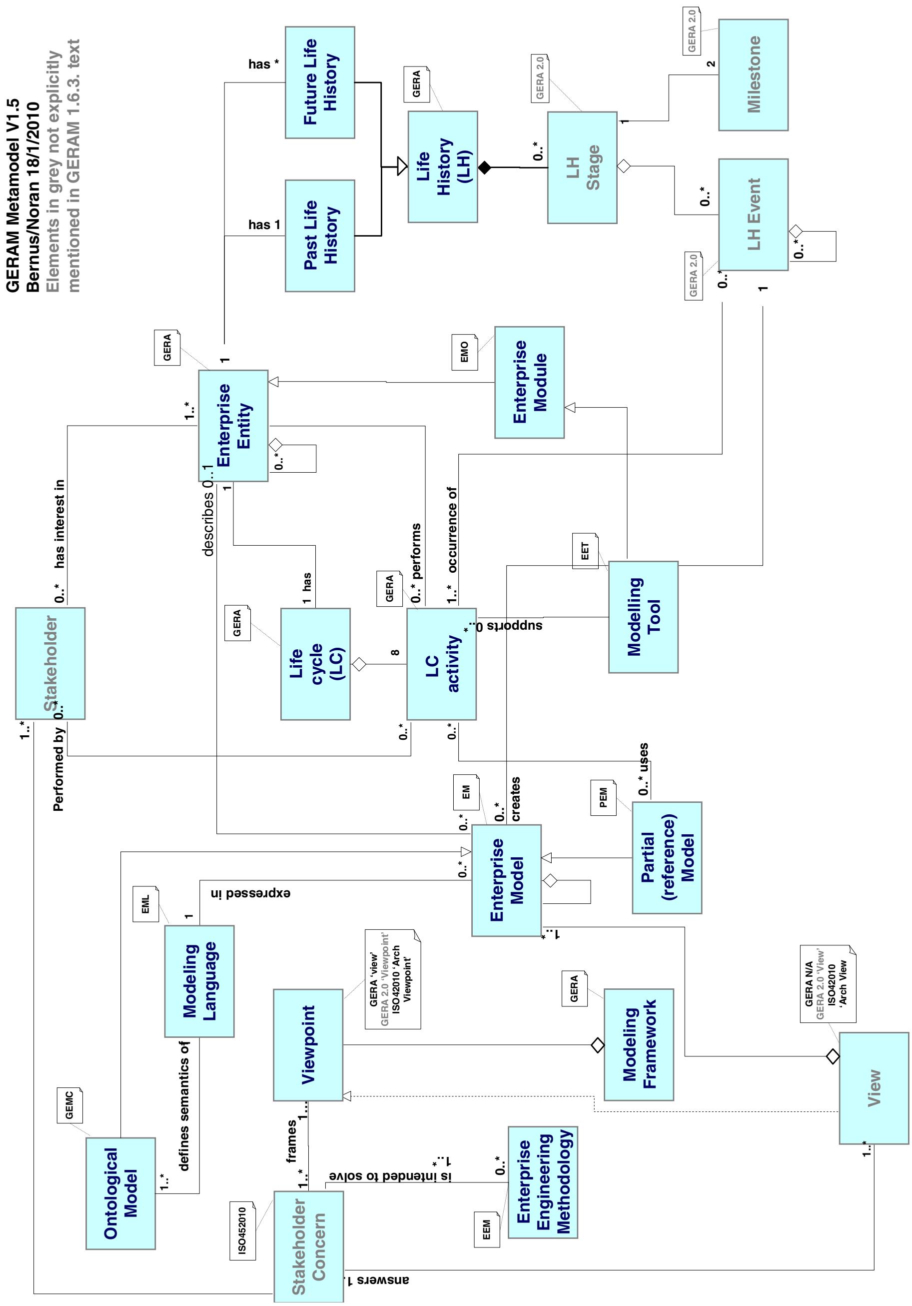

Fig. 2. Proposed metamodel v1.5

enterprise is in fact a collection of life cycle activities. Similarly, the model also communicates that a set of enterprise models can form a view that answers a stakeholder concern.

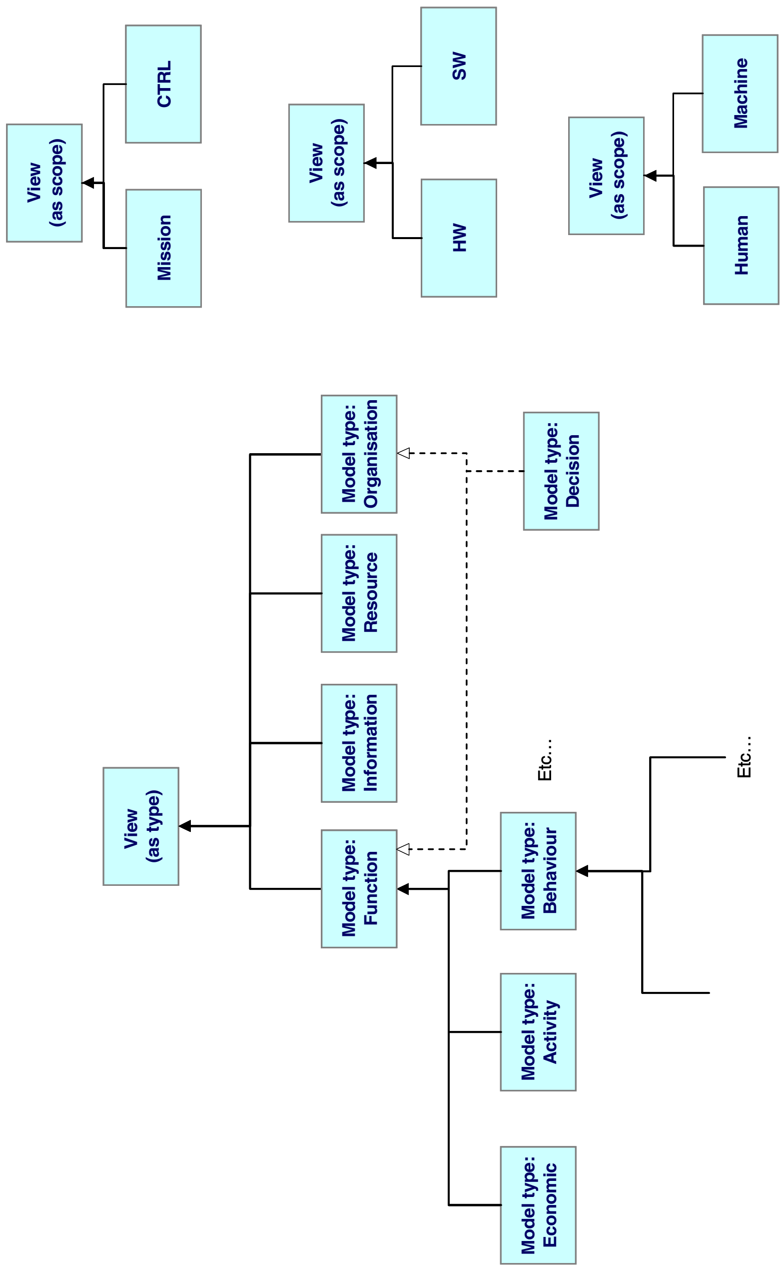

Fig. 3. Possible model typology

The specialisation of reference (partial) models and ontological models in enterprise models can now also be represented. Likewise, it can now be shown that modelling tools are a special type of enterprise module (trusted off the shelf executable components) and that an enterprise module is a type of enterprise entity (consistent with the ISO 15288 component concept).

Given the concept of Stakeholders and their relationship to models it is now clear that in the Zachman Framework the rows represent views of enterprise models rather than enterprise models themselves. This latter is a possible cause for controversy, but careful consideration shows that the problem is avoidable. Namely, Zachman insists that the cells in the Zachman Framework should contain 'elementary' models (models that are not a combination or the consequence of other models). On the other hand, stakeholders (according to ISO 42010 and ISO 15704) wish to see extracts of enterprise models which extracts together form a view through which the stakholder's concerns are satisfied. However, one needs to consider that stakeholders both create ('author') and peruse ('read') parts of such models, thus Zachman's insistence is on stakeholders *authoring* elementary models, not on exclusively reading ones.

4.3 A Classification of Model types

Fig. 3 proposes one possible classification of models using the interpretation of the viewpoint concept by type (nature of the model) and by scope (i.e. the limit of the modelling). This is only one of the many possible taxonomies. Note, as mentioned above, that the proposed metamodel calls it a viewpoint what used to be a view in GERAM 1.6.3. The taxonomy proposed is but one possible way of classifying model types (e.g. a decisonal model type is defined here as having both organisational [who is the decidor] and functional aspects [what decision function is performed], this is expressed using the UML 'interfac' notation. However, model type classification may have alternatives, and is not a crucial element of the proposed metamodel.

A model that belongs to a model type is claimed to be able to answer certain questions about the entity it describes. The ontological theory behind the kind of question that can be answered is defined (in ontology design) using a 'set of competency questions' (Gruninger and Fox, 1995, 1998). Based on this set, the ontological theory defines the semantics of the language in which the model is expressed.

A stakeholder concern can be answered by asking a set of competency questions. This set can be further subdivided into subsets (according to rules provided by viewpoints) in order to construct the models necessary to answer the concern in question.

5 Conclusions and Future Work

This paper has proposed an updated and enhanced metamodel for GERAM Future work will further develop and refine the metamodel according to feedback and testing in case studies. An important consideration of thi swork is its usability to harmonise severakl standards' terminologies, including ISO 15288 (Systems Life cycle processes), ISO/IEC 42010 (Architecture Descriptions of Siftware Intensive Systems), ISO 12207 (Software Life Cycle Processes) as well as advancing the terminology of Enterprise Architecture as a discipline.

References

Bernus, P., Nemes, L.: A Framework to Define a Generic Enterprise Reference Architecture and Methodology. Computer Integrated Manufacturing Sys. 9(3), 179–191 (1996a)

Bernus, P., Nemes, L.: A Framework to Define a Generic Enterprise Reference Architecture and Methodology. In: Proc. ICARV'96 4th Int. Conf. on Control, Automation, Robotics and Vision, December 4-6, 1996, vol. 3(3), pp. 88–92. Nanyang Technological University, Singapore (1994)

Bernus, P., Nemes, L., Morris, B.: The Meaning of an Enterprise Model. In: Bernus, P., Nemes, L. (eds.) Modelling and Methodologies for Enterprise Integration, pp. 183–200. Chapman & Hall, London (1996b)

Bernus, P., Noran, O., et al.: Using the Globemen Reference Model for Virtual Enterprise Design in After Sales Service. In: Karvoinen, I., van den Berg, R., Bernus, P., et al. (eds.) Global Engineering and Manufacturing in Enterprise Networks (Globemen). VTT Symposium 224, Helsinki / Finland, pp. 71–90 (2002)

CIMOSA Association, CIMOSA - Open System Architecture for CIM, Technical Baseline, ver 3.2. CIMOSA Association (1996)

DoD Architecture Framework Working Group, DoD Architecture Framework Ver 1.0. (2004)

Doumeingts, G., Vallespir, B., Darracar, D., Roboam, M.: Design Methodology for Advanced Manufacturing Systems. Computers in Industry 9(4), 271–296 (1987)

Fox, M.S., Gruninger, M.: Enterprise Modelling. AI Magazine, 109–121 (Fall 1998)

Gruninger, M., Fox, M.: The logic of Enterprise Modelling. In: Proceedings of the Industrial Engineering Research Conference, Atlanta, CA (1995)

IEEE, IEEE Std 1471-2000 IEEE Recommended Practice for Architectural Description of Software-Intensive Systems (2000)

IFIP/IFAC (1999) GERAM (version 1.6.3): Generalised Enterprise Reference Architecture and Methodology. In: Bernus, P., Nemes, L., Smidth, G. (eds.) Handbook on Enterprise Architecture, ch. 2, pp. 22–64. Springer, Berlin (2003), `http://www.cit.griffith.edu.au/~bernus/taskforce/geram/versions`

ISO/IEC, Annex C: GERAM. ISO/IS 15704:2000/Amd1:2005: Industrial automation systems - Requirements for enterprise-reference architectures and methodologies (2005)

ISO/IEC, ISO/IEC 42010:2007: Recommended Practice for Architecture Description of Software-Intensive Systems (2007)

ISO/IEC 12207 Systems and software engineering – Software life cycle processes (1995, 2008)

Mo, J.: The use of GERAM for Design of a Virtual Enterprise for a Ship Maintenance Consortium. In: Saha, P. (ed.) Handbook of Enterprise Systems Architecture in Practice, pp. 351–366. IDEA Group, Hershey (2007)

Noran, O.: A Mapping of Individual Architecture Frameworks (GRAI, PERA, C4ISR, CIMOSA, Zachman, ARIS) onto GERAM. In: Bernus, P., Nemes, L., Schmidt, G. (eds.) Handbook of Enterprise Architecture, pp. 65–210. Springer, Heidelberg (2003)

Noran, O.: A Meta-methodology for Collaborative Networked Organisations: A Case Study and Reflections. In: Bernus, P., Fox, M., Goossenaerts, J.B.M. (eds.) Knowledge Sharing in the Integrated Enterprise: Interoperability Strategies for the Enterprise Architect, Toronto / Canada, pp. 117–130. Kluwer Academic Publishers, Dordrecht (2004)

Noran, O.: An Analytical Mapping of the C4ISR Architecture Framework onto ISO15704 Annex A (GERAM). Computers in Industry 56(5), 407–427 (2005)

Noran, O.: Discovering and modelling Enterprise Engineering Project Processes. In: Saha, P. (ed.) Enterprise Systems Architecture in Practice, pp. 39–61. IDEA Group, Hershey (2007)

Noran, O.: A Decision Support Framework for Collaborative Networks. International Journal of Production Research 47(17), 4813–4832 (2009)

OMG (2005). Unified Modelling Language version 2.0 specification, OMG (2010)

Saha, P.: A Synergistic Assessment of the Federal Enterprise Architecture Framework against GERAM (ISO15704:2000 Annex A). In: Saha, P. (ed.) Enterprise Systems Architecture in Practice, pp. 1–17. IDEA Group, Hershey (2007)

Scheer, A.-W.: ARIS-Business Process Frameworks. Springer, Berlin (1999)

The Open Group, The Open Group Architecture Framework (TOGAF 8.1.1 'The Book') v8.1.1 (2006)

Williams, T.J.: The Purdue Enterprise Reference Architecture. Computers in Industry 24(2-3), 141–158 (1994)

Williams, T.J., Zoetekouw, D., et al.: Techniques to map the architectures directly against one another. In: Bernus, P., Nemes, L., Williams, T.J. (eds.) Architectures for Enterprise Integration. Chapman & Hall, London (1996)

Zachman, J.A.: A Framework for Information Systems Architecture. IBM Systems Journal 26(3), 276–292 (1987)

Communication as a Crucial Element for Enterprise Architecture Management in Virtual Organization

Taivo Kangilaski

Tallinn University of Technology, Department of Computer Control, Ehitajate tee 5, 19086 Tallinn, Estonia
Taivo.Kangilaski@dcc.ttu.ee

Abstract. New business condition and current economical situation are forcing companies to rethink their way of operating. The rapidity of managing changes has become increasingly important. To be more competitive, companies are forming Virtual Organizations (VO) where short-term spontaneous collaboration activities are rather common. Such interoperability leads to increasing organizational architectural complexity. As the VO interoperability availability depends on quality of companies Enterprise Architecture approach belonging to ecosystem, the current article propose focus points for architecture management in VO.

Keywords: Enterprise Architecture, Virtual Organization, Communication.

1 Introduction

Nowadays economical situation influences companies greatly – competitive pressures, corporate mergers, acquisitions, shortened product development times and production cycles, shifting supplier relationships, and various customer demands are forcing companies to adapt to the changing market conditions. Companies with better financial and market position are forming new ecosystems in order to be more competitive and flexible.

Building ecosystems means that necessary companies are initially recruited among the partners and are employed as subcontractors for the necessary tasks by the Focal Player in his role as the general project manager. In case the needed competencies are not represented in the partner network or they are not of a sufficiently high quality, the external companies will be asked to participate. Such a co-operation could be modelled through the Virtual Organization (VO) approach [1].

At the same time, it is obvious that the alliance partners have different business processes, ontologies, organizational structures, technologies, management principles etc. As the entire setup of the VO may change according to the marketplace [2], the VOs are temporary organizations and have ability to react quickly regarding to membership, structure, objectives, etc. It means increasing complexity of business as well as IT environment, which is often disabling factor for flexible enterprise architecture management.

P. Bernus, G. Doumeingts, and M. Fox (Eds.): EAI2N 2010, IFIP AICT 326, pp. 66–77, 2010.

The current article focuses on the importance of communication of Enterprise Architecture (EA) in VO as one of the most important enabler to minimize interoperability issues both between VO Collaborators (VOC) and with external contractors.

The article is built up as following: in the next section, the concept of VO is analyzed to show the key components, which should be focused on. In the third section the EA as a discipline is briefly introduced. The fourth section proposes approach, how to handle EA complexity in VO. Then the ontology conformation processes inside VO are being analyzed. Based on these, the approach how to handle EA communication in VO is proposed.

2 Virtual Organization

In theory, all companies should perform their work exceptionally well. When they succeed in the short term, they should also, to the fullest extent possible, follow their goals and strategies to pursue longer-term opportunities and threats. Such behavior requires management vision, considerable resources, infrastructure, and dedicated personnel. It is often anticipated that all employees will act effectively always, make sense of challenges, find the best approaches to handle situations, anticipate outcomes, inform all stakeholders who are concerned, etc. But the main factor here, what needs to be emphasized, is that enterprise has a common ownership. VO, contrarily has temporary nature and lack of common ownership.

Field of VO has covered with many research projects. The main focuses have been on the characteristics of a VO (e.g. purpose, time and spatial dispersion, modularity, heterogeneity, interdependence, configuration, boundaries, knowledge management, uncertainty, trust, culture) [3]-[17], the VO lifecycle management (e.g. creation, operation, dissolution) [18][19], the software integration issues (e.g. integration middleware, Service Oriented Architecture (SOA), Enterprise Service Bus, Business Process Management (BPM)) [20]-[23], integral management of information [24], but EA as a discipline for VO is weakly covered.

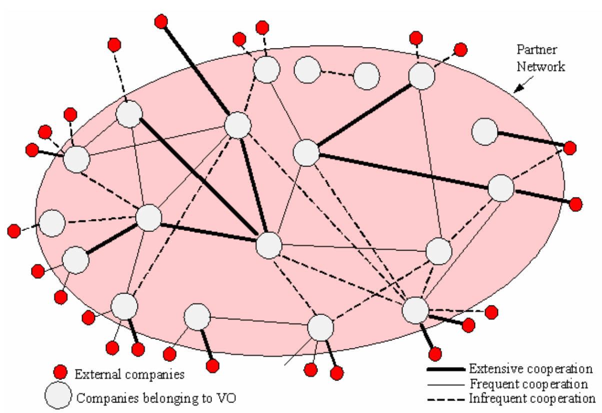

Fig. 1. Partner Network and its partners' intensity of interoperability

Table 1. Communication intensity properties

Property	Extensive communication	Frequent communication	Infrequent communication	Passive communication
Culture	Conformed	Principles are agreed	Different organizational culture, problems with semantics	Different organizational culture, -ontology
Processes	Selection of common approach	Many different tactics are used, but best practices are in place	People are dependent without any formal practices or plans	Cooperation is missing
Human factor	Permanent networking staff	Established networking; new persons are involved	Exploring collaboration possibilities	Not direct collaboration. Information through the Web
Risk taking	Low, as people know each other	Medium	Medium/High	N/A – only needed/minimal information is published
Knowledge sharing	High	High	Medium	Minimum – limited access to information
ICT support	High – most business processes are supported by ICT	Medium – different initiatives to support processes by ICT	Low – core processes are partly supported by ICT	Very low – only VO basic ICT solutions needed for VO are available
Trust	High – a lot of good references and personal experiences	Medium - previous personal experience is small. Good references about the VOC are available	Low – personal experience is missing. The trust must be developed, others VOC references are needed	Low - information is accessible only when there is an other VOC reference is available

Through the communication intensity analyzes, the other aspects of VOCs communication may be identified – working culture, process maturity, human factor, risk taking, knowledge sharing, ICT support and trust (Table 1.). Only these characteristics are elected as the focal characteristics, which will influence companies' cooperation because these are the most important factors for further VO and Partner Network EA governance.

Extensive communication is cooperation between VOCs, where amount of work covered with contracts is huge, trust between organizations is high, employees know each other, semantics is conformed and processes are combined and optimized with help of ICT solutions. Typically, VOC with extensive communications have long-term frame agreements and there are several business projects performing simultaneously. It can be said that these cooperation partners ontologies are conforming.

Frequent communication is cooperation between VOCs, where amount of work covered with contracts is considerable. These companies have earlier made successful cooperation, and now these companies have slightly different semantics, different understandings about business processes and there is a weaker social cooperation between VOC's employees. The cooperation relies largely on ICT solutions, but there is no "single work-desk on computer" for employees to support business processes. Typically VOCs with frequent communications are entering to the extensive communication when cooperation is successful, otherwise it returns to the infrequent communication until companies' organizational maturity will grow. In this type of communication, VOCs have also long term frame agreements with multiple simultaneous projects.

Infrequent communication is cooperation between VOCs, where amount of work covered with contracts is small. There may be several simultaneous projects, but all of them are covered with separate contracts. The processes, working principles, semantics, and cultures are different and will affect the cooperation also aggravating the speed to start a new cooperation project. From ICT side, the major business processes are partly covered by ICT applications to accelerate information exchange and analyzes capabilities. As the companies belong to the same VO, there may be recommendations with testimonial from others VOCs, which will facilitate the start of effective cooperation comparing with that with companies from outside VO.

Passive communication is mainly a one-way communication. It means that VOC will publish information needed for others VOCs to analyze the efficiency of value chain they belong to. Mostly that information contains VOC's most critical information for effective cooperation with partners and which refer to:

- available machinery/inventories and their location;
- available competences, skills, skills locations;
- ongoing and further known projects.

This information is accessible only companies belonging to VO. There is always a passive communication oriented to all companies to find cooperation partners if needed. Mostly, passive communication is forwarded through VOC Internet web pages to the Partner Network companies and with restricted access to external companies.

3 Enterprise Architecture

Concept of Enterprise Architecture (EA) management is well known. It is widely analyzed that well-documented and well-understood EA enables the organization to respond quickly to changes in the environment in which the organization operates. EA serves as a ready reference that enables the organization to assess the impact of the changes on each of the EA components.

According to the ToGAF ver.9 [25], it is reasonable to define Enterprise and Architecture separately. Enterprise is the highest level of description of an organization and typically covers all missions and functions. Architecture is the structure of components, their interrelationships, and the principles and guidelines governing their design and evolution over time. These definitions together will give precise meaning of EA.

In addition to ToGAF, there are many well known EA frameworks – U.S. Department of Defense Architecture Framework (DoDAF), British Ministry of Defence Architectural Framework (MoDAF), U.S. Federal Enterprise Architecture framework (FEA), Gartner Enterprise Architecture Framework, Computer Integrated Manufacturing Open System Architecture modelling framework (CIMOSA), Purdue Enterprise Reference Architecture (PERA), Treasury Enterprise Architecture Framework (TEAF), TeleManagement (TM) Forums eTOM/New Generation Operations Systems and Software (NGOSS), Center of Excellence of Enterprise Architecture (CEISAR) approach, Generalised Enterprise Reference Architecture and Methodology (GERAM), Supply Chain Operations Reference model (SCOR), ISO/IEC 42010:2007, Reference Model of Open Distributed Processing (RM-ODP), Spewak EA Planning Methodology, Pragmatic enterprise architecture Framework (PeaF).

There are also well known Zachman Framework™ and IDS Scheer ARIS framework but these are ontologies without implementation processes.

Most of these architecture frameworks have a common property – the enterprise has a common ownership. VO contrarily has a lack of common ownership, which also demands different interpretation of these frameworks.

In broadly, EA in context of VO can be documented in five layers [24] – Infrastructure layer, data layer, application layer, business process layer, and key performance indicators (KPI) layer (Fig.2.).

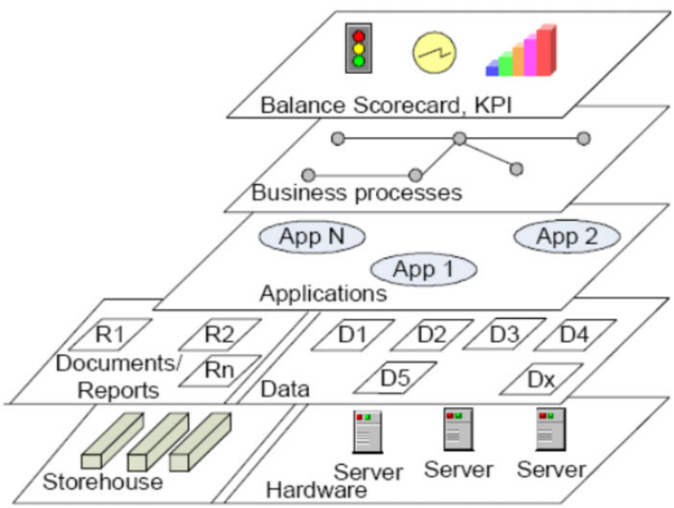

Fig. 2. Documentation layers [24]

The infrastructure layer refers to the network connectivity, hardware upon which the software runs, network routers, operating systems, and other technologies that facilitate the communication among the distributed software components and support the execution environment of the software. It is crucial for the enterprise to record its paper documents'/reports' physical locations (e.g. in storehouses).

The data layer refers to how the data is structured, stored, and handled. It includes the specification of databases, the logical and physical database design, the allocation of data to servers, the strategy for data replication and archival, as well as to the strategy and design of the data warehouse. In that level, also, all paper documents/reports produced by business processes should be described. It is important to analyze business situation to cover the new areas for the new or improved software solutions.

The application layer describes several business services (incl. web services), applications, their functionalities and Service Level Agreements. For a certain product, the application layer is the documentation about the product's software architecture. This layer provides also a set of guidelines about how the various software solutions should be consistently constructed across the VO.

The business process layer describes the business processes, their constraints, demands and goals. That documentation layer expected to give an overview of the applications being used to support the certain business processes.

The application documentation should be complementary to the business process documentation.

The KPI layer documentation describes the key business strategies, organization and goals that are closely related to business processes. This is very important in context of VOC, as it must adapt its operations according to the VO's changing environment. The goal of KPI-s is to direct the organizational behavior and its focus areas to the wanted directions.

All these layers together provide not only a vision and the consistent principles applied on all the layers, but also the addresses objectives such as security, common semantic, flexibility, make the versus buy decisions, reuse and domains where to invest.

All these documentation dimensions are very important for architecture management, which means for EA governance it is needed to handled these as:

1. EA level – defines overall management principles which determines all architecture principles and main architecture contracts for companies;
2. Domain level – specifies rules for certain business domain, focuses in more detail to certain business domain semantics, business processes, KPI-s, applications, and infrastructure;
3. Application governance level – handles EA in the lowest level, focuses on data model, application integration, business processes which are implemented into the applications and all related documentation.

To conclude, each of these levels has different generalization of these EA documentation levels described above.

4 Ontology Overlapping in VO

It is well known from theory of collective intelligence, that during the cooperation, participants in the communication will influence each other [26] in a way they will modify their behavior based upon the assessment of their roles and outcomes.

In context of VO, it means that based on VOC-s interoperability connection intensity, the mutual influences will influence VOC ontology. The influence depends, in addition, on VOC's organizational maturity, size, company geographical distribution, and on the experiences in the specific business sphere.

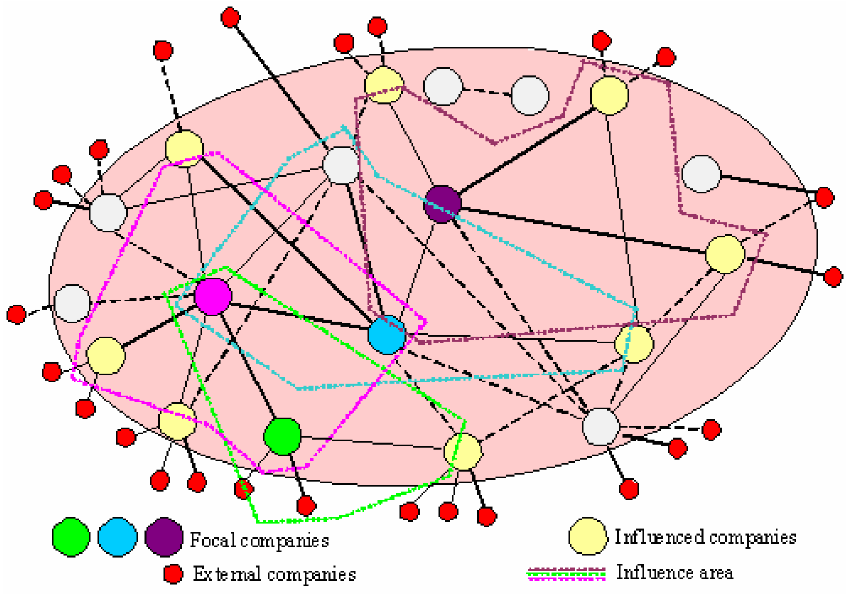

Fig. 3. VO focal players influence areas

As already described, depending on size of VO, there is usually more than one focal player, which dominates in VO value chain. These focal players have reputation, economical power and a higher or equal maturity level comparing to Partner Network, which means that focal players will influence their own partner network with which they have business relationship (first front partners). The extent of influence will depend on the intensity of the interoperability connection (Fig.3.).

As the first front partners have their own contract partners (the second front partners), it means that the focal player will influence the second front partners as well even though the influence is much weaker.

Consequently there are overlapping areas of ontology creating semantic synchronization / transformation (Fig.4.). The area bounds depend on the intensity of the interoperability connection. There is a crucial role of enterprise architects handling such semantic synchronizations / transformations.

Depending on the duration of the cooperation, the overlapping semantic areas will increase. When focal players communicate intensively with each other during the longer period, their ontology could coincide, which means that VO-s with longer history will have similar semantics, working principles, etc.

Analogically to the any organizational domain, three types of communication in EA governance can be identified – strategic, tactical and operational communication.

As usually, the strategic communication has most important influence on the company. It reinforces organizational message and brand, prevents contradictory and confusing messaging, allows creation and distribution of communication, that being different in style and purpose, has an inner coherence. Strategic communication conveys deliberate messages through the most appropriate media to the designated audiences at the appropriate time to contribute to and achieve the needed long-term effect.

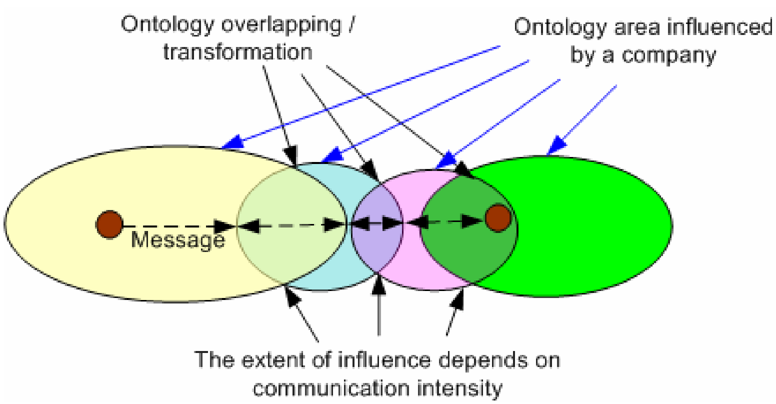

Fig. 4. Ontology transformation

The tactic communication is dealing with information that focuses from one responsible person to another certain person in tactical forces. The agreements made in this level of communication are for example Service Level Agreements, detailed business processes agreements, semantics managements, business environment monitoring. In brief, the mission of tactic communication is to provide business and technology solutions with smooth business cooperation between VOC-s and external partners, and to prepare disaster recovery scenarios and applications. The main challenges of tactic communication are to get data for operational situation management (including situation awareness), decision support, information fusion, situations control and situation prediction, semantic information processing (including semantic modeling), ontologies, knowledge representation and others.

Operational communications handles low-level topics, such as incidents, problems, change management, new developments, infrastructure management and support.

Thus, from VOC-s EA ontology harmonization point of view, the tactical communications have the highest importance, as the agreements made on that level have most significant influences to the VOC and thus also for VO (Fig. 5).

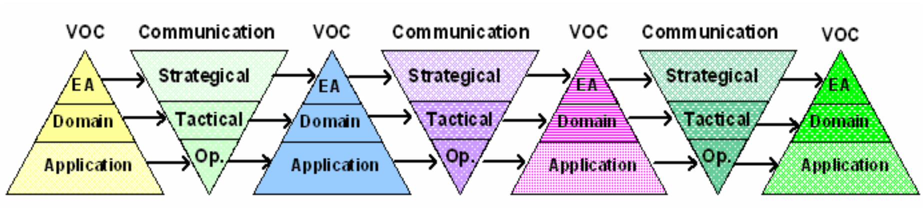

Fig. 5. Communication levels in ontology management

5 EA Roles in VOC

As above described, there are many EA frameworks available. As every architecture, according to our understanding, is context specific, it is possible to find out of the existing EA frameworks the most suitable one for an ordinary organization. The problem lies in the VO characteristic, as VO does not have a common ownership, which could force companies to operate in the same manner.

In context of VO, the EA's focus must be determined in more detail by the interoperability topics. Based on that, our research group is convinced, that the EA should be divided into three levels: EA level, Domain Level and Application level, where each of these levels will handle all five EA management layers (KPI-s, processes, data, application, infrastructure) in necessary level of generalization and in an easily communicable way.

Each of these levels should be covered by the EA architects. As EA as a discipline is quite novel (comparing e.g. with project management), then this is one of the reasons why different organizations use different titles to designate the Architect who leads the EA projects. The most commonly used are Chief Architect, Enterprise Architect, Chief IT Architect, IT/Enterprise Architecture Manager.

In addition to the Chief EA architect, there is a need for other roles in EA governance dealing with information, security, applications, infrastructure and business processes as well as with SOA (Service Oriented Architecture).

According our research group's approach, EA will be implemented through the six main EA roles:

1. Chief Architect – responsible for EA processes and EA team management;
2. Business Architect – responsible for business requirements, semantics and for consistent business processes management;
3. SOA architect – responsible for SOA governance, including service contracts;
4. Solution Architect – responsible for applications lifecycle management processes;
5. Data Architect – responsible for master data management processes and information management;
6. Infrastructure Architect – responsible for technical framework.

The discussions about the role Chief Security Architect constantly arises, yet in most cases security issues should be handled within pre-described roles.

Depending on company size, these roles should be assigned in a way where a person performs one or several roles.

What we would like to emphasize is that these roles should differentiate for themselves EA communication layers (i.e. EA level, Domain level, application level) and prepare their messages and strategies in appropriate way to simplify cooperation between collaboration partners. When these levels are accurately managed, the ontology overlapping will be accelerated and collaboration intensity will be promoted.

6 Conclusion

Globalization and the economic transformation taking place in the world economy, bring new opportunities and challenges for the domestic SMEs. The form of VO will dominate in today's marketplace. SMEs' alliance models of operations promote business process innovation and allow SMEs to compete in new ways getting better reward for their work and gaining greater financial strength, which in turn will give them the financial capability to advance and develop their products and services.

At the same time, the form of VO will raise a lot of complexity, mostly caused by missing central management. As each company in VO will have its own goals, mission, strategy, processes and characteristics, different ICT technology platforms, applications and policies, as well as different principles for Enterprise Architecture management, it is a rather a challenge to manage effective collaboration between VOC-s and VO's external partners.

The current article analyses only one aspect of VO architecture management, which is the communication, which seams to be the most important aspect. By communication, it is possible to influence companies in VO to unify their ICT technical platforms and working principles, as there is a lack of central governance, which in ordinary organization may enforce implementation of unified standards.

To conclude, our working team is convinced that in VO the VO enterprise architecture cannot be directly controlled, the VO focal players can only influence it, having intensive communication with its partners. In EA management, the EA architects' roles should focus on proposed EA levels and build up their work on a way that each EA layer can be communicated separately as the granularity, messages and the information consumers are in various levels and have different expectations.

As the communication will take the crucial role in EA management in VO, the architects need to have an excellent social skills using as much as formal and informal communication to distribute their views in VO to establish more flexible EA solution, which will enable VO to use it characteristics - flexibility, dynamism, and its robustness.

Our further research will focus on communication issues and barriers that organizations, invited to participate in VO will have and we will concentrate on the question how to accelerate the new organization adaptation into VO.

References

1. Kangilaski, T.: ICT and Business Alignment in Virtual Organization. In: 6th IEEE International Conference on Industrial Informatics (INDIN), pp. 1251–1256. IEEE Press, Daejon (2008)
2. Katzy, B.R.: Design and Implementation of Virtual Organizations (1998), http://portal.cetim.org/file/1/67/Katzy-1998-Design-and-Implementation-of-Virtual-Organizations.pdf
3. Virtual organizations: systems and practices. In: Camarinha-Matos, L.M., Afsarmanesh, H., Ollus, M. (eds.). Springer, New York (2005)
4. Camarinha-Matos, L.M.: Infrastructures for virtual organizations – where we are. In: IEEE Conference ETFA 2003, September 16-19, vol. 2, pp. 405–416. IEEE Press, Lisbon (2003)
5. Norton, B., Smith, C.: Understanding the virtual organization. Barron's Educational Series, Hauppauge (1997)
6. Davidov, W.H., Malone, M.S.: The virtual corporation. In: Structuring and Revitalizing the Corporation for the 21st Century. The Virtual Corporation, HarperBusiness (1992)
7. Ring, P.S., van de Ven, A.H.: Structuring cooperative relationships between organizations. Strategic Management Journal 13, 483–498 (1992)
8. Byrne, J.A., Brandt, R., Port, O.: The Virtual Corporation. Business Week 8, 36–40 (1993)
9. Kangilaski, T.: Virtual Organization and Supply Chain Management. In: 10th IEEE International Conference on Emerging Technologies and Factory Automation, ETFA 2005, Catania, Italy, September 19-22, pp. 705–712. IEEE Press, Los Alamitos (2005)
10. Wigand, R., Picot, A., Reichwald, R.: Information, organization and management: Expanding markets and corporate boundaries. Wiley, Chichester (1997)
11. Shao, Y.P., Liao, S.Y., Wang, H.Q.: A model of virtual organizations. Journal of Information Science 24(5), 305–312 (1998)
12. Manheim, M.L.: Cognitive Informatics: Theory and Implications for a People-Based Enterprise Information Architecture. In: Pacific Research Institute for Information Systems and Management Consortium PRIISM 1996 International Conference, pp. 341–353. Colorado Springs: University of Colorado at Colorado Springs (1996)
13. Holland, C.P., Lockett, A.G.: Business Trust and the Formation of Virtual Organizations. In: 31st Annual Hawaii International Conference on System Sciences, vol. VI, pp. 602–609. Computer Society Press, Kauai (1998)
14. Travica, B.: The Design of the Virtual Organization: A Research Model. In: Americas Conference on Information Systems,, AMCIS, Indianapolis, August 15-17, pp. 417–419 (1997)
15. Kangilaski, T.: Virtual Organization for Power Network Management. In: 2nd IEEE International Conference on Industrial Informatics, INDIN 2004, Berlin, Germany, June 24-26, pp. 169–174. IEEE, Berlin (2004)
16. Garvin, D.A.: The Processes of Organization and Management. Sloan Management Review 39(4), 33–50 (summer 1998)
17. Scott, W.R.: Organizations: Rational, Natural and Open Systems, 5th edn. Prentice Hall, Upper Saddle River (2003)
18. Quinn, B.: Intelligent enterprise: a knowledge and service based paradigm for industry. The Free Press, New York (1992)
19. Camarinha-Matos, L.M., Afsarmanesh, H.: Creation of Virtual Organizations in A breeding environment. In: 12th IFAC Symposium on Information Control Problems in Manufacturing, INCOM 2006, Industrial Engineering, Saint-Etienne, France, May 17-19, vol. 2, pp. 595–603 (2006) (preprints)

20. Strader, T.J., Lin, F., Shaw, M.J.: Information structure for electronic virtual organization management. Decision Support Systems 23, 75–94 (1998)
21. Benabdelkader, A.: Information Integration among Heterogeneous and Autonomous Applications, Ph.D thesis. Amsterdam University (2002)
22. Gou, H., Huang, B., Liu, W., Li, X.: A framework for virtual enterprise operation management. In: Computers in Industry, vol. 50(3), pp. 333–352. Elsevier Science Publishers BV, Amsterdam (2003)
23. Maloneand, T.W., Crowston, K.: The Interdisciplinary Study of Coordination. ACM Computing Surveys 26(1), 87–119 (1994)
24. Kangilaski, T.: Interoperability Issues in Virtual Organization – How to Proceed? In: 12th IEEE Conference on Emerging Technologies and Factory Automation, ETFA 2007, September 25-28, pp. 1293–1299. IEEE Press, Patras (2007)
25. The Open Group: TOGAF™ Version 9 - The Open Group Architecture Framework, http://www.opengroup.org/architecture/togaf9-doc/arch/
26. Johnson, N.L.: Collective problem solving: Functionality beyond the Individual, Los Alamos National Laboratory, New Mexico (1998), http://collectivescience.com/Documents_1/NLJsims_AB_v11.pdf

Semantic Harmonization for Seamless Networked Supply Chain Planning in the Future of Internet

Ricardo Jardim-Goncalves, Joao Sarraipa, and Adolfo Steiger-Garcao

CTS, Uninova, Dep.ª de Eng.ª Electrotécnica, Faculdade de Ciências e Tecnologia, FCT, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal
{rg,jfss,asg}@uninova.pt

Abstract. Today, enterprises are typically in a constant process of acquiring and updating its information technologies, however typically without an overall view of the global inter and intra enterprise's system integration. Foreseeing the future of internet, researchers have been proposing new methodologies and platforms to assist such integration in the network of applications and data. However, implementing new technologies in organizations is a difficult task, since its quality needs for architectures development are more exigent and critical than ever, due to the systems complexity and dimension, semantic needs, and to the interoperability requirements to interact with third party applications and infrastructures. Scientific foundations for EI are envisaged to roadmap such general knowledge covering the general laws of the operation on enterprise interoperability in the future of internet. This paper reports research results from ongoing European Commission supported projects that are members of the *Future Internet Enterprise Systems (FInES) European Cluster*[1]. The paper draws concepts from the complex systems science and proposes a methodology for seamless networked Supply Chain Planning (SCP), by using a domain reference ontology, data model representation standards, software components evaluation and interoperability checking processes. The methodology VALTE is used to assure that enterprises use tools for SCP compliant to semantics, represented in a common reference ontology, created by the MENTOR methodology. These two horizontal methodologies are vertically supported by interoperability checking processes, which contribute for an interoperable supply chain planning system on the future internet.

Keywords: Interoperability, Future of Internet, Semantics Interoperability, Quality Assurance, Networked Supply Chain Planning.

1 Introduction

The globalisation of markets and manufacturing has forced the management of supply chains not only consider business processes in the traditional value chain, but rather processes that penetrate networks of organisations. The formation of cooperation and collaboration alliances between several small organizations is proving, in multiple

[1] http://cordis.europa.eu/fp7/ict/enet/ei_en.html

P. Bernus, G. Doumeingts, and M. Fox (Eds.): EAI2N 2010, IFIP AICT 326, pp. 78–89, 2010.

cases, to be more efficient and competitive by comparison with big companies. Thus, the research on supply chain management has turned from an intra-enterprise focus towards the one on inter-enterprise running on the internet [1].

Supply chains consist of business and technological processes, and organizational, technical, topological, informational, and financial structures. All of these processes and structures are interrelated and change with their dynamics. To ensure a high responsiveness level, the supply chain plans must be formed extremely quickly, but must also be robust [2][3]. That is why it becomes very important to plan and run supply chain plans in relation to all the structures. The increasing competitive pressures coupled with the rapid advances in information technology have brought supply chain planning into the forefront of the business practices of most manufacturing and service organizations [4]. Consequently, there has been a growing interest in electronic business (e-business) solutions to facilitate information sharing between organisations in the supply chain. However, partnerships cause some problems mainly in integrating Product Life Cycle phases, since manufacturers, distributors, designers, retailers, warehouses, often acquire their proprietary solutions which are, typically, not interoperable with another [5].

Standardisation in data structures appeared to solve the referred communication problems. Several initiatives were taken to address this issue, like ISO10303. ISO 10303, also known as STEP, is the standard for the exchange of product model data. STEP Application Protocols have been widely used in industrial environments, to support systems interoperability through the exchange of product data in manufacturing domains. However, *per se* data representation standards did not solve all the problems. Semantics interoperability is of major importance, and as such it is still to be solved. More recently, the development of ontologies, as promising techniques with capabilities to solve semantic issues, has been addressed by important companies and SMEs. Thus, each company is struggling to develop competencies at this ontological level, but inevitably different perspectives will lead to different final results, and achieving different ontologies in the same business domain is an actual reality. To face it, one possible solution is to have a reference ontology for a specific domain where all the domain enterprises should use in their business. Although, to force manufacturers or suppliers to adopt a specific ontology as reference is not an easy task, since each enterprise does not foresee any outcomes by changing their knowledge. Thus, an advantageous solution would be to let them to keep their terminology and classification in use, and adopt a reference ontology. The adopted ontology will be the organization knowledge front-end, enabling inter-enterprises communications sharing the same terminology and semantics. Since this reference ontology will become their front-end, each organizational enterprise should feel motivated to participate in its building process, contributing with their own terminologies, definitions and classification structure.

The paper draws concepts from the complex systems science towards the foundation for a science-base Enterprise Interoperability and proposes a methodology for seamless networked Supply Chain Planning (SCP), by using a domain reference ontology, data model representation standards, software components evaluation and interoperability checking processes. The methodology VALTE is used to assure that enterprises use tools for SCP compliant to semantics, represented in a common reference ontology, created by the MENTOR methodology. These two horizontal methodologies are vertically supported by interoperability checking processes, which contribute for an interoperable supply chain planning system on the future internet. Thus, the paper proposes the integration of the VALTE and MENTOR methodology, complemented by interoperability checking methods, to contribute for networked seamless supply chain planning in the future of internet. The paper finishes discussing a case study in an industrial context.

2 Motivations for EI as a Science in the Future of Internet Domain

As information systems in enterprises and organizations evolve and become more complex, the need for interoperable operation, automated data interchange and coordinated behavior of large scale infrastructures becomes highly critical [6]. Lack of interoperability would disturb creation of markets and will diminish innovation and competitiveness. Apart from being a technical issue, interoperability challenges also appear in the enterprises at organizational and semantic level, underlying the need for patterns and solutions that support the seamless cooperation among ICT systems, information and knowledge, organizational structures and people [7].

Enterprise Interoperability (EI) is recognized as a high-impact productivity factor both within the private and the public sector, affecting the overall quality, yield time and cost of transactions, design and manufacturing operations or digital public services [8]. Up to now, the principal tools for targeting the above challenges appear as the various standards that try to govern information systems development and operation [9]. Such standards are usually linked with specific market sectors, application areas or technology trends, thus having a limited time span, a static nature and quite often different interpretations by technology vendors and users[9][11].

However, in spite of the research developed so far, nowadays it was not established yet the scientific foundations for EI. This is a deficit recognized by the EI research community, disabling the generalization and complete reuse of the methods and tools that have been developed [12][13].

2.2 Open Research Questions on EI

EI suggests that organizations can seamlessly interoperate with others throughout research development of focal areas, removing barriers to interoperability, fostering a new networked business culture, and transferring and applying the research results in industrial sectors. These areas are within the scientific domains of systems complexity, network science, information theory and web science. With them, the scientific foundations related with the major EI research topics can be worked out, connected with the results of the applied research that has been developed by the EI research community [13]. Among the most relevant research results achieved for EI, we identify of special interest for the establishment of the scientific foundations those on distributed systems, shared data and knowledge, evolutive applications, dynamics and adaptation of networked organizations on a global scale. Those are all directly related with rapid evolution of technology and applications, plug and play instruments, self monitoring capabilities, benchmarking and evaluation of degrading processing, automatic or on demand reprocessing, recompiling or fixing of components or processes. Moreover, to achieve a steady stable EI in a global scale there is the need for human assisted supervising systems supported by embedded supervising systems with learning capabilities.

Nevertheless, the role of standardisation policy is a major global and regional tool in EI context (e.g., ISO, CEN). Standards must point out to be perfect, completely clear but they must be implemented by the market. To reach globalization objectives for EI, they must be submitted to robust feedback mechanisms aimed to receive input from implementers, interested communities and from the market in order to assure a dynamic improving and standards maintenance. Scientific methods to assess the suitability, impact and the extension of the adoption and relevance of such standards, i.e., based on statistical methods, in the EI domain must be tightly adopted. Thus, the science foundation for EI must be well specified and general, completely unambiguous, designed to be flexible, robust and predicable in the global context, refraining from dependencies on technology and usage.

2.3 EI as a Science for Future of Internet

There are some European research projects researching in this field (e.g., iSurf, K-NET, COIN, CoSpaces, ATHENA, INTEROP) [6], but all are concentrated in developing focal solutions for specific business scenarios, in an applied research perspective, and yet none is conducting the researching towards such generalization in a scientific foundation ground [13]. One of the aims is to establish the scientific and technological ground to allow different "systems node" to be integrated in a collaborative network, advancing at its own needs, keeping interoperable in the network where it wants to be integrated. Thus, it will permit advanced adaptation and optimization of systems, e.g., supporting their maintenance processes by the use of technologies suitable for generalized knowledge representation applied to the Model Management (MoM) domain, namely dynamic models-morfisms (DynamicMoMo).

With the foreseen research results, the adoption of advanced techniques for meta-modeling and automatisms for model and data transformations, will enable to have the engine for interoperability not embedded directly in the systems coding, but through proper adaptative techniques get a suitable characterization of the actual status of the system's morphisms, supporting predictive system evolution, and analysis of its complexity in the dynamics of the network, including the respective transients and systems responsive behavior. At knowledge level, it is foreseen the need for the harmonization of ontological structures within and between the different network nodes, supported by statistical methods (e.g., stochastic methods) to permit semantic adaptability for the users specificities and to support the application dynamics. Then, enrichment of the semantic mapping will be possible, as a process to gather, classify, describe and then analyse the semantically features in the domain of the system models, and take better decisions in the advent of uncertainty [14][15].

The following research topics have been recognized as part of the core for the establishment of EI as a science:

1- Intelligent reconfiguration of components, for interoperability maintenance of evolutive networked systems.- Learning and adaptability: After indentified the need to solve an interoperability problem, the related systems typically know very few about the necessities required to have the global system completely interoperable. A learning process should be designed to support the adaption of the several system network nodes involved, and thus keep the global network interoperable.- Transient analysis: The global interoperable network, as a complex integrated system, will face transients whenever an internal or external "interference" occurs, e.g., update in one of its nodes. Thus, there will be a period of time which the systems nodes need to react and readapt to before the system becomes again stable and interoperable. The evolution and progressive adaptation of each network system node should be done supported by a systematic study and analysis of the network transients, as single node, clusters, and global network.- Interoperability checking: The global network needs to be checked and assessed to assure the maintenance of the networked interoperable system. A proper methodology for monitoring, diagnosis and prognosis, should be in place to assure the interoperability of the complex system in the advent of dynamics in the network.

2- Conformance testing and Interoperability checking for complex systems interoperability assessment- Discovery and Notification: When a new system node is integrated in the network, or it is updated, how such updates can be automatically identified and completely recognized by the network, and how the network should react to become interoperable, or keep its interoperability, with the new node, or update, through the automatic understanding of the intrinsic knowledge and behaviour of the node. Then, what such information can be processed and what are the needed adaptations of the systems node, to have the global network again globally interoperable.- Automatized catagorization of ontological structures: Automatized development of ontologies from descriptive specifications in non specialized language, e.g., queries described in natural language, supported by an engine with feedback for the user, with learning and reconfiguration capacities.- Conformance checking: The evolution of the network, by the integration of a new node or updates in the existing ones, will required checking for the conformance of data, models, knowledge and behaviours of the systems and applications. A proper methodology should be in place to assure such conformity in the advent of such dynamics.

3 - Harmonization of ontological structures to support the application dynamics and enable adaptability of users semantical specifications- Mutation of ontologies supported by stochastic methods: Mutation of ontologies using stochastic method to support the updates in the representation of concepts and its instances.- Harmonization of ontologies and semantical adaptability: Semantic harmonization, and adaptative mapping in dynamic environments, with mediation of semantic conflicts according to the interactions and evolution with the systems which it interacts.- Adaptative services for knowledge management: Knowledge is the basis for seamless interoperability of the integrated global network. Adaptative services for knowledge management will assure the accuracy of the information and behaviour of the complex system in each node and in the integrated network, support the dynamics and evolutionary characteristics of the complex system.

3 Networked Enterprise Reference Ontology for Interoperability

The development of an enterprise reference ontology can follow the MENTOR methodology [16]. Its main objective is to help an organization to adopt or use and to build, a domain reference ontology, after through several main steps as semantic comparisons, basic lexicon establishment, mappings among ontologies and others operations on knowledge base representations. The method to support the development of a common reference ontology for a group of enterprises sharing a business domain, provides several steps as semantic comparisons, basic lexicon establishment, mappings among ontologies and other operations on ontologies. This method is composed by two phases with three steps each (Fig. 1): the Lexicon Settlement - Phase 1 (steps: 1; 2 and 3), and the Reference Ontology Building - Phase 2 (steps: 4; 5 and 6). All of these steps are deeply described in the following two pictures where each step has a set of actions which has a number related to the step which belongs to (e.g. 1.1 is an action of the step 1).

The Lexicon Settlement phase (steps: 1; 2 and 3) represents a domain knowledge acquisition which comparatively to the human language apprentice phase could be represented in computer science as a semantic organized structure with definitions.

The thesaurus can represent such words structure of associated meanings and thus should be built in order to establish the lexicon of a specific domain. This phase has three steps: Terminology Gathering (step 1); Glossary Building (step 2) and Thesaurus Building (step 3). These steps define a set of workflows that establishes a thesaurus of the domain before starting the ontology building.

Figure 1 (left part) depicts the state diagram of the lexicon settlement phase. The terminology gathering step concerns to the process of collecting all relevant terms (action 1.2) in a specific domain previously defined (action 1.1). All the participants in the process should give their inputs. There is no rule from where the terms should come. Since they are related with the domain established. Tools for automatic extraction of domain related terms can be found, nevertheless there is always need of a human checking before close the terms list to not miss any domain terms. All the terms provided from the contributors are acceptable in this step (action 1.2). Nobody has authority to erase other's participant term. The term should be collected with reference to the contributor in order each contributor provide term's annotation in the next step (action 2.1).

Glossary is a specialized vocabulary with corresponding annotations. This vocabulary includes terms that are unique to the subject, have special meaning in the field of interest. The annotations include descriptive comments and explanatory notes for the terms, such as definitions, synonyms, and references. A Glossary can be used when communicating information in order to unify knowledge sharing. The Glossary Building step (step 2) intends to build a glossary in the domain defined. It starts with annotations attribution (action 2.1) to the terms collected. Each contributor should provide the annotations for his own terms. After having all the terms provided with annotations, it proceeds to the terms revision cycle (actions: 2.2; 2.3 and 2.4). In this cycle it could be useful to use a multi-language dictionary (action 2.0) in case of the organization members don't use the same natural language. The dictionary will help translations to the agreed language for the reference ontology. The terms revision process can have semantic and syntactic cases of mismatches (action 2.3), where they are recorded as a semantic mismatch for future mappings using the proposed mediator ontology.

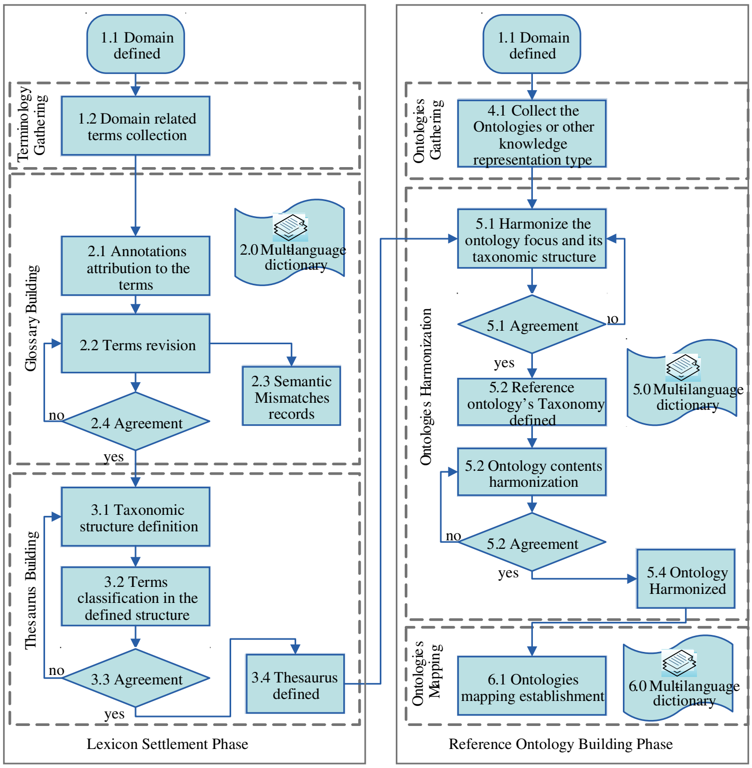

Fig. 1. MENTOR Phases and steps

After a careful revision in all the terms (action 2.2) with a successful agreement (action 2.4) in their meaning consolidation, the glossary is defined from the terminology list in the domain specified. Another output from this process is the semantic mismatch records (action 2.3): this is made using the Mediator Ontology. The Thesaurus Building step (step 3) is composed by a cycle where firstly, the knowledge engineers define a taxonomic structure (action 3.1) from the glossary terms, establishing some as thesaurus node terms. Secondly, the other terms are classified to the right paths in the existent taxonomic structure, being the thesaurus leafs (action 3.2). If there is an agreement (action 3.3) in the structure and in the terms classified, the thesaurus is defined (action 3.4). If not, the cycle starts again from the taxonomic structure definition (action 3.1). The thesaurus defined will enhance the ontology harmonization process in the next phase. The Reference Ontology Building phase - Phase 2 (steps: 4; 5 and 6) is the phase where the reference ontology is built and the semantic mappings between the organizational ontologies and the reference one is established. Figure 1 (right part) describes this.

The first step comprehends ontologies gathering (action 4.1) in the previously domain defined (action 1.1). Other type of knowledge representation could be used as input for the harmonization ontologies process together with the thesaurus defined (action 3.4) in the previous phase. The harmonization method for building ontologies, proposes the development of a single harmonized Ontology's by two cycles (actions: 5.1 and 5.3) where first the structure is discussed until having agreement on it (action 5.1), which result on the definition of the common classes and the class hierarchy (action 5.2), and then the same process for the ontology contents definition (action 5.3). From this process new semantic conflicts could be found. After agreement, the resolution could be recorded in the Mediator Ontology for further mapping establishments. With all the agreements accomplished, the harmonized ontology is finalized (action 5.4) together with the mapping tables (action 6.1), describing the ontological relationships between the harmonized ontology and each one of the individual ontologies through the use of the semantic mismatches records (action 2.3).

Semantic difficulties related to the natural language of the potential users of the harmonized ontology are likely to happen. To assist on it, the ontology is complemented with a multi-language dictionary where a set of normalized tokens gives the reference to the corresponding concepts and definitions in different native languages (actions 5.0 and 6.0).

3.1 VALTE: Evaluation Methodology for Supply Chain Software Components

The essential parts of software quality evaluation are the quality model, the method of evaluation, software measurement, and the supporting tools [17]. To develop good software, quality requirements should be specified, the software quality assurance process should be planned, implemented and controlled, and both intermediate products and end products should be evaluated [18]. VALTE is an evaluation methodology for supply chain software components, using as reference the Software Product Quality Evaluation Reference Model that describes the process, activities and tasks performed during the quality evaluation of a software product [19]. This reference models is defined by the standard [20] that contains general requirements for specification and evaluation of software quality and clarifies the general concepts providing a process description for evaluating quality of software product, stating the requirements for the application of the evaluation process. This specification is part of the SQuaRE series of standards created by ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission). SQuaRE replaces the current [21] series and the [22].

4 Case Study

This case study reports on a real case analysed during European Commission supported research projects. To guarantee the survival in today's competitive and demanding digital world of business, the European companies, especially SMEs, should be more agile, self-sustainable and responsive to the changes in the supply chain. Obtaining and maintaining a competitive edge in supply chain is not only the concern of individual SMEs, but should be also addressed by the entire chain jointly. The supply chain partners should collaborate effectively so as to better align supply and demand forecasts to have a joint strategy for handling exceptions that will occur in the way of realizing the "the network is the business" vision, nowadays on top of the internet. The simple choice of furniture components suppliers by a furniture manufacturer brings interoperability problems. Suppliers have defined various nomenclatures for their products and its associated knowledge. Thus, the need to align applications, to exchange products data and semantics emerged as a priority to solve the dilemma. Figure 2 describes the validating scenario, where a set of enterprises agreed to work together to supply a big common client with various furniture products which are built collaboratively.

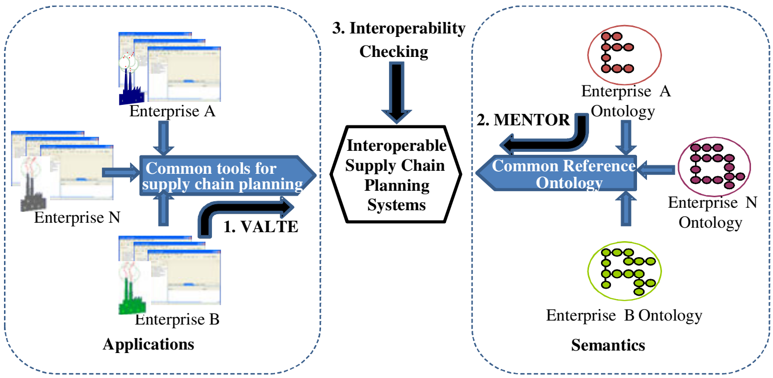

Fig. 2. Case Study overview [23]

The first step is to follow the VALTE methodology (left part of the Fig. 2), which will guide the applications evaluation activities. The evaluation follows a plan that includes the list of evaluation modules to be applied against the defined requirements related to the desired level of the software components characteristics. The evaluation results are then stated based on the metrics and measures defined and the positive or negative response of the software components evaluation to all the tests performed defines if the applications belongs to the set of common tools for a specific supply chain planning.

In the second step it is developed a reference ontology to the enterprises that are working together in this supply chain to establish between them a common semantics (right part of the Fig. 2). The MENTOR methodology is used to develop such reference ontology. During the reference ontology building phase, it is produced a mediator ontology which records all the semantic operations performed in this process. One of the applications of these semantic operations logs is to use that recorded information for semantic translation. One possible example of such process is when a message with a product request is sent to Enterprise B. The mediator ontology is used to get the "semantic translation" of the information present in the message, which uses syntax accordingly to the reference ontology, to the equivalent syntax used in the Enterprise B.

To ensure the interoperability between the systems, the third step on this use case, it is applied the Conformance Testing (CT) to its exchanged files. Based on the defined methodology for CT, the architecture shown in the Figure 3, is used to validate such files. The architecture was designed based in web-services, able to receive the files in XML format and checking them against the reference testing model using an Application Engine developed in JAVA, SAX, Schematron and XALAN.

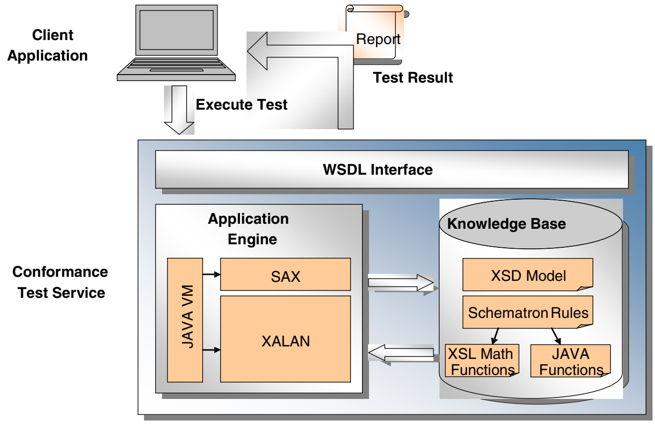

Fig. 3. Architecture for CT system validation [24]

Using the CT the user can check the files against the defined models, ensuring its correct implementation. The CT checks the XML against syntactic and semantic rules and sends back the detected errors enabling its correction. With CT executed to its XML files, the next step is the application of the Interoperability Checking (IC). To apply IC, the user will analyze and modify the test files, sent by the IC system, and send it back to evaluation. After check all the files, defined in the Abstract Test Suites (ATS) for IC, the user receives the confirmation that its system is interoperable. With all the ATS executed (CT ATS and IC ATS), the system validation can ensure that the systems are in conformance with the model defined and is interoperable with others system of this type.

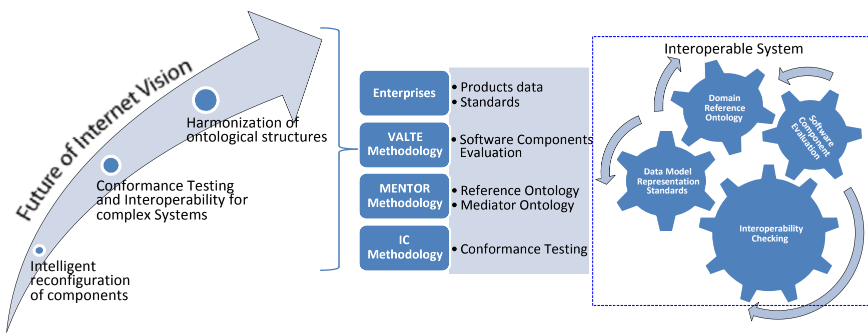

Fig. 4. System interoperability methodologies in Future of Internet Vision

5 Conclusions

System methodologies for networked enterprise interoperability facilitate organizations to keep its technical and operational environment, improving its methods of work and the usability of the installed technology through quality assurance of the system software components, ontological harmonization of the enterprises product models in use, assessed by a fitting validation framework for conformance testing and interoperability checking. However, to have an enterprise organizational system interoperable, it has to have a domain reference ontology which enhances inter-enterprise's semantics interoperability concerning to the contents of a standardized data representation model. These both components (reference ontology; data representation model) should be complemented with software quality assessment and Interoperability checking methodology able to perform model conformance testing (Fig. 4).

The proposed methodology enable the computational systems of any set of enterprises which work together in a networked supply chain planning to smoothly communicate between each other using syntax and semantic present in data representation standards and in the reference ontology respectively. This is complemented with a previous software components evaluation and a post conformance testing procedures.

Such methodology was applied with good results in a real scenario supervised by the research EuropaINNOVA initiative through the INNOVAfun and iSurf projects (member of the *European Future Internet Enterprise Systems (FInES) Cluster*). These achievements have been encouraging to the development of further framework functionalities in the future, like the generation of the reports according to a normative schema (e.g., defined in EXPRESS and XML), to enable automatic inference and reasoning on the errors found, and provide automatic correction of the identified errors by an internet-based expert system.

Acknowledgments. This work has been partly funded by the European Commission (E.C.) through EuropaInnova and IST projects: INNOVAfun - 031139; and iSURF - IST 213031. The authors acknowledge the E.C. and all the project partners for their support during the development of various ideas and concepts presented in the paper.

References

[1] Rudberg, M., Klingenberg, N., Kronhamn, K.: Collaborative supply chain planning using electronic marketplaces. Integrated Manufacturing Systems Journal 13(8), 596–610 (2002)

[2] Jardim-Goncalves, R., Grilo, A.: SOA4BIM: Putting the building and construction industry in the Single European Information Space, Automation in Construction (2009)

[3] Grilo, A., Jardim-Goncalves, R.: Value proposition of interoperability on BIM and collaborative working environments. J. Automation in Construction AUTOCON (2009)

[4] Gupta, A., Maranas, C.D.: Managing demand uncertainty in supply chain planning. Computers and Chemical Engineering 27, 1219–1227 (2003)

[5] Jardim-Goncalves, R., Grilo, A., Steiger-Garcao, A.: Developing interoperability in mass customization information systems. Mass Customization Information Systems in Business. Idea (January 2007), ISBN-10: 1599040395

[6] (follow link PUBLIC DELIVERABLES) Major worldwide repository with publications from research in the area of Interoperability, http://www.interop-vlab.eu/

[7] Jardim-Goncalves, R., Grilo, A., Steiger-Garcao, A.: Challenging the Interoperability in the Construction Industry with MDA and SoA. Computers in Industry 57(8-9), 679–689 (2006)

[8] Farinha, F., Steiger-Garcao, A., Jardim-Goncalves, R.: Integration of cooperative production and distributed design in AEC. Advances in Engineering Software 38(11-12), 772–779 (2007)
[9] Steiger-Garcao, A., Jardim-Goncalves, R., Farinha, F.: An open platform for interoperability of civil engineering enterprises. In: Advances in Engineering Software (2007)
[10] Jardim-Goncalves, R., Steiger-Garcao, A.: Implicit Multilevel Modelling in Flexible Business Environments. Comm. of the ACM 45(10) (2002), ISSN 0001-0782
[11] Figay, N., Steiger-Garcao, A., Jardim-Goncalves, R.: Enabling interoperability of STEP Application Protocols at meta-data and knowledge level. International Journal of Technology Management 36(4) (2006), ISSN 0267-5730
[12] Leyton, M.: A Generative Theory of Shape. LNCS. Springer, Heidelberg, ISBN-10: 3540427171
[13] Enterprise Interoperability Research Roadmap, European Commission, ftp://ftp.cordis.europa.eu/pub/ist/docs/ict-ent-net/ei-research-roadmap-v5final_en.pdf
[14] Jardim-Goncalves, R., Sarraipa, J., Agostinho, C., Panetto, H.: Knowledge Framework for Intelligent Manufacturing Systems. Int. J. of Intelligent Manufacturing (2009)
[15] Sarraipa, J., Jardim-Goncalves, R.: MENTOR: An Enabler for Interoperable Intelligent Systems. International Journal of General Systems (2009)
[16] Sarraipa, J., Silva, J., Jardim-Goncalves, R., Monteiro, A.: MENTOR – A Methodology for Enterprise Reference Ontology Development. In: 2008 4th International IEEE Conference on Intelligent Systems (2008)
[17] Suryn, W., Abran, A.: ISO/IEC SQuaRE. The 2nd generation of standard for quality of software product. In: Proceedings of 7th IASTED International Conference on Software Engineering and Applications, SEA 2003, Marina del Rey, CA, USA, November 3-5 (2003)
[18] Trudel, S., Lavoie, J.-M., Paré, M.-C., Suryn, W.: The design of the software quality evaluation method combining CMMI and ISO/IEC 14598: the context of a small company. In: Proceedings of 12th International Software Quality Management & INSPIRE Conference (BSI), Canterbury, Kent, UK, April 5-7 (2004); Article a obtenu le prix du meilleur article scientifique 2004
[19] Vieira, H., Jardim-Goncalves, R.: VALTE – Methodology for VALidation and TEsting of Supply Chain Software Components. In: 15th International Conference on Concurrent Enterprising (2009)
[20] ISO/IEC CD 25040: Software engineering - Software product Quality Requirements and Evaluation (SQuaRE) - Evaluation reference model and guide. International Organization for Standardization, Switzerland
[21] ISO/IEC 9126-1: Software Engineering-Software product quality-Part 1: Quality model. Geneva. International Organization for Standardization, Switzerland
[22] ISO/IEC 14598-1: Software product evaluation-Part 1: General overview. Geneva. International Organization for Standardization, Switzerland
[23] Sarraipa, J., Vieira, H., Agostinho, C., Jardim-Goncalves, R.: Methodology for Seamless Supply Chain Planning. In: The International Conference on Software, Services & Semantic Technologies Varna, Bulgaria (2009)
[24] Wiles, A.: Relevance of Conformance Testing for Interoperability Testing. ACATS ATS-CONF (2003)

Learning Interoperability in Emerging Supply Networks

Georg Weichhart, Matthias Neubauer, and Christian Stary

Johannes Kepler University Linz, Department of Business Information
Systems – Communications Engineering, Freistädterstr. 315
A- 4040 Linz, Austria
{Georg.Weichhart,Matthias.Neubauer,Christian.Stary}@jku.at

Abstract. Automotive suppliers are moving from supply-chain process design to dynamic socio-economic networking when speeding up innovation cycles to improve their competitiveness. In this way cross-organizational learning processes are triggered. Enabling team formation for collaboratively developing innovative products and services requires interoperability on several levels and in different flavors. Our empirical evidence from the European research project SUddEN (SMEs Undertaking Design of Dynamic Ecosystem Networks) reveals the need for context-sensitive learning support when starting to share and handle business opportunities in a collaborative way. The proposed support system enables partner- and network-specific emergence of situation-sensitive organizational behavior. In meeting user needs we have developed content structures and intertwined interaction features for accurate information exchange. Due to their scalability self-managed, highly structured learning processes are likely to replace prescriptive workflows in continuously changing settings.

Keywords: Enterprise Interoperability, Organizational Learning, Collaborative Networks, Topic Maps.

1 Introduction

A rapidly changing whilst competitive business environment forces organizations to respond through enterprise transformations on the structural level [1]. One effective way to support transformation processes is to provide representation schemes for conclusive information, such as business processes, as a means for documentation and mutual information exchange [2]. Such an endeavor is even more important in inherently networked organizational settings where business partners and stakeholders collaborate in different locations in an asynchronous way. However, it requires substantial learning effort [3].

In trying to meet these recent challenges several process industries, among them Automotive Industry, started to move from supply chains to supply networks [4]. The production of car parts is getting increasingly complex due to intense pressure from Original Equipment Manufacturers (OEMs). Development and engineering is performed in teams composed of partners from different locations. These teams face demanding requirements with respect to product and process quality, and tight

P. Bernus, G. Doumeingts, and M. Fox (Eds.): EAI2N 2010, IFIP AICT 326, pp. 90–100, 2010.

production schedules. Moreover, team members are selected with respect to the price of the part to be supplied.

The European research project SUddEN [5] has targeted automotive suppliers in the context described above. The project aimed at the development of a platform supporting knowledge sharing and organizational networking. It should serve teams of suppliers when improving their business performance according to market needs. Basically, it should support collaborative product development and engineering enabling innovative offerings. Guiding this transition from traditional price-based bidding to competence- and network-driven business opportunity handling we have analyzed domain data, elicited requirements of envisioned instruments and tools, and developed a first prototype of such a platform. Based on the evaluation results we could identify a set of features and system architecture required for situation-sensitive collaboration and mutual learning support in supply networks.

In the following, we reflect the research and development process by reviewing the achievements so far. Section 2 reports on eliciting and meeting automotive-network requirements. Section 3 details the platform design that could be derived from the outcomes reported in section 2. The most significant findings impacting the platform design concern the structure and representation of content, and the overall flow of control. A particular structure, the Case File, has been introduced as the focal point of collaboration, exchange of information, and learning. The representation scheme of the platform has to reflect polymorphism of content elements, as they have different meaning in different situations. The service-oriented MVC architecture ensures interoperability from the business and application perspective. The resulting adaptability of functionality allows using the platform in various domains. Section 4 concludes the paper wrapping up the results and giving an outlook on future research activities.

2 Meeting User Requirements for Automotive Networking

Since we followed a user- and task-centered approach we did not only have to interview and observe networking stakeholders, but we had also to reflect these findings in a hands-on prototype that has been evaluated by the target groups of the envisioned platform for organizational development support.

2.1 Identifying User Needs

Working with four networked automotive suppliers in SUddEN (www.SUddEN.org.uk) it turned out organizational learning is mainly triggered by performance measurement (PM). PM is an instrument which provides management information and supports decision making and organizational development [6,7], in particular by reducing a complex system to a set of manageable measures [8]. Performance Measurement has both a systemic and a behavioral aspect. Individual Performance Indicators (PIs) are aggregated and mutually related within a Performance Measurement System (PMS). It allows responsible managers to monitor and assess the performance of a network or overall system along different dimensions.

As part of organizational learning, the collaborative development and design of a PMS positively influences the performance of the overall collaboration [9]. Among other factors it supports communication and improves coordination, and as such, the operational interoperability among supply network nodes [10].

The SUddEN platform is developed to enable Small and Medium Enterprise (SME) supply networks to improve their performance through competence development (being part of PMS management). The SUddEN prototype allows individual suppliers structuring and recording performance data with respect to competences. A respective questionnaire to acquire data (structures) has been developed by domain experts. Using a generic link mechanism of the platform network members can access information about training and improvement measures addressing various competence dimensions. One innovation in this context is the direct link of individual performance data to the respective results of the comparison with other network members (shown in fig. 1).

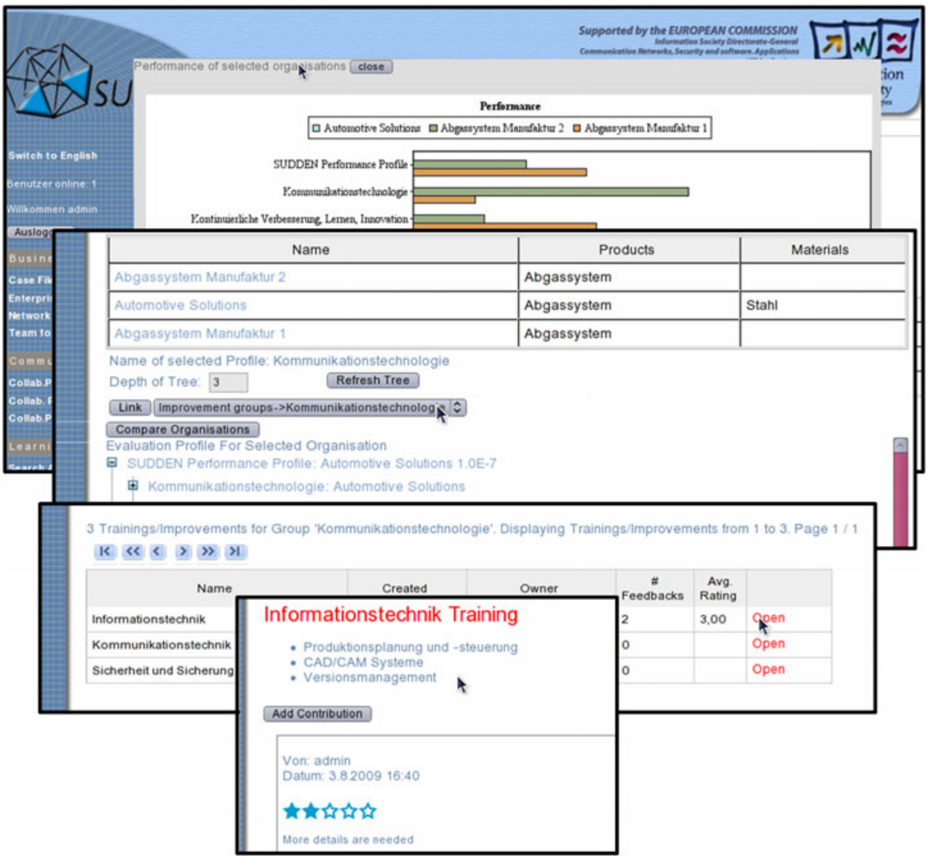

Fig. 1. Performance measurement and comparison of competences intertwined with discussions about a training or measurement for improving the competence dimension

These data are also linked to communication features on a fine level of granularity, to reflect collectively and learn mutually in a focused dialog. Figure 1 also shows the corresponding user support (bottom window). In the upper window the performance of the user's organization as checked against other suppliers is shown. When selecting a competence dimension of interest and selecting the link to available trainings for improvement the other windows pop up subsequently. Any training can be assessed in terms of effectiveness (using stars) to facilitate discourse and decision making to that respect.

The knowledge base for organizational learning is a (supply) network repository. It contains “Case Files” with relevant and specific information for each business case. A business case starts as business opportunity brought up by a network member, and might end with an innovative process specification to produce a novel (automotive) part. A Case File represents the organizational memory for collective and individual learning processes where product- and process-relevant information is detailed and supplemented over time. Of particular importance for organizational learning ensuring interoperable processes are not only documented results, but rather traceable steps including social interaction, as both are considered relevant for further decision taking.

Communication features like the context-sensitive SUddEN discussion forum allow reflecting and negotiating projects on-line. Network members may link communication entries to content elements, such as performance data, directly. In this way any social interaction becomes part of the Case File, and thus visible to all team members. It might trigger further collaborative learning processes, implementing team learning in a self-organized way.

In organizational learning team members are either involved directly or indirectly in knowledge reflection and generation [11]. Hence, they need to be supported when improving the organization’s (and network) performance in the most effective and efficient way. Learning activities become visible through individually handled content items and communication facilities. Once the corresponding features of the platform fit to user needs, stakeholders are likely to actively participate in knowledge generation and transfer (cf. [12]). Of particular importance seems to be the capability of individually linking communication entries to shared content elements (cf. [13]). When working in a collaborative project it is required that on the project level these links can be visualized and shared. This kind of transparency enables users to

- discover novel relationships between information items
- communicate these connections to project team members in a straightforward way
- direct the attention of others to relevant work items or project issues

Experiences from eLearning capturing those scenarios show that knowledge sharing and learning can be facilitated significantly once explicit features can be provided by support platforms (cf. [14]). The meaningful perception of information (domain knowledge) occurs in tandem with establishing communities of learning [15]. The SUddEN prototype encourages users arranging and combining (performance) information as they feel appropriate for the current situation. Content is represented in a flexible scheme, in order to allow situation-sensitive arrangement of content elements. For instance, a document might either serve as project report, as data collection or memo, depending on the context and situation of use.

Developing the SUddEN prototype we supported automotive suppliers improving their competence profiles. Individual improvements triggered the performance of network partners and innovative offerings when handling business opportunities. The partners intensively utilized the learning features of the prototype, both, from the perspective of content management based on domain-relevant categories, and the perspective of interaction, linking content elements to communication entries directly to share expertise in a focused way.

2.2 Evaluating the SUddEN Prototype

The prototype did not only support performance improvement methodologically, but also allowed hands-on experience of the envisioned learning processes on the individual and network level. We have evaluated the prototype's usability and usefulness through formative and summative evaluation. The results of the usability evaluation using EU-CON II have led to 'hot spots' for further development [16]. The aim of the usefulness evaluation was to finally understand the impact of performance-oriented learning on SME networks. Our intent was to examine to which extent interoperability can be established in large organizational networks.

The usefulness evaluation allowed understanding the prototype support on the operational, tactical and strategic level of interoperability. For each level a focus group has been conducted. For each focus group a questionnaire has been prepared which has been used to guide the discussions among supply network partners. Each group session lasted at least one hour, and has been recorded. In addition, the participants documented the core concepts on paper-cards. In the course of consolidating the findings, these cards have been put into mutual context leading to a concept map. Figure 2 provides a snapshot of the concept map focusing on learning aspects to establish interoperability on all three levels.

Figure 2 depicts the user requirements which have been revisited in the course of evaluation. *Encourage innovations* indicates that SUddEN supports generating economic viable business cases, facilitating interoperability on the tactical level.

Strengthening suppliers refers to improving the position of the supply industry towards their customers, the Original Equipment Manufacturers (OEM). The element *strengthening one's abilities/learning* refers to the individual organization or team of suppliers working on a project.

Communication functionality has been provided in the SUddEN prototype through a number of features. One key element is supporting presentation of ongoing work through the network repository in terms of performance competencies. Team members collaborating in an innovation project can trace decision making procedures and the current state of the project. Fundamental to this feature is the polymorph representation of content, as information items might have different meaning in different contexts.

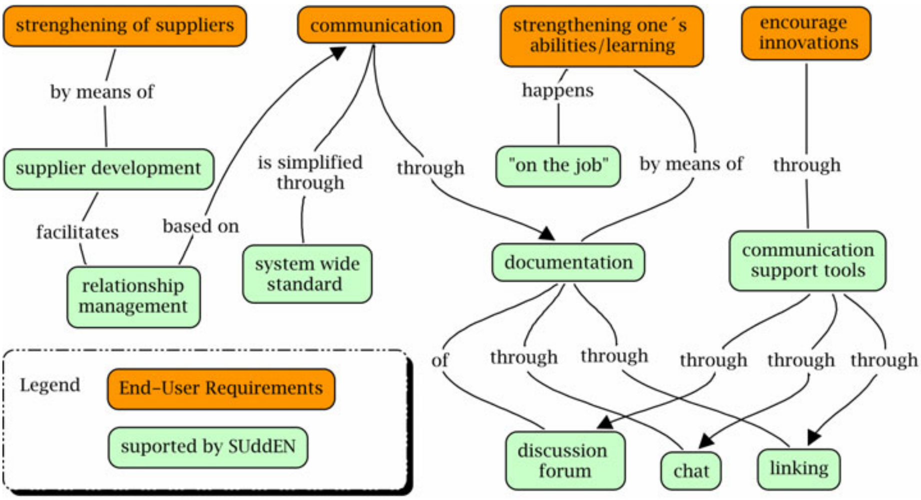

Fig. 2. Functionalities of SUddEN identified by end-users meeting their requirements with respect to learning and development

Interestingly, in the course of evaluation participants did explicitly not distinguish communication from learning. Learning is considered as exchange of relevant information. While working on a project some users contribute information relevant to other team members according to their functional role. Users communicate requirements to the overall team by providing this information. In another example, a sub-team discusses relevant team matters in a discussion forum. The results of this discussion become available through the Case File to the overall team. Thus, content creation is of equal importance to communication. Typically, the documentation of supplier development measures is an inherent part of a discussion - enabled through the SUddEN generic mechanism linking communication entries to fine-grain content elements (see above).

Due to market requirements in the Automotive Industry learning has to occur in a collaborative, but mainly self-organized manner, once a business opportunity is provided as input by the network coordinator. When dealing with innovation the respective projects are characterized by the gradual specification of the innovation through multiple team members. In order to ensure organizational interoperability, all generated content needs to be stored in a central repository. We will reflect these requirements in the next section, by discussing the representation scheme required for organizational interoperability, and the arrangement of features along services (relevant on the operational and tactical layer).

3 Platform Design

After revisiting the user requirements through evaluating hands-on prototyping, we can come up with a conceptual design of a platform supporting dynamic collaborative supply networks. An organizational learning platform of this kind needs a representation infrastructure allowing polymorph content and communication representation, as described in section 3.1. It also requires a modular and service-oriented architecture, as introduced in section 3.2.

3.1 Polymorph Content Representation

The flexible representation scheme has to allow keep content elements and link structures (including the addressed coupling of content elements to communication entries) according to their context of use. It is required to enable (i) representing different types of content, (ii) storing content elements in different, arbitrary forms of representation, (iii) adding individual information and remarks to content elements, (iv) mutually relating content elements, (v) attaching structural and domain-specific meta-data to content elements [17].

Topic Map technologies meet these requirements, as already demonstrated in the context of eLearning applications (cf. [18][19][20]). In SUddEN, Topic Maps allow team members to flexibly structure content according to their needs as well as linking content to social interventions, such as communication entries of a forum.

A topic map basically consists of topics, associations, occurrences, and scopes. Topics are the fundamental element of a topic map. They represent subjects of the perceived world (represented in a map). The relationship between topics and subjects therefore corresponds to the one between representation and referent in the semiotic thetrahedron (cf. [21]).

Associations represent relationships between subjects and, accordingly, are used to mutually relate the topics representing these subjects. Each end point of an association has to be defined in an association role. These roles are taken by connected topics. Association roles therefore represent the involvement of a subject in a relationship [23].

Occurrences are the links to the 'outer world' (outside the topic map) and complete the expressiveness of the topic map concept by adding index functionality. An occurrence is a representation of a relationship between a subject and an information resource [23].

Scopes are a means to define the contexts in which certain statements of a topic map are valid. Occurrences and associations are such statements. They can be used to describe domains captured by a topic map.

In this way Topic Maps provide inherent functionality to operate SUddEN on a flexible data model. In particular, it allows handling content elements and communication entries in the same way, while still allowing provision of meta data, as for categorizing content elements.

In fig. 3 a topic map example representing a performance measurement system (PMS) for a “Business Opportunity (BO-17)” is shown. It aggregates, using a weighted sum function, two competence dimensions – “Quality Management (QM)” and “Fault Parts”. These dimensions are in a certain role, representing the weights used. The competence dimension “Fault Parts” has different occurrences in different scopes, to allow representing context-specific values – company A (2ppm) and B (6ppm).

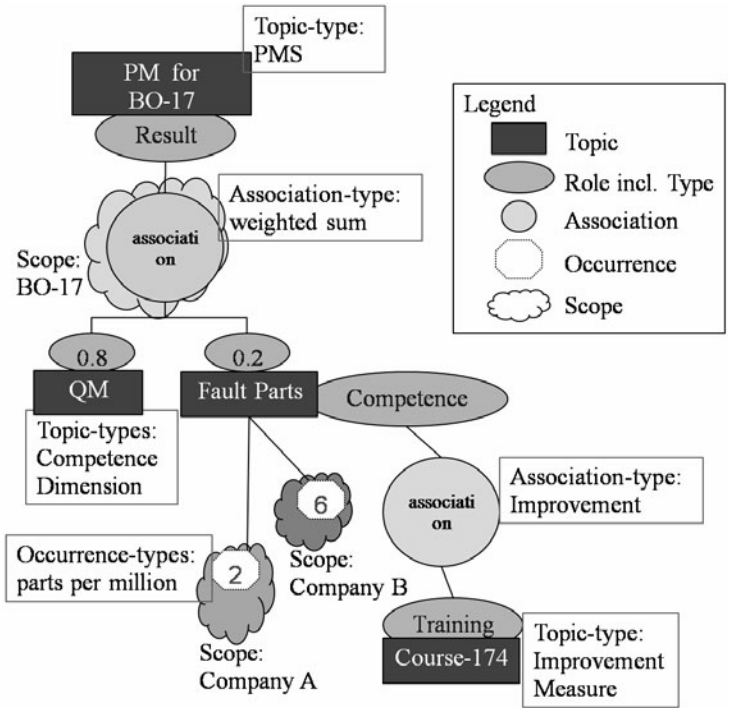

Fig. 3. Topic Map representing performance measurement systems

Each competence (dimension) is additionally associated with possible measures that a company may take to improve its performance.

3.2 Architecture

The overall architecture follows a modular Model-View-Controller approach. In fig. 4 the software packages are specified taking into account the MVC pattern. The platform is developed utilizing the Spring Framework [24], since it supports object-oriented programming principles and fosters the integration of different application APIs. Moreover, the framework is non-intrusive, as it allows developing the business logic without dependencies to Spring-specific classes.

Modules expose functionality through services. Each module is implemented following the Model-View-Controller pattern (shown on the vertical axis in figure 4). The View part of a module provides code for the web-based user interface implemented conform to the Java Server Faces (JSF) framework standard. The View part is tightly coupled with a Controller component, providing server-side Java code. A Controller facilitates access for the View to the business logic and the Model in general.

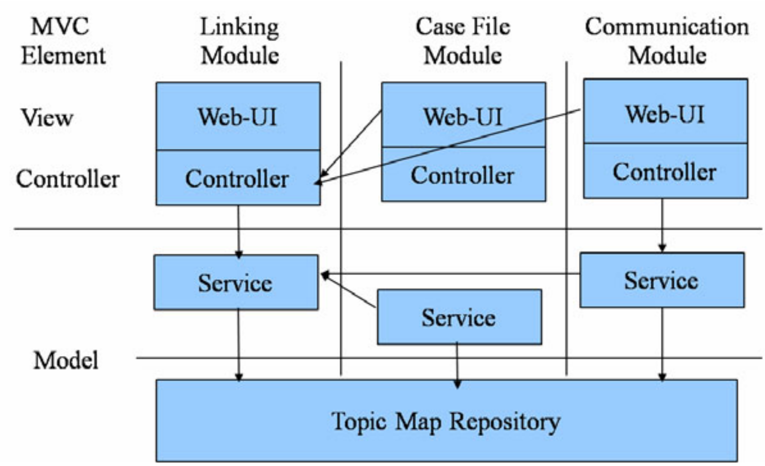

Fig. 4. Platform Architecture

The link module is of particular importance. It allows users to place links between topics, and is written in a generic manner. Services that are target or source of a link need to implement a certain interface. When implementing a module as a source for a link, developers have to include the link Controller within their User Interface JSF files. A button is used to trigger the dialog for selecting the link target. Modules which are targets of links, need to be registered using a Spring-managed configuration file. In this way the dialog of the link module can provide a list of accessible modules.

3.3 Learning Support

The SUddEN approach provides support for learning 'on-the-spot', as suppliers interpret their performance data always in a certain context. Topic Map occurrences represent performance data specific to business opportunities. Links attached to competence dimensions guide users to identify measures for improvement. They might be challenged and discussed with respect to their suitability given a certain situation. Since all proposals and modifications of performance data are stored, SUddEN ensures utmost transparency of effects when setting a particular measurement.

SUddEN also supports learning from prior business cases. Supply network performance and PMS changes, decisions and improvement measures are kept for each business case, and can be reviewed from the content and communication perspective. Closed Case Files provide insights into past experiences, and allow team members to improve mutual interaction and the process of decision taking.

The latter is of crucial importance, as it addresses organizational interoperability. Using SUddEN the interoperability between network partners, applications, or domains can be improved, since business opportunities and cases are handled in relation to the organizations involved, including particularities organizing their work. The processed and shared performance data, decision making procedures and measurements are made transparent, reducing the effort of future decision taking.

4 Conclusion

As supply chains are developed to supply networks, novel forms of learning support gain momentum. Network partners need to re-team to come up with innovative offerings to customers. Such dynamic collaborative mechanisms between SMEs can be found within the Automotive Industry. They require flexibility regarding content structures as well as closely tuned social interactions. The presented SUddEN approach is a European effort to promote semantic interoperability on several organizational network layers by means of focused learning processes.

A generic representation scheme allows for openness regarding content structure and communication, inherent to learning and/or innovation processes. The features of the platform support learning through individualizing content and communication when handling a business opportunity and developing a business case in the network. Collaboration includes individual and group development/improvement opportunities of performance in terms of competences. In this sense, SUddEN triggers the alignment of networked processes 'on-the-job', as concrete cases lead to the construction of envisioned solutions in a team. Interoperability is the target while working on a business case. It develops through understanding others. Since all learning steps are kept in a context-sensitive repository, innovations and decisions can be traced in the course of reflection and for designing further developments.

References

1. Stephenson, St.V., Sage, A.: Architecting for Enterprise Resource Planning. Information Knowledge Systems Management 6, 81–121 (2007)
2. Rouse, W.B. (ed.): Enterprise Transformation: Understanding and enabling Fundamental Change. Wiley, Hoboken (2006)
3. Brown, J., Duguid, P.: Organizing Knowledge. Reflections, Society of Organizational Learning 1(2) (1999)
4. ENSR Consortium, 2003 Observatory of European SMEs -Part 5: SMEs and Cooperation, European Network for SME Research (ENSR), European Communities (2004)
5. Weichhart, G., Feiner, T., Stary, C.: Implementing Organisational Interoperability – The SUddEN Approach. Computers in Industry 61(2), 152–160 (2010)
6. Schmitz, J., Platts, K.: Supplier Logistics Performance Measurement: Indications from a Study in the Automotive Industry. International Journal of Production Economics 89, 231–243 (2004)
7. Zäpfel, G., Piekarz, B.: Wirkungskettenorientiertes Performance Measurement für Supply Chains. In: Seicht, G. (ed.) Jahrbuch für Controlling und Rechnungswesen, pp. 377–411. LexisNexisORAC Verlag (2003)
8. Perrin, B.: Effective Use and Misuse of Performance Measurement. American Journal on Evaluation 19(3), 367–379 (1998)

9. Thrane, S., Hald, K.S.: The Emergence of Boundaries and Accounting in Supply Fields: The Dynamics of Integration and Fragmentation. Management Accounting Research 17, 288–314 (2006)
10. Lohman, C., Fortuin, L., Wouters, M.: Designing a Performance Measurement System: A Case Study. European Journal of Operational Research 156, 267–286 (2004)
11. Kim, D.: A Framework and Methodology for Linking Individual and Organizational Learning: Applications in TQM and Product Development, PhD Thesis, Sloan School of Management, Massachusetts Institute of Technology (1993)
12. Schulmeister, R.: Grundlagen hypermedialer Lernsysteme. Theorie– Didaktik– Design. Addison Wesley, Bonn (1996)
13. Kienle, A., Herrmann, T.: Integration von Kommunikation und Kooperation an Hand von Lernmaterial – ein Leitbild für die Funktionalität kollaborativer Lernumgebungen. In: Proc. Mensch & Computer 2002, GI & ACM German Chapter, Teubner, Stuttgart, pp. 45–54 (2002)
14. Auinger, A.: Didaktikgeleiteter Wissenstransfer. Deutscher Universitätsverlag, Wiesbaden (2005)
15. Stary, C.: Content als Kontext zur Kommunikation im e-learning. eLearning, vol. 1(1). Studienverlag (2006)
16. Stary, C., Riesenecker-Caba, T.: EU-CON II -Software-ergonomische Bewertung und Gestaltung von Bildschirmarbeit. Wirtschaftsverlag NW, Dortmund (1999)
17. Oppl, S.: Flexibility of Content for Organisational Learning. Master's Thesis. Johannes Kepler University Linz (2007)
18. Dicheva, D., Dichev, C.: TM4L: Creating and Browsing Educational Topic Maps. British Journal of Educational Technology – BJET 31(3), 391–404 (2006)
19. Matsuura, S., Naito, M.: Creating a Topic Map Based e-Learning System on Introductory Physics. In: Maicher, L., Garshol, L.M. (eds.) TMRA 2008, pp. 247–260 (2008)
20. Schmiech, M.: Didaktische Ontologien zur Organisation digitaler Objekte in der Arbeit von Lehrkräften, http://www.zhb-flensburg.de/dissert/schmiech/Schmiech%202006%20-%20Didaktische%20Ontologien%20zur%20Organisation%20digitaler%20Objekte%20in%20der%20AvL.pdf (2006)
21. Vatant, B.: Ontology-driven Topic Maps. In: Proc. of XML Europe 2004, Amsterdam (2004)
22. Falkenberg, E.D., Hesse, W., Lindgreen, P., Nilsson, B.E., Oei, J.L.H., Rolland, C., Stamper, R.K., van Assche, F.J.M., Verrijn-Stuart, A.A., Voss, K.: A Framework of Information System Concepts. The FRISCO Report. online version, International Federation for Information Processing WG 8.1 (1998)
23. ISO JTC1/SC34/WG3: Information Technology - Topic Maps - Part 2: Data Model. International Standard 13250-2, ISO/IEC (2006)
24. Wolff, E.: Spring 2: Framework für die Java-Entwicklung, 2nd edn. Dpunkt. Verlag (2007)

Research on Quality of Transaction Standards: The Maturity of a Research Topic*

Erwin Folmer[1,2,3], Wouter Berends[1], Paul Oude Luttighuis[4], Jos van Hillegersberg[1], and Rutger Lammers[1,3]

[1] University of Twente
[2] TNO Information and Communication Technology
[3] Netherlands Open in Connection
[4] Novay
erwin.folmer@tno.nl

Abstract. This paper contains the results of a systematic literature review executed to determine the coverage of transaction standards in top information systems (IS) and management journals. Specifically, it aims to identify a research gap with respect to this topic. The top 25 journals are thoroughly searched and the selected publications are classified in order to make grounded statements. A moderate amount of literature found specifically aims at transaction standards. Hardly any research is found on quality aspects of transaction standards, which therefore counts as the research gap.

Keywords: quality, transaction, standard, adoption, interoperability, literature, review.

1 Introduction

Information systems without standards are hard to imagine. Also in the e-business domain, standards are gaining importance and attention. Much focus is nowadays on the concept of inter-organizational interoperability: the ability of two or more socio-technical systems to exchange information, to interpret the information that has been exchanged and to act upon it in an appropriate and agreed-upon matter [16]. Inter-organizational interoperability is of special interest in the e-business domain. Standardization is one of the means to achieve such interoperability. In literature, different terms are used for this kind of standards, such as e-business standards, vertical and (business) transaction standards. A standard, in the simplest sense, is an agreed-upon way of doing something [20]. Transaction standards are often developed inside a specific industry domain, often outside the traditional standard setting organizations (also called standard development organization).

* This paper is a continuation of the study Top IS Research on Quality of Transaction Standards: A structured literature review to identify a research gap which has been presented at the 6th International Conference on STANDARDIZATION and INNOVATION in INFORMATION TECHNOLOGY (SIIT 2009), September 9th 2009, Tokyo Japan.

P. Bernus, G. Doumeingts, and M. Fox (Eds.): EAI2N 2010, IFIP AICT 326, pp. 101–115, 2010.

As standards are means to an end: interoperability. A general assumption is that a good standard will improve interoperability. Surprisingly, the question as to what makes a good standard is relatively rarely given explicit treatment in the literature on standardization [4][5], although Markus et al. [15] note that the technical contents of the standards will have impact on the standards diffusion. This suggests a relevant quality aspect attached to the technical content.

1.1 Goal

This research is a first step in developing knowledge on quality of transaction standards. The ultimate goal is to enable the measurement of quality of transaction standards. The goal of this paper is limited to assessing the topic of quality of transaction standards as a possible research gap. A derived goal, and contribution to the knowledge area, is the analysis of coverage of this research subject within the most important Information Systems and Management literature.

1.2 Research Questions

In order to get an overview of existing state-of-the-art in top journals regarding the topic of quality of transaction standards, the following research questions have been constructed:

1. Are there any studies related to quality of transaction standards published?
2. Are there many studies related to transaction standards, and specific for certain domains (verticals)?

Based on the outcome of the structured literature review it will be interesting to see what other remarkable insights can be learned. These will be presented in the discussion section. as well as a preliminary view of main contributions of all selected studies based on a selection of only several papers. The corresponding research question is:

3. What can be learned from selecting a minimal set of studies identified within the structured literature review, as preliminary results of assessing all studies?

1.3 Research Method

A systematic literature review [15] has been set-up and performed to enable grounded statements to the research questions and to assure that no major publication will be missed. The search was constructed based on Rumsey's [17] description of planning the campaign. The goal of identifying a research gap implies that the top 25 information systems journals and top 25 management journals should be included (and restricted to) in the search phase. Search engines were selected based on our analysis of coverage of the journals in the search engines. The selection of journals and search engines was based on previous work [16][12][18]. More information on the research method, journals and search engines is available in the corresponding paper [8].

From the domain of quality measurement of business transaction standards, keywords have been selected. To assure the quality of the keywords, the selection was done iteratively by testing the keywords in the search engine and by adding multiple synonyms. The selected keywords are visualized in figure 1.

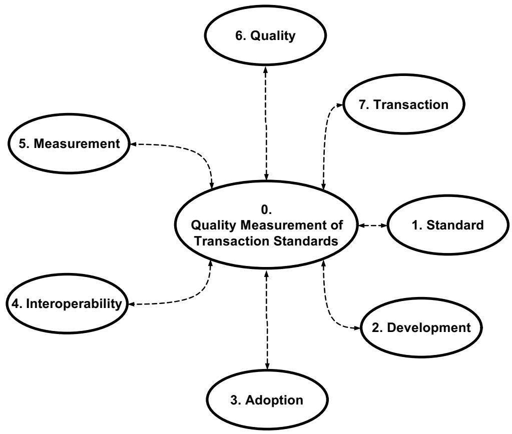

Fig. 1. Keywords

The searches conducted with the search engines yielded several articles per query. Search queries where designed so that manageable amounts of publications were found. Then, an exclusion process has been initiated as described by [22]. First, abstracts and keywords were assessed manually on relevance; in order to ensure that nothing was overlooked this process was done twice and by two individuals. This resulted in a list of 100 papers. A second screening on relevance took place by scanning the whole publication, again double-blinded. This resulted in a list of 48 publications, these publications were classified according to the framework. During this classification we found out that an additional 5 papers were out of scope, which resulted in a final list of 43 publications (the complete list can be found in the appendix). Even though this selection process has been carried out, it is a weak spot in this methodology, because the selection criteria are subjective and difficult to trace. In the first step many papers related to software engineering, healthcare, multimedia and accountancy were removed. The second step removed publications with only marginal attention for standards.

2 Classification Framework and Results

Based on the research questions and other systematic literature review research [23] several classifiers regarding the standardization subject were selected, as well as classifiers regarding the research rigor. They are:

- Topic: The topic (domain) of the research
- Standard Lifecycle: The phase within the lifecycle of a standard
- Standards View: The actor's viewpoint on the subject
- Type of Standard: What kind of standards is the paper about?
- Research Approach: The research approach (fundament) for the paper
- Research Method: The applied research method of the paper

Like the selection process, the classification process has been carried out double blinded to improve the quality of the results. Differences in the classification have been solved by analyzing the differences and achieving consensus from both individuals and to make use of a third individual. The complete list of papers and their classification can be found in [8].

2.1 Topic

Based on the keywords and brainstorming, five different topics have been identified.

Table 1. Standardisation topics

Topic	Description	Count
Standards Lifecycle	The publication discusses one or more steps from the standards life cycle, such as standards development or standards diffusion.	16
Standards and Interoperability	The publication concerns interoperability issues, or other higher-level aspects of standardization.	3
Standards Quality	The publication addresses the quality aspects of standards.	1
Standards Policy/Strategy/Impact (PSI)	The publication concerns economics of standardization, business cases, general advantages, the impact of usage of the standard, or the effectiveness of standards.	11
Standards Organization	The publication concerns standards setting organizations (SSO) and standards development organizations (SDO), National Standards Organizations, etc.	2

Remarkable is the low number of studies in the third and fifth categories. The second category contains papers that are more high level and standards are often not the main subject. This is also the reason why especially these papers could not be scored on the Standards Lifecycle (see next table).

2.2 Standards Lifecycle

Considerable literature on standards lifecycles exists. Amongst others are Cargill [3], De Vries [5] and Egyedi and Blind [7]. Söderström [19] compared seven different standards life cycle models, and build a new model based on that. Each of these seven may be useful for classification, but we chose Söderström's extended general lifecycle as a start, because it takes most other lifecycle models into account.

Although this model fits our purposes we need to condense it for pragmatic reasons; it contains too many steps, which may result in fragmented results. We combined the Initiate and Standards Development phase (and kept the latter name), and did the same for Develop Product, Conformity Assessment, Educate and Implement. Also, Feedback is combined with Maintain. In comparison with lifecycle models from other domains (e.g. software domain [1]) the standardization lifecycle models found are

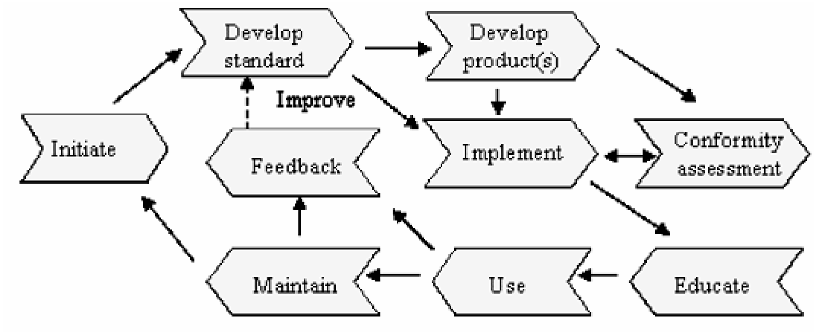

Fig. 2. Extended general lifecycle [19]

Table 2. Standards Lifecycle

Standards Lifecycle	**Description**	**Count**
Development	The creation and development phase of a standard.	4
Implement	Implementation of the standard in products or systems, including implementation services.	1
Use	The usage of the standard, the adoption in the market (diffusion).	23
Maintain	The maintenance phase where standards (periodically) are improved to current needs.	-
Retirement	The phase when a standard is withdrawn from maintenance.	-
Not applicable		15

open-ended: they lack an “end” phase. Based on the Enterprise Unified Process, we therefore decided to add a Retirement phase to the lifecycle model.

Remarkable are the low scores for the maintain and retirement phases, and the high score for the use/adoption phase. The table below contains the results on the Standards View.

2.3 Standards View

Different roles take part in the stages identified in the lifecycle model. We however see no one-to-one correspondence between lifecycle stages and roles. For instance, it is possible to have a user view on the implementation of standards, but also the view of the creator of the standard on implementation phase. Krechmer [10] identifies three main recognizable views on standards: User, Implementer and Creator. We added the Policy Maker role. One might argue that this constitutes a specific type of user, but for our goals we decided to add this additional view.

Table 3. Standards Viewpoints

Standards view	Description	Count
Creator	The developer of the standard. (creates the standard)	7
Implementer	The implementer of the standard. (implements the created standard)	15
User	The (end) user of the standard. (uses the implementation of the standard)	20
Policy Maker	The policy maker about standards. (develops policy about the standard)	1

This shows, in combination with the results on standards lifecycle, that most of the papers are dealing with a user view on standards. Hardly any have a creator's view, or deal with the development life cycle phase of the standard. The table below contains the results on the Type of Standards.

2.4 Type of Standards

Many classification of standards exists [4]. As this paper focuses on transaction standards we chose to use the classification also used by Steinfield et al. [21], as closest fit to our research questions.

Table 4. Type of standards

Type of Standard	Definition	Count
Syntactical	The scope is related to technical standards like TCP, IP, SOAP	10
Semantic – Horizontal	The scope is related to cross industry standards like ebXML, UBL	11
Semantic – Vertical	The scope is related to industry standards like MISMO, hr-XML	14
All	Multiple types are covered	8

The classification process for this category was somewhat difficult, because many papers did not completely focus on one type. Also, the emphasis was not always clear. It is remarkable that only 14 papers have been found that mainly deal with vertical standards, as the keywords were specifically aimed to find as many as possible. Next are the results on the Research Approach and Research Method.

2.5 Research Approach

An often-used classification of the research approach is from Orlikowski and Baroudi [14]:

Table 5. Research approaches

Research Approach	Description	Count
Positivist (Theoretically grounded)	Propositions or hypothesis are formulated and tested, or analytical propositions are derived. Typically quantifiable measures on stated populations (Klein & Myers, 1999).	5
Positivist (Descriptive)	Describes current practices, without theoretical grounding or rigorous data collection and analysis. They describe issues to be shared with the community. Typically case studies (Orlikowski & Baroudi, 1991).	26
Critical	Critical perspective if the main task is being seen as being one of social critique, whereby the restrictive and alienating conditions of the status quo are brought to light (Klein & Myers, 1999).	6
Interpretive	A basis premise is that the perspective is fundamentally subjective, and thus, attempts to understand the phenomena through the meaning that participants assign to them (Orlikowski & Baroudi, 1991; Wareham, 2005). Typically orientated at social constructs, or the context of information systems.	6

Table 6. Types of Research Methods

Research Method	Description	Count
Conceptual	Conceptual analysis, theoretical analysis, mathematical models, analysis or narration based upon author's experience, observation or thoughts. No strong empirical evidence to support author's conclusion. Descriptions of current practices, situations and imagined scenarios.	11
Data Analysis/ Survey/ Experiments	Mail survey, online survey, use of questionnaires to obtain quantitative or qualitative data. Lab experiment, field experiment, free simulation. Document analysis, content analysis, secondary data analysis, field data analysis, and other analysis based on data not from questionnaire instruments and/or experimentation.	5
Review	Literature review, historical rendition, commentaries, current status review, practice review.	9
Development	Techniques, methods, frameworks, instruments to develop some technical application, system, protocol, etc.	7
Case Study	Intensive analysis of cases based upon interviews, observations and analysis in some specific context.	11
Other	Ethnography, action research, other.	-

Remarkable is the low amount of papers with a positivist approach, fundamentally grounded with thorough data analysis, and the high amount of descriptive research.

2.6 Research Method

Wareham [23] uses for his e-commerce literature review: Conceptual, Survey, Experiment, Development, Data Analysis, Case Study, Review, Others. Our literature review parallels Wareham's, although the subject is different. The following table is based on Wareham's [23], but slightly adapted by combining Survey, Experiments and Data Analysis into one category.

3 Findings

This section revisits the first two research questions.

1. Are there any papers related to quality of transaction standards?

Within these top journals hardly any (only 1 paper) research has been published about the quality of transaction standards. This clearly suggests that quality of transaction standards constitutes a research gap. With only two results, the subject of standardization organizations can be called a research gap as well.

2. Are there many papers related to transaction standards, specifically for certain domains (verticals)?

Although the keywords were specifically aimed at transaction standards, including search terms such as e-business and vertical, only fourteen papers have been found that deal with vertical industry standards. Much attention is paid to technical standards, but research regarding vertical standards seems not to reach major journals. The fourteen papers found moreover revisit the same vertical standards, which makes the unique number even lower.

4 Discussion

The outcome of structured literature review was valuable for answering the research questions, but gave also insight to other relevant issues which will be presented in this discussion section.

Remarkable is that all six MISQ papers were part of a special issue on standard making (Volume 30, August 2006). These papers are probably the most acclaimed studies on standardization. Although the structured literature review was limited to top 25 journals, it is remarkable that when broadening the scope than again one of the most valuable resource is a special section within Electronic Markets (Volume 15, Issue 4). Broadening up the scope from transaction standards to general standardisation, and removing the limitation of top journals, a wide range of studies appear in different gremia. For instance the following groups / journals / conferences communicate about standardisation studies:

- EURAS: European Academy for Standardisation (conference, proceedings, book series)
- SIIT: International Conference on Standardization and Innovation in Information Technology
- ICES: International Cooperation for Education about Standardization
- ITU-T Kaleidoscope: International Telecommunication Union, Telecommunication Standardization Sector, Kaleidoscope event. JITSR: International Journal of IT Standards and Standardization Research I-ESA : The international conference on Interoperability for Enterprise Software and Applications
- IFIP WG 5.8: International Federation for Information Processing, Workgroup Enterprise Interoperability

Some topics (like Standardization organization) that was not covered in top journals is often covered in those journals and other edited books by members of the EURAS community. Based on these findings we may conclude that:

- Standardisation studies are common, but mainly present in journals outside top 25 journals, or limited to special issues in higher ranked journals.
- Although standardisation studies are common, studies specifically aimed at transaction standards are scarce in general. Although not proven it is expected that the proven research gap for top journals is also valid for all journals.

We have to select a minimal set of studies in order to be able to discuss the final research question:

3. What can be learned from selecting a minimal set of studies identified within the structured literature review, as preliminary results of assessing all studies?

Noticeable is that healthcare and financial domain are often used as context for the studies on business transaction standardization. Looking in general, but for this discussion specifically at both special issues, the amount of case studies is also remarkable. In general not only the amount of cases, but there is also overlap in the cases itself. For instance the MISMO (mortgage) case is twice listed on the list of 43 selected studies. While half of the special issue MISQ papers are case studies, it is even two-third of the studies presented in the special section of electronic markets. It seems that case study as research method is appropriate when transaction standards are involved. Many of the case studies focus on the adoption (diffusion) of the standard. Arguable the most valuable case studies are the MISMO case [11] and RosettaNet [2]. Interesting is to see what we can learn from comparison between different transaction standards (and different standards development organisations). There is only one study [13], to this authors knowledge, in which such a valuable comparison has been performed. Next to these three papers there are several studies that can be seen as fundament for this area of expertise, however many have a different viewpoint, like for instance the economics of standardization. In our research focussed at improving the quality of transaction standards, a good fundament for the development viewpoint is the conceptual framework of Zhao et al. [23], while the conceptual model of Zhu et al. [25] is appropriate for the adoption viewpoint.

This leads to a list of five valuable contributions related to the domain of transaction standards, and related to the subject of development and adoption of high quality standards resulting in interoperable inter-organizational systems, presented in the table below:

Table 7. List of valuable contributions

Type	Conceptual -Development
Study	Vertical E-Business Standards and Standards Development Organizations: A Conceptual Framework [24]
Contribution	It proves the uniqueness of e-business standards, in comparison with other standards (in particular IT product standards). It describes challenges faced by the vertical e-business SDO's (different organisation than traditional SDO's like ISO) such as rapid technology development and divergent preferences of stakeholders. And most important it presents a Participants - Technical content - Institutional structure framework for studying vertical e-business standards. These three components are interrelated and determine the performance of the SDO, implying that the SDO should address all three components in an efficient and balanced way. The three components consists of the following features: Participants (number, sector, bargaining power) Technical contents (maturity) Institutional structures (structure, procedures, openness)
Type	Conceptual - Adoption
Study	Migration to Open-Standard Interorganisational Systems: Network Effects, Switching Costs and Path Dependency [25]
Contribution	It focuses on the migration to an Interorganisational system (IOS) based on open standards, including XML based horizontal and vertical standards. It provides a conceptual model, supported by a large scale survey, for open standard IOS adoption. This conceptual model indicates three variables influencing adoption of the standard: 1. Network Effects (Trading community influence, Peer adoption) 2. Expected Benefits (influenced by Network Effects) 3. Adoption costs (Financial costs, Managerial complexity, Transactional risk, Legal barriers) While adoption costs are a significant barriers there is a dependency based on the path taken. In this study non-EDI users were insensitive to adoption costs, in contrary to EDI users.

Table 7. (*continued*)

Type	Case Study – Adoption
Study	Industry-Wide Information Systems Standardardisation as Collective Action: The Case of the U.S. Residential Mortgage Industry [11]
Contribution	This study look at the development and diffusion (adoption) of the MISMO standard based on the viewpoint of collective action. Based on the MISMO case four propositions are formulated for vertical standards development and adoption in general: Proposition 1: To successfully develop a vertical standard that meet the business needs for interoperability it is necessary to ensure participation of representative members of heterogeneous user groups, and avoid natural tendency to splinter into rival homogeneous groups. Proposition 2: To successfully achieve adoption it must be ensured that users groups that have the greatest ability to influence adoption must be present in the development process without having disproportionate influence on the content of the standard. Proposition 3: To successfully achieve adoption a set of tactics is needed that jointly solves the standards development dilemma without jeopardizing the solution to the adoption dilemma. This suggest that there is a relation between the development choices and the adoption of the standard, which is also present in the final proposition: Proposition 4: The success of the adoption of the standard is affected by the technical content of the standard, which is affected by the tactics used to solve the development dilemma.
Type	Case Study – Adoption
Study	Standards Development and Diffusion, A Case Study of RosettaNet [2]
Contribution	It focuses on the adoption of RosettaNet standards, and presents categories of adoption strategies and lessons learned regarding development and adoption. Adoption (Diffusion) strategies can be classified in four categories: 1. Market: Promote awareness 2. Technology: Improve standard (lowering costs of implementation) 3. Policy: Change regulatory environment 4. Relational: Co-opt key players to pressure their trading partners

Table 7. (*continued*)

<table>
<tr><td></td><td>The presented lessons learned from the RosettaNet case are:
Only organization involvement that are committed to solving the problem.
Focused, quick, problem solving approach to standard setting.
Investing significantly in standards adoption.
There is no one right approach for to the standards development process, even not a full open approach.
Adoption strategy should be aligned with the development process.
The set of adoption strategies (see above) should be locally adapted.</td></tr>
<tr><td>Type</td><td>Comparison of multiple cases</td></tr>
<tr><td>Study</td><td>Interorganisational System Standards Development in Vertical Industries [13]</td></tr>
<tr><td>Contribution</td><td>Based on a comparison of nine different vertical standards, key drivers, differences and similarities are identified. Key drivers for vertical standards development are:
Technological innovations (Internet, XML, etc)
Need for interoperability (to survive)
Value proposition of vertical standards consortium (pooling of R&D, time savings renegotiating with each new trading partner, etc)
Differences between vertical standards include alignment with more established organisations, balance between vertical and horizontal focus, adoption with the target domains including the use of tracking mechanisms for monitoring adoption. Similarities include non-profit status, vertical orientation, provision of standards freely, vendor neutral, platform independent, membership and fee structures.

Another important contribution is the interorganisational system (IOS) standards development cycle, containing of the following phases:
Choreography & Modularity (key cross-company business processes)
Prioritize & Schedule (planning of business processes)</td></tr>
</table>

Table 7. (*continued*)

	3. Document & Standardize (develop specifications sets, including technology) 4. Review & Test (permit user community to provide feedback) 5. Implement & Deploy (provide implementation support and forecast adoption) 6. Compliance & Certification (validate standards conformance to insure interoperability)

The selection of most relevant studies for the research domain of transaction standards is suggesting by selecting two studies from outside top 25 journals, that a scope of only top 25 journals is too limited for this area of expertise. A possible indication of immaturity is the inconsistent use of terms for this type of standards within these five studies, including transaction standards, IOS standards, vertical (information systems) standards and semantic standards.

5 Conclusions

At least two research gaps have been identified, which was the primary focus of this research. Also the second goal was achieved; the overview gives some remarkable insights of the coverage of standardization research within the top IS and management journals. It is important to notice though that the validity of these conclusions is limited to the set of journals we have investigated.

Based on the five selected studies, we can conclude that there is a need for transaction standards [13][24]. The development strategy of the transaction standard, which should be aligned with the adoption strategy [2][11] will determine the technical content, which will affect adoption [11]. A justification for further research on the quality of standards, including the quality of the technical content.

The goal of this research, as has been set earlier, has been achieved by declaring the quality of transaction standards as research gap. However, this is only a first step in achieving the ultimate goal of measuring the quality of transaction standards. The second step is to deeply analyze the 43 selected studies on its value for this ultimate goal, and to broaden the horizon with searching and analyzing of studies beyond the top journals.

References

1. Ambler, S.W.: Enterprise Unified Process (EUP) (2009), `http://www.enterpriseunifiedprocess.com/`
2. Boh, W.F., Soh, C., Yeo, S.: Standards development and diffusion: A case study of RosettaNet. Communications of the ACM 50(12), 57–62 (2007)

3. Cargill, C.F.: A Five-Segment Model for Standardization. In: Kahin, B., Abbate, J. (eds.) Standards Policy for Information Infrastructure, pp. 79–99. The MIT Press, Cambridge (1995)
4. De Vries, H.J.: IT Standards Typology. In: Jakobs, K. (ed.) Advanced Topics in Information Technology Standards and Standardization Research, vol. 1, pp. 1–26. Idea Group Publishing, Hershey (2006)
5. De Vries, H.J.: Fundamentals of Standards and Standardization. In: Hesser, W., Feilzer, A., De Vries, H.J. (eds.) Standardisation in Companies and Markets, 2nd edn., pp. 1–43. Helmut Schmidt University, Hamburg (2007)
6. DuBois, F.L., Reeb, D.: Ranking the international business journals. Journal of International Business Studies 31(4), 689–704 (2000)
7. Egyedi, T.M., Blind, K.: General Introduction. In: Egyedi, T.M., Blind, K. (eds.) The Dynamics of Standards, pp. 1–12. Edward Elgar, Cheltenham (2008)
8. Folmer, E., Berends, W., Oude Luttighuis, P., Van Hillegersberg, J.: Top IS research on quality of transaction standards, a structured literature review to identify a research gap. Paper Presented at the 6th International Conference on Standardization and Innovation in Information Technology, Tokyo, Japan (2009)
9. Klein, H.K., Myers, M.D.: A Set of Principles for Conducting and Evaluating Interpretive Field Studies in Information Systems. MIS Quarterly: Management Information Systems 23(1), 67 (1999)
10. Krechmer, K.: Open Standards Requirements. In: Jakobs, K. (ed.) Advanced Topics in Information Technology Standards and Standardization Research, vol. 1, pp. 27–48. Idea Group Publishing, Hershey (2006)
11. Markus, M.L., Steinfield, C.W., Wigand, R.T., Minton, G.: Industry-wide Information Systems standardization as collective action: The case of U.S. residential mortgage industry. MIS Quarterly 30, 439–465 (2006)
12. Mylonopoulos, N.A., Theoharakis, V.: Global perceptions of IS journals - Where is the best IS research published? Communications of the ACM 44(9), 29–33 (2001)
13. Nelson, M.L., Shaw, M.J., Qualls, W.: Interorganizational System Standards Development in Vertical Industries. Electronic Markets 15(4), 378–392 (2005)
14. Orlikowski, W.J., Baroudi, J.J.: Studying information technology in organizations: Research approaches and assumptions. Information Systems Research 2(1), 1–28 (1991)
15. Petticrew, M., Roberts, H.: Systematic reviews in the social sciencesa practical guide. Blackwell, Malden (2006)
16. Rukanova, B.: Business transactions and standards: towards a system of concepts and a method for early problem identification in standa[r]d implementation projects. Enschede (2005)
17. Rumsey, S.: How to find information: a guide for researchers. Open University Press, Maidenhead (2008)
18. Schwartz, R.B., Russo, M.C.: How to quickly find articles in the top IS journals. Communications of the ACM 47(2), 98–101 (2004)
19. Söderström, E.: Formulating a general standards life cycle. In: Persson, A., Stirna, J. (eds.) CAiSE 2004. LNCS, vol. 3084, pp. 263–275. Springer, Heidelberg (2004)
20. Spivak, S.M., Brenner, F.C.: Standardization essentialsprinciples and practice. Dekker, New York (2001)
21. Steinfield, C.W., Wigand, R.T., Markus, M.L., Minton, G.: Promoting e-business through vertical IS standards: lessons from the US home mortgage industry. In: Greenstein, S., Stango, V. (eds.) Standards and Public Policy, pp. 160–207. Cambridge University Press, Cambridge (2007)

22. Van der Linde, H., Hofstad, C.J., Geurts, A.C.H., Postema, K., Geertzen, J.H.B., van Limbeek, J.: A systematic literature review of the effect of different prosthetic components on human functioning with a lower-limb prosthesis. Journal of Rehabilitation Research and Development 41(4), 555–570 (2004)
23. Wareham, J.: Critical themes in electronic commerce researcha meta-analysis. JIT: Journal of Information Technology 20(1), 1 (2005)
24. Zhao, K., Xia, M., Shaw, M.J.: Vertical e-business standards and standards developing organizations: A conceptual framework. Electronic Markets 15(4), 289–300 (2005)
25. Zhu, K., Kraemer, K.L., Gurbaxani, V., Xin Xu, S.: Migration to Open-Standard Interorganizational Systems: Network Effects, Switching Costs, and Path Dependency. MIS Quarterly 30, 515–539 (2006)

Digital Business Ecosystem Tools as Interoperability Drivers

Miklós Herdon[1], Mária Raffai[2], Ádám Péntek[1], and Tünde Rózsa[1]

[1] University of Debrecen, H-4032 Debrecen Böszörményi út 138., Hungary
[2] Széchenyi István University, H-9026 Győr, Egyetem tér 1., Hungary

Abstract. Today's businesses form a highly interconnected network of companies, organisations, technologies, consumers, products and services. The concept of the Digital Business Ecosystem (DBE) has been come life in order to build an Internet-based environment in which businesses will be able to interact with each other more efficiently. In a Digital Ecosystem, a leadership structure is formed in order to be capable of responding to the dynamic needs of the environment. The agent in a Digital Ecosystem can both be a client and a server at the same time. With the same message, agents can simultaneously offer a service to others as a Server and request help as a Client. Industries may have their own systems but they are not yet business ecosystems. Digital ecosystems rely on a technological infrastructure to mediate the formalisation of knowledge in SME networks, the creation of software services, and different type of interactions between SMEs. There are many fields of application in the agro-food industry where interoperability of information system would be essential. Amongst others food tracking and tracing, logistics, SRM and CRM integration all need interoperability solution in a heterogeneous environment. Our prototypes can help in building these cooperative information systems.

Keywords: business ecosystem - enterprise information systems – SME.

1 Introduction

The Digital Business Ecosystem (DBE) is attainable technological solution for business ecosystems. The concept of DBE was first realized in Europe in 2002. Today there is a progress in European approach towards Digital Ecosystems and currently there are many important ongoing projects related to this in Europe. The concept of Digital Business Ecosystem (DBE) was invented to build an Internet-based environment in which businesses will be able to interact with each other more efficiently. In the near future with the realization of this platform Small and Medium Enterprises (SMEs) will have the chance to compete on the market with the same prospects, regardless of the size and the distance of the city from their businesses [3]. The DBE is supported by new hardware and software technologies as well as network topologies. An Open Source and component-based software, the collaborative environment, development and the popular and quick developing network technologies can help in establishing an extensive use of DBE [2].

P. Bernus, G. Doumeingts, and M. Fox (Eds.): EAI2N 2010, IFIP AICT 326, pp. 116–127, 2010.

In a Digital Ecosystem, a leadership structure is formed in response to the dynamic needs of the environment [4]. An agent in a Digital Ecosystem can be both a client and a server at the same time. With the same message, agents can both offer a service to others as a Server and request help as a Client without interfere. In this system there is no centralized control structure or fixed role assignment as there is no preconfigured global architecture, in which communication and collaboration are based on swarm intelligence. Unlike in traditional environments, digital ecosystems are self-organizing systems with the capability of forming different architectural models through swarm intelligence, where local interactions between agents determine the global actions. Occasionally, intelligent agents or entire species may as well configure themselves into a hierarchical organization where the communication channels are defined with a leading agent.

Industries may have their own systems which, however, are not yet a business ecosystem since a business ecosystem has three characteristics as it transfers the business strategies from single co-work to synergic and systematic cooperation (the first characteristic), from product competition to platform competition (the second characteristic), and from single growth to co-evolution (the third characteristic).

Digital ecosystems are based on a technological infrastructure, which mediate the formalisation of knowledge in SME networks, as well as the creation of software services, and B2B interactions between SMEs. The realisation this has by now become commonplace and is in fact provided the initial motivation for CRM, SRM and ERP systems.

In general, ERP systems ensure the integration of the suppliers and buyers (clients) into the business' own systems (communication). However, in case the companies used different ERP systems (from different vendors) in order to get on-line (real-time) connection they required special developments. Small and medium-sized enterprises which have implemented information system (ERP standard created by different developers), recognised that this system does not provide them with interoperability. The DBE concept to achieve the particular case of SMEs may give benefits and ensures the appropriate use of DBE Toolset can provide interoperability. Our goal was to facilitate the implementation of the DBE concept modules, which allows existing systems to get access to the common marketplace more easily.

With our prototype solution the SMEs can provide safe, transparent, direct services to potential customers. With the Client-Server architecture, all data are stored on a dedicated server which can provide great advantages for the server's owner. Our vision is based on P2P and SOA technology and all components are written with Open Source tools [13].

2 Needs for DBE

The Digital Business Ecosystem is an evolutionary, self-organized system, which can contribute to the sustainability of the local and regional development through a well-defined software platform [14]. The DBE works just like a natural ecosystem. It is self-organized and able to learn become more efficient. From the Information Technology point of view, a Digital Business Ecosystem is a structure of distributed open-source packages and mashups, based on the Internet ensuring an optimum, stimulating and competitive business development environment, in which all companies, especially Small and Medium Enterprises , can cooperate and develop their business affairs [16].

The idea of the Digital Business Ecosystem is "to create an integrated, distributed pervasive network of local digital ecosystems for small business organizations and for local e-governance which cooperates exchanging dynamically resources, applications, services and knowledge." [9]. The aim of the Digital Business Ecosystem (DBE) is to overcome existing barriers and to promote innovative forms of software creation, knowledge sharing and community building, thereby enabling long-term growth and, competitiveness of the European SME sector. As envisioned by [9], the DBE is intended to foster new and flexible ways of co-operation and networking through a dynamic aggregation and self-organizing evolution of services and organizations by means of open-source methods of software and service creation.

Moore first introduced the concept of a business ecosystem as a strategic plan [8]. Moore indicated that organisations form a part of a business ecosystem and as such they should be viewed as a collective rather than an individual entity. In a business ecosystem that crosses a variety of industries, organisations cooperate, compete, and co-evolve capabilities around a new innovation, support new products, satisfy customer needs, and eventually incorporate the next round of innovation.

According to Nachira [10], the key elements of a business ecosystem (top-most layer) include 1) governance, regulations and industrial policy, 2) human capital, knowledge and practices, 3) service and technical infrastructure, and 4) business and financial conditions.

The idea of a technology (or industrial) ecosystem has been used to describe relationships between technologies and organizations. As an example, consider the specific ecosystem view, which had laptop computers as the focal technology and the wireless networking capabilities as the context. The framework is based on a laptop-related Wi-Fi technology ecosystem. Another more comprehensive demonstration of the analitical approach is an ecosystem model of technology evolution facilitates by focusing on the digital music industry.

3 Functionality of Enterprise Information Systems

Integrated information systems under large-scale company conditions have become widespread tools over the past few decades [7]. Information, data management and systematic information derived from these data and arranged according to needs, however, are required by not only large-scale companies but also by small and medium-sized enterprises. This need that was also recognised by the staff developing the ERP system and successfully and as a consequence appeared on the market with a range products developed especially for SMEs.

Different technologies and solutions, such as SOA (Service Oriented Architecture) provide opportunities for further technological and content-related (functional) extensions and assist the development and spread of new business models (SaaS – Software as a Service) [5]. We also conducted an important part of our research while getting to know and analysing ERP suppliers. It was also an objective of ours to get to know the situation of supply in Hungary and to look out on the market in abroad. We got to the conclusion that the market of ERP, as other markets, is characterised also by globalisation and based on the number of its implementation the solutions in Hungary are developed by well-known international market leaders (SAP, Microsoft, …). The analysis of the supply and demand of the markets of ERP systems has a major effect on the part of this work which is dealing with the constructing of a functional system of requirements.

In our research we made survey on using ERPs in SMEs. Approximately 600 requests to fill in the questionnaire were sent out by e-mail or by post. The rate of the response to this request was 16%. 96 % of the respondents come from small and medium sized businesses. The processing of the questionnaires sent back revealed that 45 % of the respondents used integrated ERP systems and 43 % of them indicated that they used standalone systems while the ratio of the ones using both integrated ERP and standalone systems as well was 4%. The remaining 12% do not use and do not plan to implement any information systems. As for the developers of the systems 39% of the respondents credited Hungarian developers with the system while 14% thought they were of foreign developments. Of the foreign developments SAP, AXAPTA, Microsoft, Abas were named while Cobra, Topinfo, Agroorg were Hungarian developers.

In order to get a more accurate picture of the technological preparedness of the meat industry, we found it necessary to examine the circumstances of the European food industry in general, from the aspects of its use of information and communication technologies (ICT). We conducted our examinations on the basis of the database of e-Business W@tch research.

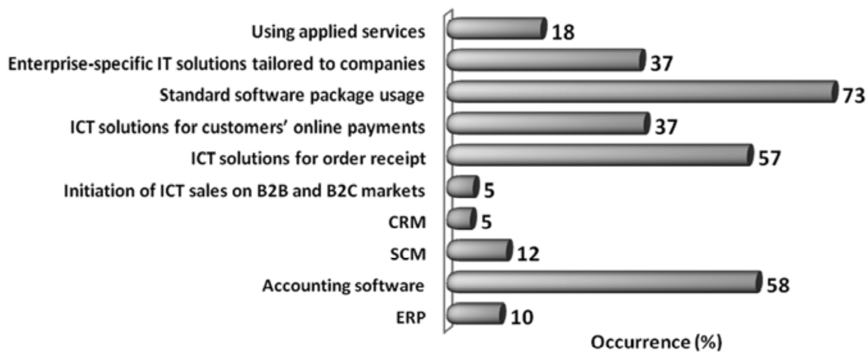

Fig. 1. Ratio of using software in the food sector (2006)

It is clearly shown from the results that the majority of food industry companies already have Internet access, most of which are of-broadband connections. Nevertheless, only 38% of companies have their own websites and the ratio of those with electronic connection to their suppliers and customers is even lower. As for the applied information system, we can assume that almost three quarters of the enterprises use some kind of standard software packages. The number of accounting software products and systems which are for receiving orders is high also: their ratio is around 60%. Nevertheless, the number of CRM and integrated corporate management systems is rather low, whereas the proportion of software products applied for the initiation of ICT sales is also rather moderate on B2B and B2C markets (Fig. 1.).

This figures show that the internet access penetration relatively good, the e-cooperation level is very low. We have to make effort for improving this ability.

4 Interoperability in a Business Environment

The interoperability focuses on inter-enterprise distributed business processes and flows. According to IEEE's definition [5], interoperability represents "the ability of two or more systems or components to exchange information and to use the information that has been exchanged". These interoperability solutions have of both information integration and application integration. Application integration (comprising message, process, transport and interface) represents the technological solution, while information integration refers to the linguistic, social and philosophical solution (comprising data, context, ontology and interpreter). By integration we mean the cooperation of processes and applications at the event and message levels while multiple systems become one logical unit [1].

Collaborative business requires reliable exchange of data commercial, financial and technical ones as well. Legacy ERP, SCM, LCM and CRM enterprise applications generally manage information which is required for the collaboration, but the software itself is for the most part realised and programmed to be run within specified organizational boundaries.

These systems would allow interoperability between enterprise models as it would facilitate the customisation of suitable software. Enterprise software tools like Enterprise Resources Planning (ERP), Supply Chain Management (SCM) or Customer Relationship Management (CRM) are today's strategic investments for all types of companies. However one should bear in mind that the implementation of such Enterprise Software Applications (ESA) is rather difficult and takes a long time while it costs a lot of money and introduces a lot of inconveniences within the company. In addition to this, the customization of such ESA is not easy either and sometimes it leads the enterprise to make important changes in its organization and which decreases its performances. The last but very important point is the issue of the interoperability. The aims of the INTEROP project were to harmonize and synthesize existing researches around new flexible and adaptive architectures of the interoperability, - such as the model driven approach, service-oriented architecture approaches, peer-2-peer architectures, agent architectures and federated architectures [12]. A P2P network is built of interconnected smaller networks which are the result of long-running transactions corresponding to automated (B2B) business activities [15]. ERPs for SMEs do not have such wide of range functions as ERP II which is for a large organisation but many basic functions are necessary for the interoperability features with other SMEs in the DBE (Figure 4.). An example for creation of a DBE for the shoe domain which requires a reliable and secure communication infrastructure among SMEs describe by Chituc [1].

Interoperability is a multidimensional problem that can concern different layers of the enterprise. One of the difficulties enterprises are facing with is the lack of interoperability of systems and software applications which are managing progress in their business. Organizations are looking for new methods of work and business relationships, and the exchange of information and documents with new partners are often impossible to be executed automatically in an electronic format. The above mentioned problem is mainly caused by incompatibility in the information representation and in adopted software application methods [6]. Several approaches have been developed in order to achieve a collaborative network their focus, however, is mainly on technical aspects related to inter-organizational communication. The service-oriented architecture (SOA) as ‘‘a set of components which can be invoked, and whose interface descriptions can be published and discovered’’ does not take into consideration the service architecture. Technical interoperability concerns technical issues related to e-communication, e.g., issues on linking applications and services addressing aspects related to: interfaces; ICT platforms; information integration; exchange and accessibility; security, standards; services but this is not enough to achieve the best solution in business applications. Information /knowledge interoperability has to focus on the following aspects: information/knowledge representation and management, learning ability, rights to access information, knowledge sharing, aspects related to adaptation and recombination of knowledge in a collaborative network during its life-cycle. The Framework for Enterprise Interoperability (FEI), which is currently under standardisation (CEN/ISO 11354) defines a classification scheme for the categorisation of knowledge for interoperability in the line of three dimensions: interoperability barriers, interoperability approaches, and enterprise levels [11]. The technical architecture of KodA is based on SOA and subsequently consists of three basic layers: business process management layer, business services layer, business application layer. The KodA focuses on the supply chain for processing food products which was communicated and discussed at different forums. This has resulted in establishing the agriXchange group that has the objective of harmonizing agricultural data exchange on a European level [17].

5 A Solution Architecture and Possible Application Domains

Applications based on DBE philosophy can be used in many places. As it can be seen in the figure (Fig. 3.) the data are stored in individual peers separately and there are DBE servers which require data from these peers. This structure of the data storage creates the possibility that all of the data owner store own data securely and the data are send only to an appropriate request by a duly authenticated server. This method is very advantageous in many ways.

DBE applications according to the Lisbon agreement [9] are developed for SMEs to help them in winning over the competition and stay on the market. Our solution is quite generic and it can be used in many domains wherever value chains can be developed and computer-aided business management exist. Usually one SME cannot cover the entire value chain as oppose to a multinational company. Joining to a value chain can be a breaking point for them. Nowadays the main field where the DBE philosophy is used is mainly knowledge sharing.

Fig. 2. shows that many master servers can be implied in the ecosystem and the peers can connect to them.

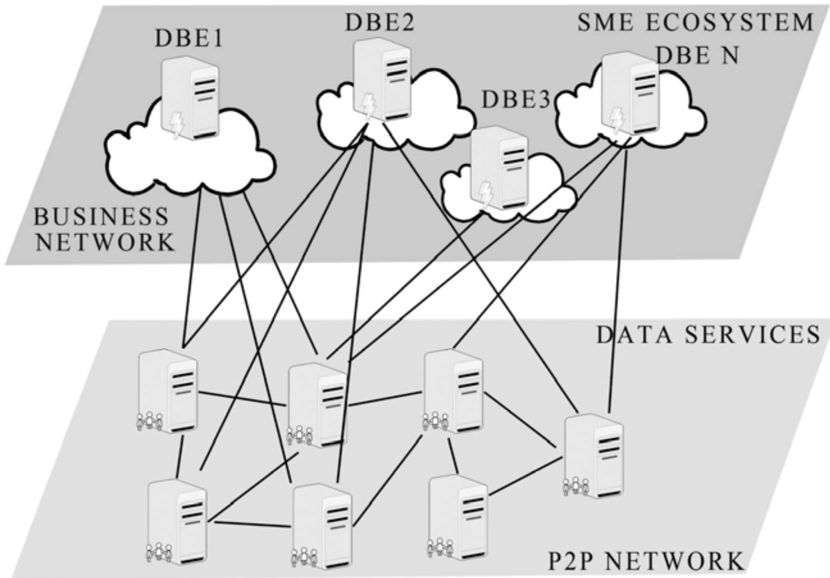

Fig. 2. The DBE concept

Since it is designed in a way that a peer can connect to more than one main server the data modified in one place (maintained) can be displayed in several places (servers). It is a cost friendly solution from the clien side, especially as the data can be managed, updated, modified, saved, etc in one place. Another advantage is if one or two peers are out from the network the ecosystem can work further. Contact between peers and servers are made by XML, so a peer can connect to any of this ready-made ERP for accepting the request to join.

With our prototype solution the SMEs can provide safe, transparent, direct services to potential customers. According to the Client-Server architecture, all data are stored on a dedicated server. This can provide great advantages for the server's owner. Our vision is based on P2P SOA technology and all components are written with Open Source tools. The main features of the prototype system are the following.

- The first idea was to try to create a general service flowchart.
- Next if you needed a service probably you would need other ones from the flowchart. (Example: If you booked a room somewhere next week, probably you would like to use the public transport or would like to know the theatre program, or the time-tables, etc.).
- The prices of services, unique features, or discounts, etc. are not stored on the server.
- An adequate identification system will be worked out.
- Our aim is not to cover all the business processes, but to model a new procedure.
- Many processes are similar to each other therefore the system has to suggest a join possibility for the Peer.

- Since in many cases the SME-s especially the Micro enterprises have no adequate expert, we have to create an easily manageable layout.
- Open source software is used.
- Easy and friendly development of services and application interfacing between companies;
- Easy publishing of the services and applications, including the relevant information,
- Utilization of combined services and applications, in heterogeneous forms.
- In multi-agent systems, the underlying networks in a Digital Business Ecosystem are always dynamic and network topologies are always changing over the time. The main server is always able to work, but the other habitats sometimes are up or down. The P2P communications are working via OWL, WSDL, XML, RDF technologies (Fig. 3.). It can be seen that after a query the system process the query and the BPE try getting up what we want (If it has enough experience about it) or the adequate informations are stored in the knowledge base. Afterwards it collects all the necessary data and it compose the result. All movement and arose data are stored in the database for further utilization.

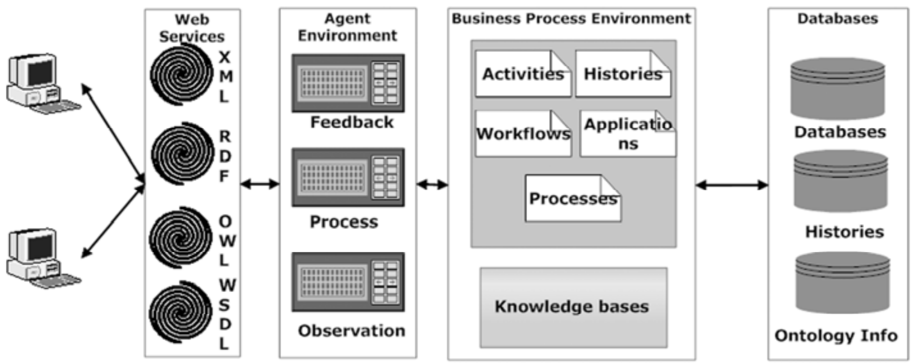

Fig. 3. Layered model of the prototype

XML Web services are the fundamental building blocks in the move to distributed computing on the Internet. Open standards and the focus on communication and collaboration between people and applications have created an environment where XML Web services are becoming the platform for application integration. Applications are created using multiple XML Web services from various sources that work together regardless of where they are or how they were implemented.

- XML Web Services provide useful functionality to Web users through a standard Web protocol. In most cases, the used protocol is SOAP.
- XML Web services provide a solution to describe their interfaces which enough detail to allow a user to build a client application to talk to them. This description is usually provided in an XML document called a Web Services Description Language (WSDL) document.
- XML Web services are registered so that potential users can find them easily. This is done with Universal Discovery Description and Integration (UDDI).

The above mentioned technologies are feasible to connect different systems. The interface can be adapted in the various systems for real-time interface connection. The development is related to DBE marketplace testing of modules are in progress (Table 1).

Table 1. Main parts of our model

NAME	DESCRIPTION
Knowledge Base (KB)	The function of this module is to collect information with along the community principles
Service Generator (SG)	Its function is to analyse the requirements, generate the workflow and collect relevant information from the provider.
Relevance Generator (RG)	It tries to generate a relevance number from the tabs, queries, and stored history
Message System (MS)	It is a private and secured mailing system
History Base (HB)	The function is to store and process the requirements, data, tabs, etc.

Given our research project is rather complex; we decided to split it into parts. The main advantage of our approach is that each program module works alone. We defined the input and output of each part, but we didn't define how to reach it. So in the prototype there is a possibility of changeing parts.

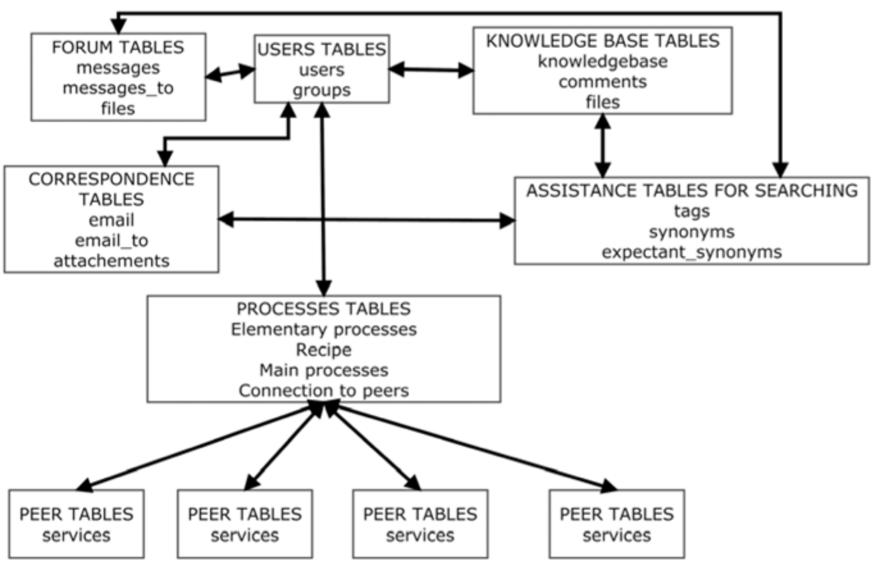

Fig. 4. Layered model of the prototype

Fig. 4. shows the structure of the database and as it can be seen in the portal it is made up of modules. Some modules are compulsory (example user or log), and others are optional. The peer tables are installed on the peers. The peer-specific offerings are stored in these tables, which are downloaded to the portal after the site selection process. The other tables are located in the main server (portal). These tables help to communicate, sharing the knowledgebase, blogging, etc. and store the coherence as well. Besides of these the main task of the server database is to store the new arosen information. This information can help for the portal becoming better. The database is placed in a MySQL server because it is easy to use and free.

We believe, it is worth to capitalize the potential of the DBE philosophy in much more fields. Our prototype can assist that kind of businesses which are able to join to any value chain. For instance the typical good application area is the tourism management, especially the destination management.

5.1 Applications in Tourism

Many SMEs who work variety of business activity can join to the value chains in tourism sector. These SMEs can create value chains according to community principles and find our places within the value chain. Additional services make the site to become more useful for the members of the community and for the potential costumers as well. The different types of knowledge basis which are characterized by meta-data attached to each other and to adequate part of the value chain as well, thus extend the usefulness of the portal. Because the most of enterprises already use different ERP system or at least their data are stored somehow. To get out the problem of the duplicate storing, we offer the opportunity supplying the data from their own database with the help of XML technology. With the XML technology the companies without any particular investment can join to the DBE community and they can find new markets, knowledge and community.

5.2 A Prototype Tracing Solution Based on DBE Consept and Toolset

IT solutions of the food chain traceability could be based on DBE solutions. In case of the traceability the XML file contains the following information: Company name, TRU (Traceable Resource Unit) identification number, Output id., Input id. In addition, we need a web server where the portal software is running. The portal prepaired with open source tools according to DBE principles. The prototype system is suitable for both top-down and bottom-up tracking and traceing. The working methods are the follows:

Top-down: The web server can identify the producer by the barcode. Certainly, it works only if the company has joined the community and their barcodes are stored in the database. We can reach the data wich are strored in the ERP system by the product‘s barcode. The data show us the ingredients of the product. Inputs displayed on this page, so that the input supplier of the database searches the details of ingredients and send to the server for further processing and display, and then recursively to the product suppliers to get the similar information. We can reach the bottom level of the supply chain. It looks like a tree-structure.

Bottom-up: The knowledge of the barcode of the lowest level of basic ingredient we can get besides of the basic details we can know the place of the deliveries as well.

Then, either of the products manufactured by the companies which are on the N-1st level will be choosen which contain the ingredient of the company on the Nth. level. This goes on, until we reach the top level.

With this prototype we have an opportunity to trace the full path of life of the product, if only all participant have been joined to the community. The above solution can greatly facilitate the precise monitoring the flow of substances occurring in food. Thus, the appearance of any food safety hazard we have opportunity to achieve rapid and efficient product recall.

6 Conclusions

The concept of Digital Business Ecosystem (DBE) is to build an Internet-based environment in which businesses are able to interact with each other efficiently. In the near future when this platform will be realized, it will make it possible to Small and Medium Enterprises (SMEs) to compete on the market with equal opportunities, independently of size and distance from the city, of their business. The first characteristic of an ecosystem is that business ecosystems have a loose network of suppliers, distributors, outsourcing firms, makers of related products or services, technology providers, and a host of other organizations. The second characteristic is the of ''platform'' – services, tools, or technologies – that other members of the ecosystem can use to enhance their own performance. The third characteristic is that, business ecosystem evolves participants to a new landscape [7]. The Open source approach is the only possible choice for the Digital Ecosystem infrastructure [3]. We created our own vision which is able to help the SMEs to appear on the market while protecting its own data. The communication interface allows connecting the existing ERP systems into one DBE cluster. The use of the suggested security tool helps to keep authenticity of the companies.

References

1. Chituc, C.-M., Toscano, C., Azevedo, A.: Towards the Creation of a Digital Business Ecosystem for the Shoe Manufacturing Domain. In: Digital EcoSystems and Technologies Conference, DEST (2007), Inaugural IEEE-IES 88 – 93, doi:10.1109/DEST.2007.371951
2. Digital Business Ecosystem Contract n 507953: DBE Peer-to-Peer Architecture Design. TCD, DBE Deliverable, D24.3 – Final version of the P2p architecture for service search (2005)
3. European Commission. Digital Business Ecosystem. Luxembourg Office for Official Publications of the European Communities (2007), ISBN 92-79-01817-5
4. Adomavicius, G., Bockstedt, J.C., Gupta, A., Kauffman, R.J.: Technology roles and paths of influence in an ecosystem model of technology evolution. In: LLC 2007. Inf. Technol. Manage., February 14, vol. 8, pp. 185–202. Springer Science+Business Media, Heidelberg (2007), doi:10.1007/s10799-007-0012-z
5. IEEE: IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries. Institute of Electrical and Electronics Engineers, NY (1990)
6. Jardim-Goncalves, R., Grilo, A., Steiger-Garcao, A.: Challenging the interoperability between computers in industry with MDA and SOA Computers in Industry 57(8-9), 679–689 (2006)

7. Li, Y.: The technological roadmap of Cisco's business ecosystem. Technovation 29, 379–386 (2009)
8. Moore, J.F.: Predators and Prey: A New Ecology of Competition. Harvard Business Review 71(3), 75–85 (1993)
9. Nachira, F.: Towards a Network of Digital Business Ecosystems Fostering the Local Development. European Commission DG INFSO, Tech. Rep., pp. 1–23 (2002)
10. Nachira, F.: Innovation Ecosystems: Una Strategia europea per l'innovazione e lo sviluppo economic (2005), `http://www.digital-ecosystems.org` (retrieved August 21, 2006)
11. Naudet, Y., Latour, T., Guedria, W., Chen, D.: Towards a systemic formalisation of interoperability. Computers in Industry 61(2), 176–185 (2010)
12. Panetto, H., Scannapieco, M., Zelm, M.: INTEROP NoE Interoperability Research for Networked Enterprises Applications and Software. In: Meersman, R., Tari, Z., Corsaro, A. (eds.) OTM-WS 2004. LNCS, vol. 3292, pp. 866–882. Springer, Heidelberg (2004)
13. Pappas, N., Kazasis, F.G., Anestis, G., Gioldasis, N., Christodoulakis, S.: A Knowledge Management Platform for Supporting Digital Business Ecosystems based on P2P and SOA technologies. In: IEEE DEST 2007 (2007)
14. Peltoniemi, M., Vuori, E.: Business ecosystem as the new approach to complex adaptive business environments. In: eBRF Conference: Frontiers of e-Business Research (2004)
15. Razavi, A., Moschoyiannis, S., Krause, P.: An open digital environment to support business ecosystems. In: Peer-to-Peer Netw. Appl. Springer Science + Business Media, LLC 2009 (2009), doi:10.1007/s12083-009-0039-5
16. Szerb, L.: The connection between innovation and business growth in the Hungarian SME sector. In: Innovation, Competitiveness, Growth and Tradition in SMEs, Rencontres de St-Gall, September 1-3 (2008)
17. Wolfert, J., Verdouw, C.N., Verloop, C.M., Beulens, A.J.M.: Organizing information integration in agri-food—A method based on a service-oriented architecture and living lab approach. Computers and Electronics in Agriculture 70(2), 389–405 (2010)

XML in Enterprise Systems: Its Roles and Benefits

Jaroslav Pokorný

Charles University, Faculty of Mathematics and Physics,
Malostranske nam. 25, 118 00 Praha 1, Czech Republic
pokorny@ksi.mff.cuni.cz

Abstract. Enterprise information integration (EII) requires an accurate, precise and complete understanding of the disparate data sources, the needs of the information consumers, and how these map to the business concepts of the enterprise. In practice, such integration takes place in context of any enterprise information system. In the paper we explain various approaches to EII, its architectures as well as its association to enterprise application integration. We justify why XML technology contributes to finding sufficiently powerful support for EII. We present some features of the XML technology, mainly its database part, and show how it is usable in EII.

Keywords: XML, enterprise information integration, XQuery, XSLT, Web services, XML databases.

1 Introduction

The language XML originally designed as a standard protocol for data exchange, serves today as a data model and background for databases of XML documents. Its main advantage is that it enables to create a background for applications beyond conventional data models, i.e. everywhere where we need, e.g., hierarchical data structures, recursive data structures, regular expressions, missing and/or duplicate data, and other non-traditional data requirements. XML creates a technological platform for Semantic Web.

A collection of languages, techniques, and standards developed by the World Wide Web Consortium (W3C[1]), called *XML technology* today, contributes to many application areas, as, e.g., B2B interactions, Web services, as well as, in general, to improvement of inter- and intra-enterprise applications. In the paper, we focus just on use of XML technology in enterprises.

Often an *enterprise information system* (EIS) is characterized as an information and reporting tool for the preparation, visualization, and analysis of operational enterprise data. An associated collection of activities and software components supporting accessing data from any source systems is then called *enterprise information integration* (EII). In other words, EII provides programmers with a single-site image of disparate data that may be maintained in different formats, retrieved via different application programming interfaces (APIs), and managed by

[1] http://www.w3.org/standards/xml/

P. Bernus, G. Doumeingts, and M. Fox (Eds.): EAI2N 2010, IFIP AICT 326, pp. 128–139, 2010.

different remote servers. The analyst community and other observers talk often about "virtual data federation". Data integration is crucial in large enterprises that own a multitude of data sources, like relational databases, Web services, files, and packaged applications. The same holds for offering good search capabilities across amounts of data sources on the Web.

Integration-related area contains also *enterprise application integration* (EAI). EAI integrates application systems by allowing them to communicate and exchange business transactions, messages, and data with each other using standard interfaces. It enables applications to access data transparently without knowing its location or format. EAI is usually employed for real-time operational business transaction processing. It supports a data propagation approach to data integration. A strong separation of EII and EAI can mean that enterprise data is accessed by an EII tool and updated by an EAI tool. EII solutions today should address both application and information integration.

A special form of data integration is required by data warehouses and business intelligence. *Extract*, *transform* and *load* (ETL) processes were considered the most effective way to load information into a data warehouse.

In general, EII needs [6] to

- support all information types, structured, unstructured and semi-structured,
- provide for context, i.e., where does the information fit in the schema or ontology of the receiving repository/application, and what are the relevant behavioural constraints.

Many enterprises today are moving towards the adoption of *service-oriented architectures* (SOAs) based on XML and Web services [5]. Web services represent a less costly and loosely-coupled approach for EII. Often Web services are considered as part of the EII whole. Consequently, a *service composition* gains strength in EIS today. A relatively little work has been done to facilitate integration at the *presentation* level, i.e. the development of user interfaces. This part of application development in EIS belongs to the most time-consuming activities. Other direction of the EAI industry is toward the use of an *enterprise service bus* (ESB) that supports the interconnection of legacy and packaged applications, and also Web services.

XML, enabling to declare and enforce structure of content, plays an important role both in EIS development and EII processes. The reason is simple. In the past, any exchanging information between content repositories and data-oriented applications within and across enterprise was very difficult due to incompatibility of supporting systems. Even data warehouse solutions were considered inappropriate for supporting such needs. EII vision is namely to provide tools for integrating data from multiple sources without first loading their data into a central warehouse. EII should perform the integration in real time on an on-demand basis. Emergence of XML made it possible to build EII on an XML data model and query language XQuery, i.e. with XQuery interface to these multiple sources.

The purpose of this work is to summarize some parts of the XML technology relevant for EII and show, how XML databases can help to create more responsive EII architectures. The remainder of the paper is organized as follows: Section 2 mentions some approaches to EII as well as commercial products based on these approaches. After summarizing some basics of XML database technology in Section 3, in Section 4 we focus on applications of XML databases in EII. We mention also the concept of content management system there. Finally, Section 5 concludes and lists future work.

2 EII: Approaches and Related Works

By [18] EII is defined as the integration of data from multiple systems into a unified, consistent and accurate representation geared toward the viewing and manipulation of the data. Data is aggregated, restructured and relabelled (if necessary) and presented to the user. In viewing EII from a software engineering point of view, it is a type of middleware that allows companies to combine data from disparate sources into a single application.

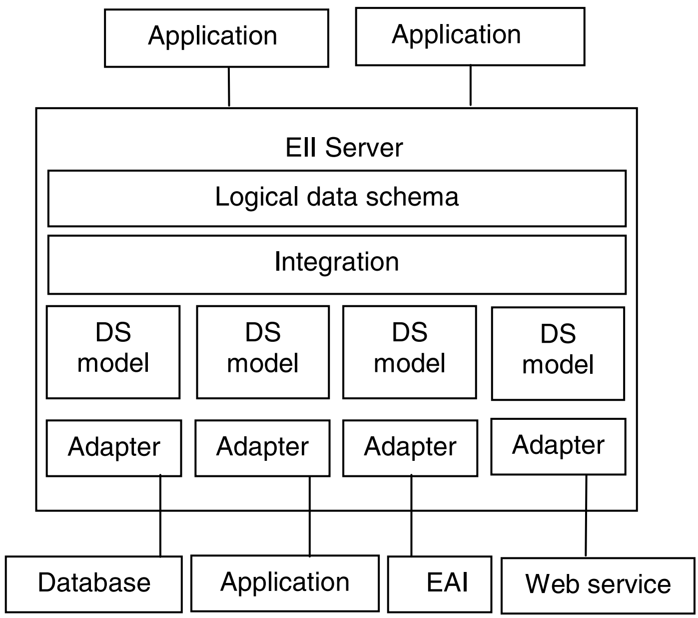

Fig. 1. EII approach to data integration

EII is based on a more flexible form of integration than simple data integration. EII data sources (DS) are viewed by applications as a single virtual database (see Figure 1). EII is based on a framework that exposes rather declarative interface for specification of integration requirements. EII provides applications a single, *virtual view* across multiple data sources. Applications access data sources through these views and through only one API of the EII server. Queries are transformed into queries against data sources. In other terminology, this approach is based on *mediation*. There is also a variant called *federation*, which integrates data by defining mappings between all pairs of schemas of the member databases. This variant called also a *loosely coupled federated system* is not broadly applied in real enterprise environment because of the using of private protocol and data model, low performance, laborious process, critical implementation conditions, immature technology and the lack of reliable infrastructure [23]. Although the federated systems are relatively easy to implement, they do not scale well. By [10] an information integration infrastructure should support placing and managing data at multiple points in the data hierarchy to improve performance and availability. By the way, most of today's EII systems are really federated information systems.

To implement mediation, EII requires an accurate, precise and complete understanding of the disparate data sources, the needs of the information consumers, and how data model is mapped into a single, generic representation – a *logical data schema* that specifies the virtual view.

Therefore, the available approaches to EII can be considered based on the underlying logical model, the data transformation framework, and the query interface. Due to the well-known restrictions of relational data model in context of enterprise variety of data, it is not too perspective solution now. For example, iWay Data Hub[2] enables to create reusable relational views.

Purely XML-oriented approaches use XML as the logical data model. All data sources are represented as XML document collection and XQuery serves as the language of transformation as well as the query language. The EII server is a virtual XML database. As examples in this category we can mention Ipedo's XIP[3] and Liquid Data for WebLogic [3]. In XIP it is possible to query not only collections of XML documents, which is the best known use of XQuery, but also relational databases, web services, common data formats like CSV and fixed length formats. In addition, the Ipedo XQuery engine also allows users to create custom data sources and make them available to XQuery developers. In combination with the distributed SQL query engine, also offered in XIP, these capabilities represent one of the most powerful ways for EII.

However, a use of XML can be only a part of EII solution. There are tools, e.g., MetaMatrix [7], providing an integrated environment for modelling different types of data and information systems. In MetaMatrix different layers of metadata are created in more domain-specific languages (including XML Schema), i.e. XML is not a target language here. The support for multiple metamodels is ensured by OMG's MOF (Metadata Object Facility) architecture, i.e. relationships among metadata of different layers are expressed by mapping specifying transformations.

Although all the approaches have their advantages and disadvantages, the XML approach is excellent in data modelling and query capabilities, in particular with applications that use data from non-relational data sources, such as message queues, EJBs, XML documents, and Web services.

A more advanced approach to integration in EIS is enterprise mashups. Remind that a *mashup* is a Web application that combines content from two or more applications to create a new application. The applications can be built on-the-fly to solve a specific business problem. For example, Damia [1] is inspired by the Web 2.0 mashup phenomenon. It consists of (1) a browser-based user-interface that allows for the specification of data mashups as data flow graphs using a set of operators, (2) a server with an execution engine, as well as (3) APIs for searching, debugging, executing and managing mashups.

---

[2] http://www.iwaysoftware.com/products/eii.html
[3] http://www.ipedo.com/html/ipedo_xip.html

Web mashups perform integration both at the application level and at the presentation level. Unfortunately, due to very little support both in terms of model and tools, the presentation part of mashups is developed manually today. An interesting approach to component integration at the presentation level is proposed in [20].

However, the mentioned approaches did nothing to address the semantic integration issues – sources can still share XML files whose tags are completely meaningless outside the application. In consequence, almost all EII products in the market are limited in, or totally lack, the capabilities of semantic interoperability and dynamic adaptation upon changes.

3 XML Technology – A Database Approach

XML documents can be either data-centric or document-centric. *Data-centric* XML is that which has record structure as its focus. Data-centric XML serves a similar function to a database; a set of fields are pre-defined, and records (think records here, not documents) must conform to that structure. *Document-centric* XML is that which has the document (the text, something pre-existing with its own structure) as its focus. A collection of XML documents can be conceived as an *XML database*.

Any access to XML data must be done through an XML data model. Traditional databases are based on the notions of a *database model* and a *database schema*. Elements, attributes, mixed content, and other features of XML do not give good assumptions for development of a unique model of XML data. For that reason different XML applications use different models of XML data, usually tree- or graph-oriented, or, more recently, combined with full text features. Perhaps the most important XML data model is that one used by languages XQuery, XSLT 2.0, and XPath 2.0. This model is richer than usual tree-like representation. In XPath 2.0, e.g., sequences replace node sets from XPath 1.0.

Solutions of many problems with manipulating XML data rely on a query language. We categorize XML queries into two classes: *databases queries* and *Information Retrieval (IR) queries*. Database queries return all query results that precisely match the queries, which reminds SQL querying in relational databases. IR queries allow "imprecise" or "approximate" query results, which are ranked based on their relevance to the queries. Only the top-ranked results are returned to users. Another proposal of W3C, rather delayed, is to effectively and efficiently update XML data (XQuery Update Facility).

One solution how to store XML data is to use conventional databases. It means to map (shred) the XML documents into data structures of the existing DBMSs (*XML-enabled database*). Detaching generic mappings of XML data into universal tables has the following properties:

- predefined schema is necessary,
- joins of tables are necessary for query evaluations and row ordering is done in an explicit way,
- navigations in XML data are transformed into SQL and full-text operations are also needed,
- scalability problems.

Another possibility is to store XML data into tables generated algorithmically from an XML schema.

A more advanced solution is to develop a DBMS with a native XML storage (*native XML database* or *NXD*), whose advantages include a support of:

- natural nested hierarchies,
- element ordering,
- documents as single objects,
- schema is not necessary,
- XPath and XQuery have a direct implementation,
- better scalability.

A *hybrid database* is a relational database that is XML-enabled, but also offers native XML capabilities as defined above. It is a database that supports both the relational data model and the XML data model in all its processing and storage mechanisms.

The XML technology relevant to XML databases concerns mainly XML schema and query languages. In the next two subsections we will discuss possibilities that both kinds of languages offer. Their choice in EII design can significantly influence the success of EII in practice.

3.1 Database Schemas and XML

By a schema we describe types of XML documents. In principle, two main possibilities are at disposal: DTD and XML Schema language. Current projects prefer schemas expressed in XML Schema.

XML Schema provides the ability to define an element's type (string, integer, etc.) and much finer constraints (a positive integer, a string starting with an uppercase letter, etc.). There is certain relationship between schemas expressed in these languages and database schemas. As in other DBMSs, an essential part of each schema definition languages is made by *integrity constraints*. Comparing to SQL in relational databases, possibilities of them in XML Schema are rather poor.

The specific problem is to design XML schemas. There are three ways to design XML schemas. The first, and the most difficult, is to attempt to create the schema directly element by element. This requires knowing in advance what specific elements already go where. The easier solution is to create an instance of the XML document, then use schema extraction tools to generate a schema that is valid for that instance. The last and most database-oriented possibility uses conceptual modelling XML data. Today, structure of XML data is designed usually directly, without the conceptual schema. This makes more difficult, e.g., modelling hierarchies like it is used in ER modelling. With XML conceptual modelling also automatic transformations to XML Schema are easier and more accurate. The research in this area is represented, e.g., by [13]. Dynamicity of EII conditions requires yet an existence of tools for schema evolution and schema versioning.

Unfortunately, today’s observation of EIS shows that requirements gathering, schema design and upgrade costs are far more than application development costs. A special feature of XML databases is that many XML documents exist whose schema was *not known* at design time. Thus, many vocabularies are developed without any schema. As a consequence there are XML databases without any schema. This fact belongs among the key reasons for existence of NXDs. Rather loose possibilities of XML schema development are much more flexible than relational or object-oriented structural definition. A sufficient compromise between completely schemaless and strict schema-oriented approach is to add cheaply and manageably a small amount of structure which provides a more compelling solution.

Often there is a need to extract the schema information from XML documents. The extracted schema should, on one side, tightly represent the data, and be concise and compact, on the other side. As the two requirements essentially contradict each other, finding an optimal trade-off is a difficult and challenging task. For promising results in this area see, e.g., [11].

3.2 XML Query Languages

XML query languages serve to querying, extraction, restructuring, integration, browsing XML data. They include the following demands:

- pattern matching,
- navigation along the structure of XML tags via (regular) path expressions,
- powerful approach to structured data similar to SQL,
- querying both data and metadata,
- generating structured answers to queries (new XML data, derived values)

There are a lot of standards in area of XML query languages designed by W3C, namely XPath 1.0 and 2.0, XQuery 1.0, XSLT 1.0 and XSLT 2.0. XPath 2.0 is a strict (rather large one) subset of XQuery 1.0. The main use of the XPath language is in other XML query languages, namely XQuery and XSLT. XSLT is a language of transformations. It provides instructions that help to transform XML data into a rendered format. The focus and strength of XQuery seems to be the data-centric queries (regularly structured markup), while XSLT has its advantages in document-centric queries (semi-structured markup).

Integration of relational and XML data resulted in development of SQL/XML language. SQL/XML allows relational data to be published in an XML form (XPath data model instance) that can then be queried using XQuery. It provides to define table columns of the XML type.

As the web-style searching becomes a ubiquitous tool, the need for integrating exact querying (see languages like XQuery, XSLT, SQL/XML) and IR techniques becomes more important. For example, in EIS environment we meet cases in which users provide keyword queries and require a ranking of partial results. In the case of XML, relevance scoring becomes more complex because the data required for scoring have a tree structure. An attempt to integrate IR functionality with XQuery is described in W3C proposal [19]. For an excellent survey of XML retrieval see [14].

3.3 Architectures of XML Databases: Solutions

A significant role in storing XML documents is whether the documents are data-centric XML documents or document-centric XML documents.

As we have mentioned earlier, one possibility how to store XML data is an XML-enabled database. Experiments show that such database is most feasible if only simple

XPath operations are used or if the applications are designed to work directly against the underlying relational schema. For similar reasons XSLT implementation can be based on use of a relational database, which serves as a temporal storage for source and target XML documents (e.g., [9]).

An implementation of NXD is undoubtedly a challenge in the last years both for developers and researches of database systems. In database architectures, NXDs provide a nice example when a DBMS needs a separate engine (see [15] for more deep discussion). There are three main approaches to NXD implementation today:

- NXD DBMS as a separate engine (Tamino, XHive/DB, XIndice, eXist, etc.),
- adding native XML storage to RDBMS (e.g., XML Data Synthesis by Oracle),
- hybrid solution (e.g., IBM DB2 9, ORACLE 11g, SQL Server 2008).

An advantage of the last two approaches is the possibility to mix XML with relational data. While critical data is still in a relational format, the data that not fit the relational data model is stored natively in XML.

With the new option of storing and querying XML in a RDBMS, schema designers face to the decision of what portion of their data to persist as XML and what portion as relational data. ReXSA described in [12] is a schema advisor tool that is being prototyped for IBM DB2 9, enabling to propose candidate database schemas given a conceptual model of the enterprise data.

Bourret in [4] registers more than 180 XML database products, among them 40 NXD, and more than 40 XML data binding products.

4 EII Through XML Technology

A motivation for maintaining XML data in databases has roots in application demands, in particular to ensure a better work with content in enterprises. With an XML database one can, e.g., process external data (Web pages, other text databases, structured data), resolve tasks of e-commerce (lists of products, personalized views of these lists, orders, invoices in e-commerce, e-brokering), and support integration of heterogeneous information sources. A typical example of the latter is an integrated processing data from Web pages and from tables of a relational database. There are XML database vendors who market their platforms as EII solutions (e.g., Software AG, IBM, Ipedo). In other words, o store XML data in a database means to manage large numbers of XML documents in a more effective way.

Since storing and querying XML data as well as data integration are crucial for EII we focus on these kinds of NXDs uses in detail. We also mention Web services in context of EII and, finally, some EII trends.

4.1 Content Management Systems

It is well-known that reuse represents an important way for companies to extend the value of their investment in content. According to the study by ZapThink [22], producers of content spend over 60% of their time locating, formatting, and structuring content and just 40% for creating the content.

Stand-alone relational DBMSs are not well prepared for management such content due its unstructured nature. XML offers a robust technology that becane a background of *content management systems* (CMS). Such systems provide users tools for automatic conversion and distribution of native content via the Web. As XML separates formatting data from XML content, a new trend is to build CMS on the top of NXD. As a consequence the distinction between structured and unstructured information may now be blurring.

By SYS-CON Media Inc. [17], the following XML features are essential in the context of CMSs:

- *Content contribution and conversion.* Storing content in XML enables its various transformations into a variety of formats, such as HTML, for reuse by multiple applications.
- *Content access and exchange*. XML content can be easily merged with other sources and represented in an unified way in content management repository.
- *Content formatting and presentation*. A separation of content and presentation allows different formatting to be applied to the same content in different situation using XML stylesheets.
- *Content storage*. XML content stored in an XML database can be more easily searched by XQuery or XPath.
- *Content personalization*. Based on user profiles and type of device, CMS can deal with the content accommodated by an associate XSL stylesheet. Such tailored content is then delivered to the user.
- *Content management Web services*. Most of CMSs use Web services to share and deliver data and specific content management features in the Internet.

4.2 Data Integration

XML databases have separated into three categories. The first one has focused on managing XML content or documents (e.g., MarkLogic). For example, MarkLogic Server provides a platform for CMS combining traditional DBMS based on XML with full-text searching. The other two categories are related to EISs. In the second category, XML database can provide a middle tier *operational data store* (ODS) platform. In the third category, XML database focuses on managing persistent data on a middle tier for data integration applications, in particular EII applications (e.g., Ipedo).

Operational data store. A middle tier ODS can provide the necessary infrastructure for managing enterprise data and bringing it closer to the consuming business application, while simultaneously reducing the burden on backend systems of record. XML databases are an ideal technology to serve as an ODS because of their ability to maintain schemas and to bind heterogeneous data sources.

Enterprise information integration. Most current EII approaches are still based on similar principles of loosely-coupled federated systems. Moreover, a key issue, i.e. resolving differences in schemas and integrating them into one central schema, is often not requited in today’s EII applications. XML databases enable EII by providing a platform for querying across heterogeneous data sources, resulting in view of all common entities spread across enterprise systems or services. For business users, typically, CMSs can become a source of integration in EII. In such systems data is managed as schema-less, eliminating the need for schema management and database administration.

4.3 EII and Web Services Integration

Web services create huge amounts of new data, specifically the exchange of data-rich XML messages. Many organizations want and need to store, access, query, audit, analyze, and repurpose information in these messages. It is nearly impossible to persist all of these messages in a relational database because of the inflexible data model they impose.

Here it is possible to use NXD as a "glue" to connect existing enterprise systems. For example, in SOAP XML-based object serialization format can be used to perform asynchronous messaging and RPC between non-XML applications. Although messages are probably data-centric, their natural format is XML. It makes sense to build a message queue on a NXD, particularly in cases when EII is *event-driven* rather than *query-driven*. Then data changes, for example, could be accumulated in a message queue and an EII query scheduled to run at periodic intervals to read the data from the queue and update a data store with the changes. We obtain XML-specific capabilities and, consequently, better scalability as the volume and complexity of e-business transactions increases. XML databases are particularly useful for handling new message types or evolving message structures. Storing message content in a native XML database reduces the development time and cost at least 50 percent by eliminating the need to define object-to-relational mapping [16].

4.4 EII Trends

The ability to efficiently store and access XML and relational data types in one system represents a key point of differentiation among enterprise database vendors. It also allows enterprise developers to build data-driven applications using XML data types. Open source RDBMS from companies such as PostgreSQL currently also supports this hybrid XML-relational data-storage capability.

The popularity of XSLT accelerated the EAI development, and some use of XSLT is probably a requirement in all EII solutions today. Any exchange of XML information is namely going to involve a combination of mapping of information objects, and in most cases these will involve structural transformations to account for different contexts, i.e., uses of the information.

Approaches to EII based on Semantic Web technologies like, e.g., RDF and OWL-DL ([2], [21]) are in development today. Authors of [2] use OWL-DL to integrate enterprise applications. Document content models are rendered into OWL-DL ontologies. This enables to designers to readily use automated reasoning methods of reasoners like e.g. RacerPro[4]. It means that a *model-driven* enterprise is achievable today.

[4] http://www.franz.com/agraph/racer/

5 Conclusions

EII is a broad area that in other terms and under other conditions restates problems studied in databases during the whole time of their existence. In [23] the authors address four challenges of EII including scalability, horizontal vs. vertical integration, central integration, and semantics. For example, with an increasing number of sources, the scale-up efficiency decreases. Integration is mostly horizontal than vertical in the most EII systems and the only vertical part is their centralized administration. We have seen that EII products fall into two categories, those that grew from an RDBMS background and those that emerged from the XML world. Particularly, users of hybrid RDBMS can profit from easier integration of structured and semistructured data. Really significant challenge is information sharing, which requires considering more semantics in EII. As we mentioned in the paper, techniques of the Semantic Web can contribute to this problem. According to prediction by META Group from 2005, ETL, EAI, and EII converge in the general Data Exchange Facility in the service-oriented architecture.

Acknowledgement. This research has been partially supported by the grants of GACR No. GA201/09/0990 and P202/10/0761.

References

1. Altinel, M., Brown, P., Cline, S., Kartha, R., Louie, E., Markl, V., Mau, L., Ng, Y.-H., Simmen, D., Singh, A.: Damia – A Data Mashup Fabric for Intranet Applications. In: Prof. of VLDB 2007, Vienna, Austria, pp. 1370–1373 (2007)
2. Anicic, N., Ivezic, N., Jones, A.: An Architecture for Semantic Enterprise Application Integration Standards. In: Interoperability of Enterprise Software and Applications, pp. 25–34. Springer, London (2006)
3. BEA Systems: Liquid Data for WebLogic: Integrating Enterprise Data and Services. In: Proc. of SIGMOD 2004, Paris, France, pp. 917–918 (2004)
4. Bourret, R.: XML Database Products (2009), `http://www.rpbourret.com/xml/XMLDatabaseProds.htm`
5. Fremantle, P., Weerawarana, S., Khalaf, R.: Enterprise Services. Communications of the ACM 45(10), 77–82 (2002)
6. Gilbane, F.: What is Enterprise Information Integration (EII)? The Gilbane Report 12(6), Bluebill Advisors, Inc. © 1993 - 2005 The Gilbane Report (2004)
7. Hauch, R., Miller, A., Cardwell, R.: Information Intelligence: Metadata for Information Discovery, Access, and Integration. In: Proc. of SIGMOD Conf., Baltimore, Maryland, USA, pp. 793–798 (2005)
8. ISO/IEC 9075-14: Information technology – Database languages – SQL – Part 14: XML-Related Specifications, SQL/XML (2008)
9. Kmoch, O., Pokorny, J.: XSLT Implementation in a Relational Environment. In: Proc. of the IADIS Multi Conference on Computer Science and Information Systems - subconference Informatics 2008, Amsterdam, The Netherlands, pp. 91–98 (2008)
10. Mattos, N.M.: Integrating Information for On Demand Computing. In: Proc. of VLDB 2003, Berlin, Germany, pp. 8–14 (2003)

11. Mlýnková, I., Nečaský, M.: Towards Inference of More Realistic XSDs. In: Proc. of the 24th Annual ACM Symposium on Applied Computing - track Web Technologies, Honolulu, Hawaii, USA, pp. 632–638. ACM Press, New York (2009)
12. Moro, M.M., Lim, L., Chang, Y.-C.: Schema advisor for hybrid relational-XML DBMS. In: Proc. of the 2007 ACM SIGMOD Int. Conf. on Management of Data, Beijing, China, pp. 959–970 (2007)
13. Nečaský, M.: XSEM - A Conceptual Model for XML. In: Roddick, J.F., Annika, H. (eds.) Proc. Fourth Asia-Pacific Conference on Conceptual Modelling, Ballarat, Australia. CRPIT, vol. 67, pp. 37–48. Australian Computer Society (2007)
14. Pal, S., Mitra, M.: XML Retrieval: A Survey, Technical Report, CVPR, 2007, TR/ISI/CVPR/IR07-01 (2007)
15. Pokorný, J.: Database Architectures: Current Trends and Their Relationships to Requirements of Practice. In: Advances in Information Systems Development: New Methods and Practice for the Networked Society. Information Systems Development Series, pp. 269–279. Springer, Heidelberg (2007)
16. Smik, R., Parikh, A., Ramachandran, A.: Use XML databases to empower Java Web services - Integrate a native XML operational data store into your enterprise application JavaWorld.com, pp. 1–7 (2004)
17. SYS-CON Media Inc.: The Role in XML in Content Management. XML Journal (2008)
18. Tailor, J.T.: Enterprise Information Integration: A New Definition. Integration Consortium, DM Review Online (September 2, 2004)
19. W3C: XQuery and XPath Full Text 1.0 Requirements. W3C Working Draft (2008)
20. Yu, J., Benatallah, B., Saint-Paul, R., Casati, F., Daniel, F., Matera, M.: A Framework for Rapid Integration of Presentation Components. In: WWW 2007, Banff, Alberta, Canada, pp. 923–982 (2007)
21. Yuan, J., Bahrami, A., Wang, C., Murray, M., Hunt, A.: A Semantic Information Integration Tool Suite. In: Proc. of VLDB 2006, Seoul, Korea, pp. 1171–1174 (2006)
22. ZapThink: Market for XML-enabled Content Lifecycle Solutions to Exceed $11.6 Billion by 2008; XML Key to Solving Critical Content Management Problem: Content Reuse. Business Wire (2003)
23. Zhou, J., Wang, M., Zhao, H.: Enterprise Information Integration: State of the Art and Technical Challenges. In: Proc. of PROLAMAT, IFIP TC5 International Conference, pp. 847–852 (2006)

Software Interoperability Tools: Standardized Capability-Profiling Methodology ISO16100

Michiko Matsuda[1] and Qian Wang[2]

[1] Kanagawa Institute of Technology, 1030 Shimo-ogino, Atsugi-shi, Kanagawa 243-0292, Japan
matsuda@ic.kanagawa-it.ac.jp
[2] South-East university, No2, Si Pai Lou, Nanjing, 210096, China
qwang@seu.ac.jp

Abstract. The ISO 16100 series has been developed for Manufacturing software interoperability through capability profiling. Theses international standards are also applicable and usable for developing general software applications including enterprise applications. In this paper, ISO 16100 methodology and its usage in the trial implemented environment are introduced and discussed as software interoperability tools. The capability profile is created by filling an adequate template. The templates are prepared corresponding to activity classes which construct the application. In the development stage of new application software, the adequate software units for reuse can be found to match the requirement described in the required capability profile. The matching algorithm for capability profiles using an application domain dictionary is also provided when the profiles come from different activity class trees.

Keywords: Software interoperability, Capability profiling, Capability template, Application domain data, Profile matcher, International standard.

1 Introduction

In the development of application software systems in any area such as business, game and manufacturing, there is globalization from building an application system by developing all software units by themselves to building a application system by combining software units which are provided by various vendors. To follow this change, key technologies concentrate on how to skillfully find and use software units which are provided by various vendors and how to reuse existing software units. However, there is no standardized mechanism to search for good and proper software units in the world. Even if proper units could be found, big efforts are required to know the precise capabilities and assurances of the software units because of a lack of standardized description methods of their capabilities and assurances. On the other hand, for the vendor of software units, there exists no distribution chain. Even if they have a distribution chain, there is no standardized mechanism to show the precise capability and assurance of their software units.

P. Bernus, G. Doumeingts, and M. Fox (Eds.): EAI2N 2010, IFIP AICT 326, pp. 140–151, 2010.

This paper provides the methodology to resolve the above mentioned problems. When this mechanism is provided as an international standard, it will provide the interoperability and assurance of software units using capability profiling. This paper is associated with the ISO/TC 184/SC 5/WG 4 [1] activities: ISO16100 series [1][2][3][4][5][6] which is titled 'Manufacturing Software Capability Profiling for Interoperability.' This methodology proposed in ISO 16100 is applicable not only in the manufacturing enterprise but also in other area's enterprise such as in the chemical and amusement industry. The ISO 16100 series enables manufacturing software integration by providing the following : 1) standard interface specifications that allow information exchange among software in industrial automation systems developed by different vendors, 2) software capability profiling using a standardized method to enable users to select software that meet their functional requirements, and 3) a conformance test method that ensures the integrity of the software integration.

2 Software Interoperability Using Capability Profiling Methodology

In the ISO16100 series, the interoperability framework for manufacturing software is based upon a more general interoperability framework for applications. An integrated manufacturing application is modeled as a combination of a set of manufacturing processes, a set of manufacturing resources and a set of information units whose data structure, semantics, and behavior can be shared and exchanged among the manufacturing resources. Manufacturing resources are to support the processes and information exchanges required by the application. The set of integrated manufacturing resources forms a manufacturing system architecture that fulfils a set of manufacturing application requirements. These manufacturing resources, including the manufacturing software units, provide the services, activities and functions associated with the manufacturing processes.

In an appropriate operating environment, the combined capabilities of the various software units provide the required functionality to control and monitor the manufacturing processes according to the production plan and the allocated equipment. A manufacturing process is composed of a set of manufacturing activities. A manufacturing software unit consists of one or more manufacturing software sub-units, performing a definite function or role within a manufacturing activity while supporting a common information exchange mechanism with other software units. The manufacturing software interoperability of a set of manufacturing activities are described in terms of the interoperability of the set of manufacturing software units associated with each manufacturing activity. These relationships are used for capability profiling.

Interoperability on manufacturing software is the capability of a software unit to support a particular usage of an interface specification in exchanging a set of application information with another software unit. The interoperability of software units is described in terms of their capabilities that are associated with the aspects of services, activities, function, interface and structure. Fig. 1 depicts the use of a

---

[1] Authors are experts in ISO/TC 184/SC 5/WG 4 whose convenor is Prof. M. Matsuda.

capability profile concept to integrate interoperable software. In Fig. 1, the left side shows the capability profile registration flow for software vendors for wide distribution of their software units. The software unit's capability profile definition is registered in an appropriate database after passing the conformance test which assures the software unit profile and the software unit itself. On the other hand, the right side shows the flow for finding capability profiles for development of new applications through reuse of adequate software units. The required profiles are compared to existing profiles in the database. When a match occurs, the software unit being profiled is considered to be ready for reuse and integration. When no match occurs, a new software unit with the required capabilities will be developed, profiled, and registered in the capability profile database.

The capability profiling methodology is defined in terms of the rules and elements provided in following sections. The methodology makes use of the domain-specific attributes and methods associated with each specific software unit to describe capability profiles in terms of software unit name, functions, and other needed class properties.

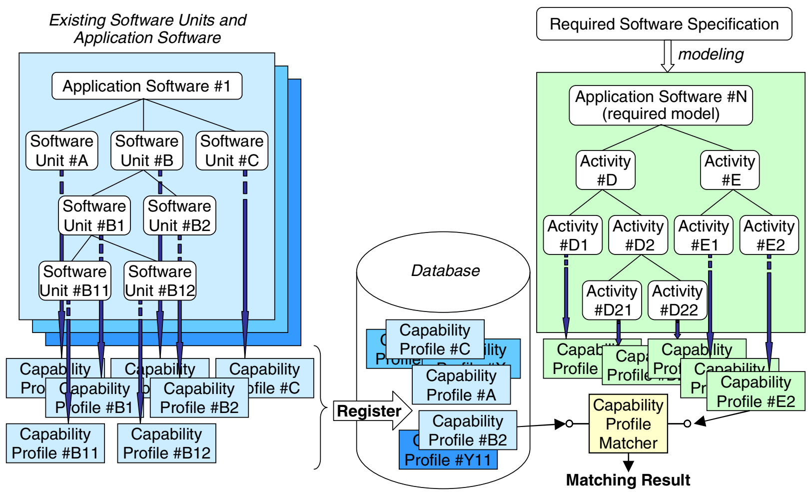

Fig. 1. Software interoperability through capability profiles

3 Rules and Elements in ISO 16100 for Software Interoperability

3.1 MDM (Manufacturing Domain Model) and MDDs (Manufacturing Domain Data)

The manufacturing domain that includes discrete, batch, and continuous control encompasses many types of industries. For manufacturing software, the interface between plant management systems and floor control systems is described by the same method regardless of whether control systems are discrete, batch, or continuous. Similarly, the control flow inside a control system is also described by the same method regardless of whether the system is discrete, batch, or continuous. However, a key aspect of terminology is delicately different in each domain. A key aspect of a terminology for capability profiles is its ability to identify the contents that constitute a capability definition. A terminology is constructed that provides a means for the interchange of the capability information. The terminology describes a partial set of activities undertaken within the lifecycle of a manufacturing enterprise and domain. For capability profiling of software units, the applicable manufacturing domain must be focused, and the set of terminology must be common in the domain.

Two new elements are introduced for capability profiling. One is the ***MDM*** (Manufacturing Domain Model). MDM is a model of an applicable manufacturing domain for manufacturing software. Another one is the ***MDD*** (Manufacturing Domain Data). The MDM is a particular view of a manufacturing domain, consisting of MDDs and relationships among them, corresponding to the domain's applications. The MDD represents information about manufacturing resources, manufacturing activities, or items exchanged among manufacturing resources within a particular manufacturing domain. A set of MDDs works like a terminology set in the applicable domain.

MDDs represent different types of manufacturing information, including those that are exchanged between the resources within an application and between applications. Fig. 2[5] shows an example of a structure of a MDM with multiple MDDs. Within a specific manufacturing domain, a manufacturing application can be represented as a set of MDDs. An MDD provides information about various aspects of a manufacturing application such as manufacturing resources, manufacturing processes, manufacturing information exchanged, and relationships among the resources, processes and information exchanged. Each MDD within a specific manufacturing domain consists of attributes, operation types and a mapping between them. The mapping identifies the operation types associated with an attribute. In a typical mapping, not all operation types will be associated with an MDD's particular attribute. Typical operation types include initialization of an attribute's value and rewriting an attribute's value. The MDD exchanged among manufacturing functions or among manufacturing activities is descriptively named such that each MDD is unique in the target manufacturing domain.

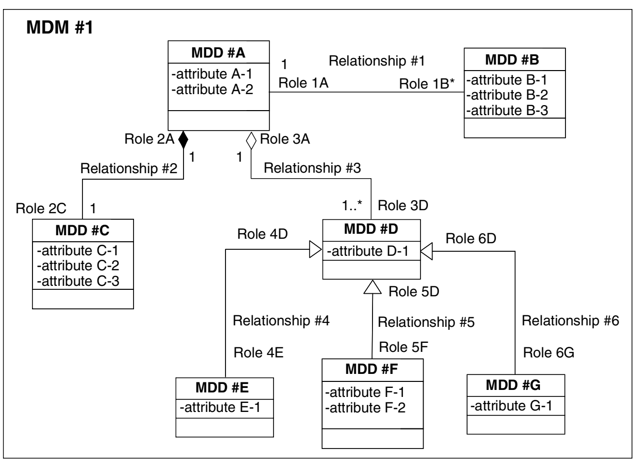

Fig. 2. Target Manufacturing Domain Model and Manufacturing Domain Data in the manufacturing area

The MDM creator represents a manufacturing application as a set of MDDs within a specific manufacturing domain. An MDD provides information about various aspects of a manufacturing application such as:

- Manufacturing resources (ex. manufacturing software unit, equipment, automation devices, personnel, material, work-in-process inventory),
- Manufacturing processes (ex. operations, activities),
- Manufacturing information exchanged (ex. product data, recipe, manufacturing data, quality data),
- Relationships among the resources, processes and information exchanged.(ex. data flow, network configuration, work flow).

3.2 CCS (Capability Class Structure) and Capability Template

A manufacturing application is modeled as an activity tree structure that is both nested and hierarchical. The activity tree is structured based on the MDM from the requirements of the manufacturing application. To distinguish a particular activity in an activity tree, an activity has an unambiguous and unique name, along with semantic information expressed in terms of a sequence of MDDs. The ***CCS*** (Capability Class Structure) is formed from the activities in the activity tree. As shown in Fig. 3, a CCS corresponds to the activity tree and a capability class is unique when the activity can be pointed to in the activity tree. The capability of a software unit is expressed in terms of capability classes. At each level, the software unit is modeled as a set of capability classes organized in a similar structure. These classes also denote the manufacturing function, resource, and information handled by the software unit according to the requirements of the manufacturing process. As a result, an activity tree and a CCS have a one to one mapping.

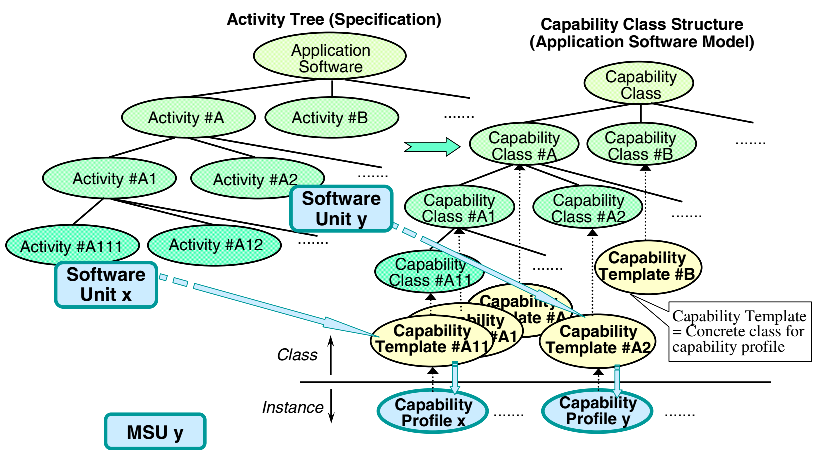

Fig. 3. Capability Classes Structure and Capability Template

If a manufacturing software vendor wants to widely distribute his developed software unit, the vendor makes several profiles for one component corresponding to each CCS. When a system integrator or manufacturing application developer wants to search proper software units, the developer creates the profile by filling the ***Capability Template*** with required capabilities. A software vendor registers a capability profile of a software unit so that it is widely available to many potential users of the software unit.

Usually the vendor who is the supplier of software components, and the application developer who is the user of software components, are in the same MDM but not in the same CCS. To allow matching existing capability profiles of software component and required capability profiles derived from multiple CCSs, MDDs are used.

Fig. 4 shows the conceptual structure of the Capability Template. The sets of elements in the Capability Template are filled by the concrete values corresponding to the target profiled software unit's capabilities. The profile is described using XML. A capability profile template contains a Common Part and a Specific Part. The Specific Part contains the elements: Reference MDM Name, list of MDD objects, and Capability Definition (e.g. time ordered access to MDD objects).

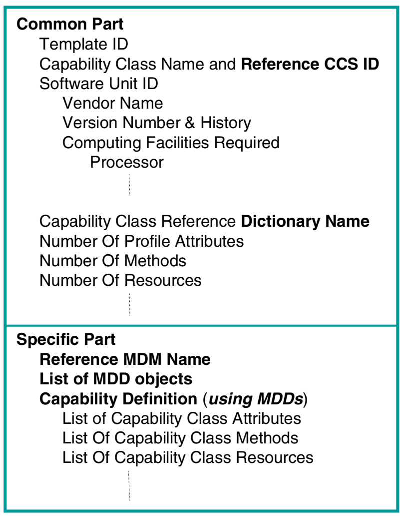

Fig. 4. Structure of Capability Template

4 Interoperability Tool: Matcher of Capability Profiles

4.1 Interoperability Framework for Application Development

To increase the efficiency of application software development, it is desirable to reuse software units previously deployed in a similar application. For this purpose, the required software unit for the new application needs to be compared to the software unit capability that will be re-used. In this comparison, the reference CCS of the software unit to be re-used may not be the same as the CCS of the target application. In this case, the application developer is not limited by the existing CCSs within the same application domain.

In Fig. 5, the flow shows the procedure that a software vendor performs to prepare and register a capability profile of a software unit. After choosing a suitable MDM, the first step is to analyze the set of activities that the software unit enables. The software unit can enable one or more activities. The second step is to identify the capability class corresponding to each activity and search for the associated CCS to which the capability class belongs. If a software unit provides capabilities for two or more activities, those activities can belong to the same CCS or to a different CCS. The third step is to select the capability template for each capability class identified. If there is no suitable CCS, the fourth step is to construct the appropriate CCS and register it, and then to generate the corresponding template and register it. The last step is to create the software unit capability profile by filling in the capability template and register it[7].

When a new manufacturing application is developed, the following procedures are performed as shown in Fig. 5. The first step is to analyze the functional capability requirements of the manufacturing application and create an activity tree in the appropriate MDM. The second step is to create a CCS using existing or new capability classes to match the activity tree, or select an existing CCS. The third step is to fill in the corresponding capability template for each capability class in the created or selected CCS to create the set of required capability profiles. The sets of elements in the template are satisfied by the concrete values for the requirement upon the software unit capabilities. The profile is described using XML. The required profile contains a set of mandatory and optional capabilities. The fourth step is to compare the set of required capability profiles to the available set of software unit capability profiles using a capability profile matcher, to find a set of existing software units that matches the set of required capability profiles. The fifth step is to select the set of existing software units that meets the requirements of the new manufacturing application. If the set of software units that meets the requirements is not found, a set of the missing software units has to be developed. The last step is to combine the set of reused software units and any set of developed software units to meet the requirements of the new manufacturing application[7].

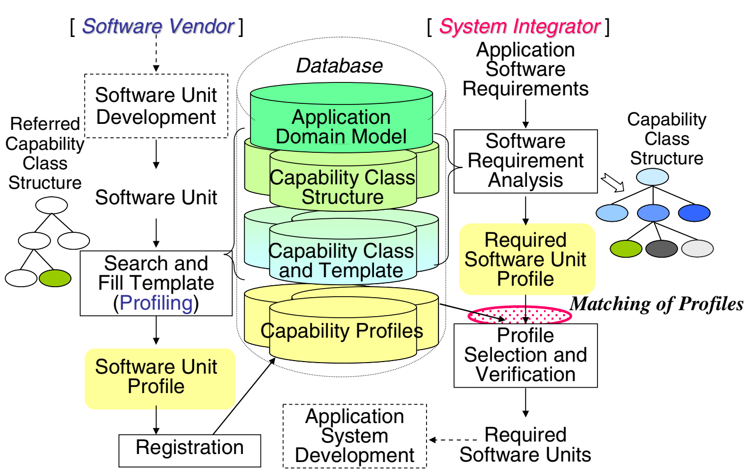

Fig. 5. Conceptual Interoperability Framework

4.2 Matching Procedure of Capability Profiles

A Matcher is used to match a required capability profile and an existing capability profile for a software unit. A Matcher makes use of the reference CCS names and related information from the two inputted capability profiles in order to determine if these profiles are based on a common MDM and common set of MDDs. When these profiles are based on a common MDM and common set of MDDs, a Matcher can evaluate the existence of a functional correspondence between these profiles.

The matching processes in the matcher are shown in Fig. 6. The first step is to extract the reference MDM IDs from the inputted capability profiles and compare these MDM IDs. If they are not the same, then the matcher reports that a comparison of the inputted profiles cannot be made. If these MDM IDs are the same, the second step is to extract the capability definition formats from the inputted profiles and compare these formats. If these formats are the not the same, the MDDs in the capability definitions are converted to a single capability definition format by means external to the matcher. If these formats are the same, no conversion is made. The third step is to extract the sets of MDDs contained in the capability definitions for these profiles. The fourth step is to compare them to determine the existence of functional correspondence between the profiles. At the last step, the matcher reports the matching level of the capability profile relative to the required profile[5][8].

When comparing the contents of two target capability profiles, the matching level generated by a Matcher is assumed be one of Complete Match, All Mandatory Match, Some Mandatory Match or No Mandatory Match. Complete Match means that both sets of manufacturing functions are fully equivalent in terms of both the MDD objects being

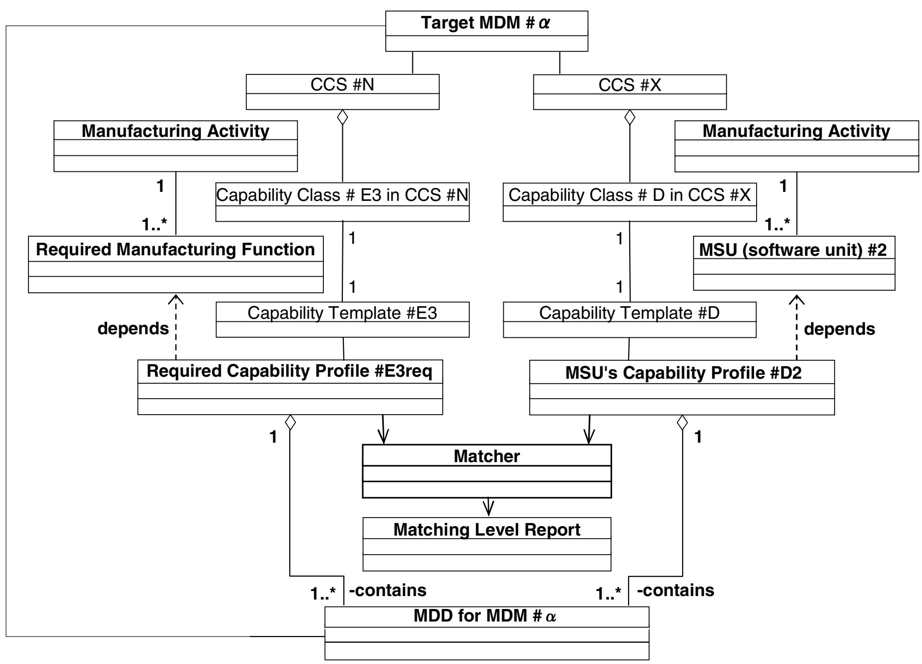

Fig. 6. Matching for software capability profiles

equivalent and the time ordering of these objects being equivalent. All Mandatory Match means that all the mandatory functions in the required capability profile are completely matched with a corresponding set of manufacturing functions referenced in the MSU capability profile. Some Mandatory Match means that the required capability profile is matched partially by the MSU capability profile. No Mandatory Match means that none of the mandatory functions referenced in the required capability profile match the functions referenced in the MSU capability profile.

5 Trial Implementation of Capability Profile Matcher

Based on the capability matching procedure mentioned above, a capability profile matcher is developed. The prototype system is performed in Widows 2000/Windows XP/Windows Vista .Net Framework 2.0 in C#. The system is based on the ISO 16100 framework[1][2][3][4][5] of the software capability profiling for interoperability. The prototype system consists of following functions as shown in Fig. 7.:

- For CCS (Capability Class Structure)
  - Create / register a new CCS based on an activity tree for a particular application
  - Edit / register a capability class for an activity
  - Delete a capability class for an activity
- For Capability Template
  - Create / register a Capability Template for a capability class based on the formal structure
  - Edit / register a Capability Template based on the particular activity
  - Delete a Capability Template
- Creating a capability profile based on a Capability Template
  - Create / register a new capability profile based on the particular Capability Template
  - Edit / register / a capability profile
  - Delete a capability profile
- Searching a proper Capability Template and return the search result with the detail report
- Matching a user required capability with a set of existing capabilities and return the matching result with the detail report

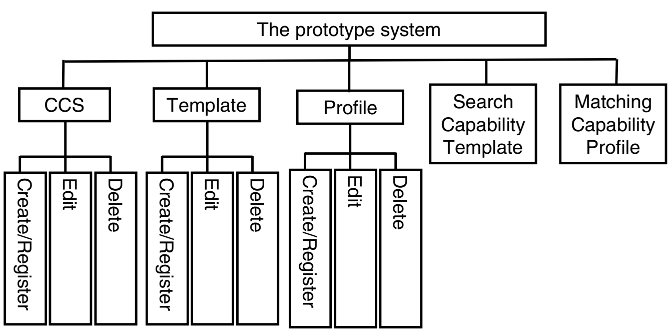

Fig. 7. The functions of the prototype system

Fig. 8. shows the screen for editing a capability profile. When the profile template ID and its name is input, the tree-style schema of this profile template will appear on the left part of the screen. Profile information is shown on the right part of the screen. From top to bottom, there are the head part (Profile Type, Package Type, Version, Profile ID, etc.) of the profile, the common part of the profile and the specific part (Operations. Exchanged information, Resources and Constraints, etc.) of the profile. Before storing/registering the profile into the database, a conformance test is done automatically. The XML format file for profile is stored in the database. Also any XML file in profile style is presented in a tree on the screen.

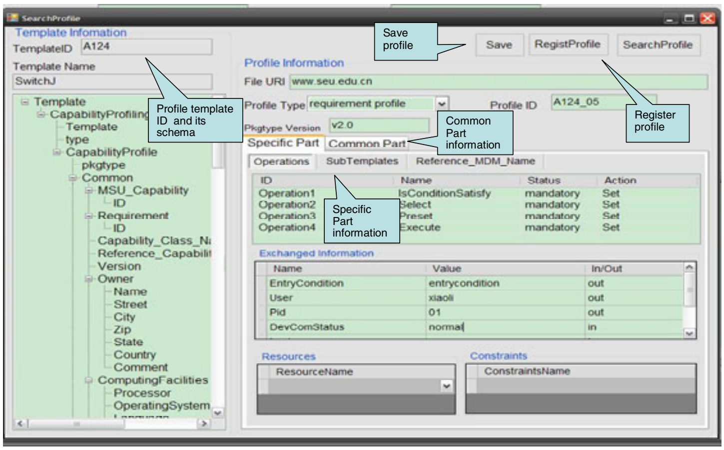

Fig. 8. Editing a capability profile

Matching on the prototype matcher is shown in Fig. 9. This prototype matcher can match two profiles which come from different Capability Templates. Two profiles may have different schema. The prerequisites for the matcher are that these two profiles are in the same application area: same MDM, and using the same MDD dictionary during the filling in of values. After giving the required capability profile (Source profile) and one existing capability profile (Target profile), the matching starts. During the matching, the matching process is shown in the middle of the screen. On the left part of the screen is the Source profile, and on the right part of the screen is the Target Profile. They are both in a tree style. The red color stands for the matched terms. Each matching step (matching point in each tree and its matching action) is shown below the two profiles' trees. A matching speed adjuster called "interval" is used to adjust the interval for each matching step in order to watch the process step more clearly.

The matching for the head part and the common part in two profiles are simple string comparisons, however, the matching for a specific part is more sophisticated. It follows the following procedures:

1. Compare each operation in 'Source Profile' with each operation in 'Target Profile' until an operation is matched;
2. For each operation, compare each element of the exchanged information in 'Source Profile' with each element of the exchanged information in 'Target Profile' until an element is matched;

3. For each operation, compare each element of resources in ‘Source Profile’ with each element of resources in ‘Target Profile’ until an element is matched;
4. For each operation, compare each element of constraints in ‘Source Profile’ with each element of constrains in ‘Target Profile’ until an element is matched;

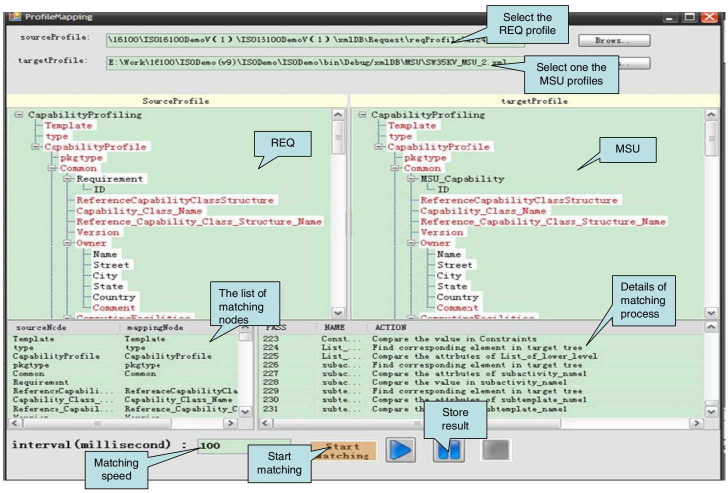

Fig. 9. Matching a capability profile

6 Conclusions

ISO16100 provides the standardized framework for software interoperability. In other words it provides a methodology to search for a good and proper manufacturing software unit and to show the precise capability of this software unit. In ISO16100, the interoperability and assurance of software units can be managed through their capability profiles which describe their capabilities that are associated with the aspects of functionality, interface and structure of the software unit. At present, ISO1600 consists of six parts. Even though ISO16100 is developed for manufacturing software, the concepts and methods which are proposed in ISO16100 are generally applicable to software interoperability and assurance. MDM, MDD, CCS and Capability Template are basic tools and the capability profile matcher is a most useful tool in ISO16100 framework. Trial implementation of the matcher shows the practical usefulness of the methodology. When the proposed environments are available, software interoperability and assurance will be enhanced on a grand scale.

Acknowledgments. The authors thank ISO/TC 184/SC 5/ WG 4 members for fruitful discussions and their useful effort to complete international standards. The author is also grateful to Dr. U. Graefe, the previous convenor of ISO/TC 184/SC 5/ WG 4 for his helpful assistance with the writing of this paper in English.

References

1. ISO 16100-1:2009 Industrial automation systems and integration – Manufacturing software capability profiling for interoperability – Part 1: Framework (2009)
2. ISO 16100-2:2003 Industrial automation systems and integration – Manufacturing software capability profiling for interoperability – Part 2: Profiling methodology (2003)
3. ISO 16100-3:2005 Industrial automation systems and integration – Manufacturing software capability profiling for interoperability – Part 3: Interface services, protocols and capability templates (2005)
4. ISO 16100-4:2006 Industrial automation systems and integration – Manufacturing software capability profiling for interoperability – Part 4: Conformance test methods, criteria and reports (2006)
5. ISO 16100-5:2009 Industrial automation systems and integration – Manufacturing software capability profiling for interoperability – Part 5: Methodology for profile matching using multiple capability class (2009)
6. ISO/CD 16100-6 Industrial automation systems and integration – Manufacturing software capability profiling for interoperability – Part 6: Interface services, protocols for matching profiles based on multiple capability class structure (2010)
7. Matsuda, M., Arai, E., Nakano, N.: Capability Profiling for Interoperability of Manufacturing Software. The CIRP - Journal of Manufacturing Systems 34(1), 63–70 (2005)
8. Yu, W., Matsuda, M., Wang, Q.: Enhancing Interoperability of Manufacturing Software Units Using Capability Profiling Enterprise Interoperability. In: IFIP the new Challenges and Approaches, pp. 451–460. Springer, Heidelberg (2007)

Value Added by Interoperable Information Systems in Spread Production Networks

Dirk Oedekoven, Volker Stich, and Bojan Stahl

Research Institute for Operations Management at RWTH Aachen University,
Pontdriesch 14/16, 52062 Aachen, Germany
{Volker.Stich,Dirk.Oedekoven,Bojan.Stahl}@fir.rwth-aachen.de

Abstract. What is the competitive advantage of interoperable information systems? Taking this research question as a guideline the paper discusses how to approach the challenge of assessing the benefits of integrated systems. The main focus is laid on the direct and indirect effects of standardization projects which aim at continuous and homogenous order processing data. The knowledge based approach starts on data level and takes care of the interdependencies between the subsequent levels of aggregation. The problem immanent complexity is caused by the variety of heterogeneous product and process describing attributes. The application of management cybernetics in order to handle this challenge constitutes the focal point of this paper.

Keywords: interoperability of information systems, standardization, management cybernetics, value added, order processing architecture.

1 Introduction

1.1 Initial Situation and Conceptual Background

The European Union (EU) is presently funding a research project (IMS2020) fostering the achievement of "Sustainable Manufacturing, Products and Services" by the year 2020. The project team consists of industrial and research competences from all over the world. Leading institutes and enterprises from Switzerland, United States, South-Korea and Japan participate from the beginning of 2009 until the end of 2010.

One of the main activities of IMS2020 is the identification of relevant research topics to set up a Roadmap describing how to achieve the desired vision of the year 2020. In fact, 20 world wide existing roadmaps and 13 ongoing research projects have been mapped, identifying a total of 754 Research Issues. The development of the Roadmaps has been supported by collaborative tools shared with all the Roadmapping Support Group, a growing community that, at the moment, counts 254 participants from 108 mainly industrial organizations. The project is embedded in the global activities of the Intelligent Manufacturing Systems (IMS) initiative. This initiative is a platform for industrial research to share experience and best practices.

The first steps, after the mapping, have been an open online survey, with 261 participants, two brainstorming workshops and 106 interviews. All these activities

P. Bernus, G. Doumeingts, and M. Fox (Eds.): EAI2N 2010, IFIP AICT 326, pp. 152–163, 2010.

involved experts not only from Europe, but from all over the world, with special focus on the IMS regions (Japan, Korea, US). Based on these inputs, the IMS2020 team developed a vision for the 2020 manufacturing with a set of 62 Research Topics to be implemented in order to achieve it. These topics have been shared and refined with the input of the community through an online wiki (http://ims2020net.wik.is/) that has more than 2500 visits up to now. Finally the research topics have been validated and prioritized through a second online survey (n=359). Additionally the interest of the different IMS regions to participate in corresponding collaborative research projects has been taken into account.

Sustainable manufacturing can be defined as "[…]*the vision of a production system, in which production and consumption support the quality of individual and social life, in ways that are economically successful while respecting environmental limits. Knowledge and technology, capital, resources and needs are harnessed and governed so people can live better lives while consuming less material resources and energy"* [26]. To achieve the goal of consuming less material resources and energy it is important to avoid any kind of waste. This is valid for specific production procedures as well as for all superior supply chain coordinating processes. For that reason it is not remarkable that the investigation of possible research topics led to the problems caused by inconsistent and redundant data.

In the past decades production systems became more and more spread all over the world. The increasing number of multi-site enterprises imposes a tremendous challenge to the performance especially of enterprise resource planning (ERP) systems. Furthermore cross-company processes within the order management are steadily gaining importance. Companies realize efficient communications with their network partners as competitive advantages. Efficient and real time information sharing is more and more understood as a strategic instrument affecting the value of the company [3][4][5][6]. The growth of importance of IT infrastructure has increased disproportionately high since the 80ies [1][2]. Nevertheless, enterprises struggle fighting the problem of inconsistent and redundant data. On the one hand they are not able to avoid the appearance of these challenging effects. In consequence this leads to an inadequate support of cross-sectional order processing tasks. On the other hand the benefits of required projects to harmonize and standardize data and data structures cannot be evaluated with an adequate accuracy in advance. The value added by interoperable information systems is not known. In the end projects run out of budget or are not even launched although there is a high potential for improving processes and gaining competitiveness.

Coming up in a lot of expert interviews as well as in a high number of survey returns this problem put the IMS2020 consortium to call for a sustainable management concept in one of its research topics. Especially product and process describing data with relevance for order processing should be in the centre of attention (RT1.20). Following this intention the underlying research work of this paper investigates how to estimate the competitive advantage of harmonization and standardization projects by making use of knowledge about the interdependencies among benefit dimensions.

1.2 Problem Definition

Knowledge about the actual state of work is nowadays an indispensible competitive advantage acting on global markets. The competitiveness of an enterprise is not any longer defined only by its products and services but in fact by its ability to execute orders at maximum efficiency. Information is required to be accessible in real time and across all levels of production management. Nowadays a companies IT infrastructure is characterized by a high number of applied IT solutions. Taking a look at the process of order handling it becomes obvious that relevant data will not only be found in ERP Systems. Product Data Management (PDM), Product Lifecycle Management (PLM), Manufacturing Execution (MES) and even systems for production data acquisition (PDA) on shop floor level contain important knowledge for excellent order handling processes as well. The economic and logistic potential within the system interfaces is enormous, independent if it is rooted in intra company networks or among autonomous companies [7][8][9]. The challenge is originated in **spread production systems**.

Identical products do not automatically guarantee synchronized process- and attributes structures. Not standardized processes lead to inadequate ERP system support, even if the objects and objectives are consistent. The results are inefficient information flow and poor transparency. The coordination between the different facilities is time-consuming and costly because integration and standardization potentials are not utilized. In addition the potential to integrate modern concepts of cooperation into operational and cross-site planning habits remains limited. Last but not least, the extent of the corresponding influences on the company's key figures (e.g. ROCE) cannot be determined currently. The **interoperability** of a company is affected and remains far below its natural potential.

For that reason harmonization activities are needed, that create an integrated, accurate and consistent data basis for all company-relevant master data [10]. An

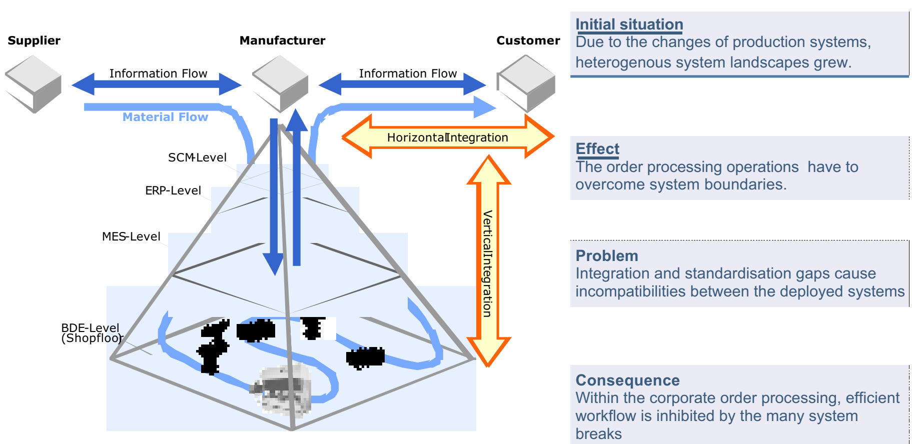

Fig. 1. Initial Situation

investment to a harmonization plan as an IT project remains undone, if only one of the involved entities appreciates the not negliable investment as too expensive, project risks as too high and the profitability ex ante not to be identified [11]. In times of intense global competition it is of particular importance, to ensure the plausibility of costly large-scale projects in terms of their real potential benefits. Otherwise companies are risking their existential business actions through wasting liquid funds. The **value added** must become assessable.

A segmentation of the system discontinuities' causes helps to structure the problem: On the one hand supply relations between the entities of a production network exist but the use of different ERP systems determines physical incompatibility of the interfaces. This case can be described as the integration gap. On the other hand compatible ERP systems are used, but semantic differences in the order processing data lead to incompatibilities. This can be summarized as the standardization gap [APMS proceedings]. The closure of integration- and standardization gaps through corresponding harmonization projects is the precondition for interoperability. Accordingly this segmentation will be regarded as a guideline for the ongoing research work and help to quantify the **value added by interoperable information systems in spread production systems**.

1.3 Objective of Research Work

The objective of this research work is to develop a method for the identification and estimation of the benefit potential of harmonized order processing attributes and data. The focus is on companies which act within the frame of spread production systems. The method should be useable to support decision processes regarding investments into corresponding harmonization projects within a company, a group or a network. It should provide an assistance to enable and raise the rationality of the decision and modern techniques to analyse cost-benefit potentials.

Furthermore it is explicitly important to consider the induced dynamics, variety and complexity. This will be guaranteed by locating the respective processes in a reference model that fits these requirements.

To provide useful results the development of the method has to include an investigation of all relevant interdependencies regarding the single benefit dimensions. A preceding analysis of the underlying complex structure identifying each relevant benefit dimension is indispensable. As different effects can occur whether in reinforcing or in inhibiting affection the necessary exploration of the corresponding relations can be processed from there on. This should lead to a deduction of the correlations between the single dimensions of benefit and the underlying heterogeneous data. Finally the qualitative benefits of potential should become assessable on a monetary level despite some uncertainties making use of such functional chains.

1.4 Scope of Research Work

Existing assessment approaches usually focus on the implementation of specific systems such as SCM or ERP applications only. Indeed, harmonization projects should not only be qualified by verifying their contribution to a single systems performance. Furthermore it is essential to become aware of the total impact on all strategic goals, which usually affect vertical and horizontal integration and standardization needs.

To narrow the scope of investigation contract manufacturers of products with variants are the initial point of work. Furthermore it is necessary to stick to processes that are suited as references of real actions. An analysis of reference processes ensures a complete enumeration of all interfaces that may suffer from heterogeneous data and attributes in and between enterprises. Accordingly for each interface a number of potentials can be identified. In order to structure potentials and relations the set-up of a benefit model comes into place. By developing a coherent target system connecting subordinate objectives of data harmonization with superior objectives such as cycle time reduction, the interdependencies can be evaluated. Starting from a detailed reference model, making use of knowledge about functional chains and ending up in an integrative assessment based on an overall target system is essential.

Regarding information flows the Aachener PPC Model offers the most detailed and feasible reference model of order processing activities [13]. SCHMIDT amends this model by a description of the coordination points in 2008 [27][28]. But although the additional modelling of control loops concerns science as well, an explicit analysis and description of product and process describing data is still missing. Taking this spadework to another level several authors investigated the functional chains of benefit effects while having different target systems in mind [14][17][21]. A continuative connection of product and process data with any of the target systems is not performed. A universally valid model of respective functional chains keeps missing. Only a few authors try to elaborate the impact of IT integration but they keep focussed one specific system. They do not have the fundamental process of order processing in mind [21].

So far, there is no accordant technique which addresses the deduction of potentials that occur from a harmonization of product and process describing data in terms of order processing requirements.

2 Research Design

The course of action described below is geared to the approach to research according to ULRICH [15]. The research focuses on the effects of data harmonization regarding the monetary success of the companies. The description and explanation of the impact of data harmonization projects is the aim of the research work. The steps of the research process include terminological-descriptive, empirical-inductive and analytical-deductive components [16].

First of all the problem is embedded within management cybernetics. The order processing procedure is characterized by an interaction of diverse participants as well as by a high number of systemic interfaces. This results in a complex interplay of the entire observed systems which is difficult to be dealt with for a scientific analysis. In literature various models try structuring order processing activities according to a certain classification scheme in order of an integrative description of information interfaces. However, due to their focus and level of detail they do not afford a sufficient categorization of the diverse starting points for harmonization projects.

In this research work, management cybernetics is used as a starting point and initial approach for identifying potential benefits. The Viable System Model (VSM) has to be adapted in order to fulfil the research requirements which emerge from the consideration of dynamic effects. Hence, it serves as an essential basis for the description model.

The second step involves the identification and localization of harmonization objects. In this case, harmonization objects are specific spots in the process which require certain coordination. Those spots are indicated by shifts from one medium into another, involvement of different types of information and the constraint to be crucial in decision-making or producing new information. Hence, the term harmonization object can be defined as certain step in the order processing, where incongruent data and/or the usage of different, not-connected IT systems finally lead to an increase of decision-making complexity. The harmonization object is therefore a part of the entire process, where those states can be identified. Harmonization demand causes negative consequences in the end to the monetary ratios of an enterprise which e.g. is done by longer work, information comparison tasks and reliable tasks. Therefore, the localization of harmonization objects within the entire order processing chain serves as a first step. In order to gain comprehensive results all information processed through all systems and activities in the sub-process are gathered and analysed.

The harmonization objects arise from diverse typologies of causation, whereas in fact two different types can be differentiated. First order harmonization demand is existent if the same information is described by two syntactical different data sets. Second order harmonization demand is existent if a data set is changed and saved in another IT-system, so that the identical information has two different characteristics. Those harmonization demands lead to harmonization objects. As stated above, harmonization objects are steps in the order processing where harmonization demands of first or second order or a combination of both can be identified.

The functional analysis of the harmonization objects' influence on specific target elements prepares the ground for the final assessment. The target system, based on the spadework of FIR [22], lists all important and necessary management ratios on different hierarchical levels with certain dependencies. The identification of the decisive interdependencies between harmonization objects and elements of the target system is a crucial step. The proper assessment and estimation is the initializing path towards a monetary evaluation of the potential benefits of harmonization projects. An accurate detailing is therefore pivotal.

Finally the design of a procedure for identification and assessment of potential benefits in harmonization projects is performed. The procedure is structured by three steps. The first one leads to an evaluation of each harmonization object. Secondly, the effect to a single business ratio is determined. Finally, an instruction for accumulation is given.

In the end, the accomplishment of several activities leads to the method that has to be developed for the identification and assessment of potential benefits in harmonization projects. It includes the specification of various potential benefits and costs as well as the systematic analysis of the interdependencies referenced to an integrated target system. The following will give a brief overview how the VSM was applied in terms of management cybernetics to ensure a resilient reference model as an initial point of work.

3 Management Cybernetics

The conventional methods of the model theory do not provide fitting approaches to face the system-immanent complexity of production systems. On the contrary systems theory and management cybernetics specifically start at this point. In contrast to the general approach of engineering or business sciences, these approaches do not exclude the complexity through restrictions and simplifying assumptions, but are setting the focus on it. The discipline of management cybernetics founded by BEER delivers receipts and methods to manage the company effectively because of a system oriented approach [12].

3.1 Viable System Model

The Viable System Model (VSM) was developed by Stafford Beer upon a trilogy of his publications [18][19][20]. BEER created the VSM in analogy to the human nervous system in regard to homomorphism and assigned the principles of control patterns of a living and life-sustaining biological system to social systems in order to adapt the attribute of system performance. Thus, it executes various operations like adjustment to changes in the environment and self-coordination of its parts. It contains multi-level combined closed-loop systems and consists of an adequate and inevitable set of organizational functions for viable organizations and is able to maintain the organizational structure as well as to install internal stabilization, whereas from a cybernetics perspective viable means to maintain a separate existence. The VSM is a recursive system, where each VSM contains and is contained within other viable systems [19].

The VSM displays companies independent from their size or branch into a system with five subsystems with identical structures. The VSM is a cluster of operations, management and the environment and it provides design techniques regarding information, material and energy flows. Hence, the VSM defines principles for organizations that need to be fulfilled in order to maintain viability. A VSM is composed of five interacting subsystems which are described below.

System 1 incorporates the operations and primary activities where the system's purpose is fulfilled. The entire operation unit may contain several System 1. Every System 1 consists of a management and operation unit which is connected due to certain principles to the environment and other systems.

The other systems are so called meta-systems which means they are above logical order. They perform as a management unit and control system for the operation units.

System 2 performs the coordination of the operation units. Typical specifications are information systems, coordination teams or internal service units. The behavior of the autonomous operating System 1 has to be adjusted in order to prevent dysfunctionalities and oscillation.

System 3 is the operative planning and therefore responsible to ensure efficiency in the operation's performance. It is accountable for the internal control of the organization and functions as a supervisor for the System 2 activities. System 3* is directly connected to System 3. It fulfills direct monitoring operations in System 1 via sporadic audits and supports System 3 with necessary information about the operations performance.

The main purpose of System 4 is to gather information from the environment, to separate it, and to generate potential future models of the environment and the organization. It derives and develops strategies for prospective corporate development.

System 5 is the normative management. On the one hand it is responsible for the interaction of the operation and strategic management, and on the other hand represents the corporate values, norms and rules. It builds the ethic and culture of an organization [19].

The information generated from and by management activities is distributed through the closed-loop channels between the five subsystems. Every system has a certain configuration of information type executed and processed to other systems:

- System 1: Information about the primary activities and information that is forwarded between the operating systems
- System 2: Information that is required to assure harmonization between all the operating systems
- System 3: Information that is used to enhance the operating S1 systems activities
- System 4: Information from the environment and from the organization that is significant to strategic development
- System 5: Information of a normative quality

The Viable Production System (VPS) serves as an organizational corporate model to understand and explain the flow of information in the company regarding the control of processing of orders. Particularly, the information processed by the meta-system is in focus.

3.2 Viable Production System

The structure of the VPS is defined by the application of the order transaction processes of manufacturing companies to the operational systems of the VSM. It is characterized by a concurrent appearance of a process-oriented view as well as an organizational control-oriented-view in one holistic enterprise model method.

According to SCHMIDT, the order processing consists of nine key processes: process offer, projecting, product design, order executing, parts procurement, parts production, parts assembly, distribution and after sales service [22]. Furthermore, the key processes can be divided from sub-processes to employee level. The nine key processes establish the nine main activities of the Systems 1 in the first recursion level in order to afford major autonomy. Taking an ideal case as a basis the order processing can be proceeded without further intervention of the control units or the meta-system. The control units are assigned with two tasks:

- process monitoring to handle disturbances
- organizing the operational elements according to guidelines of the meta-system

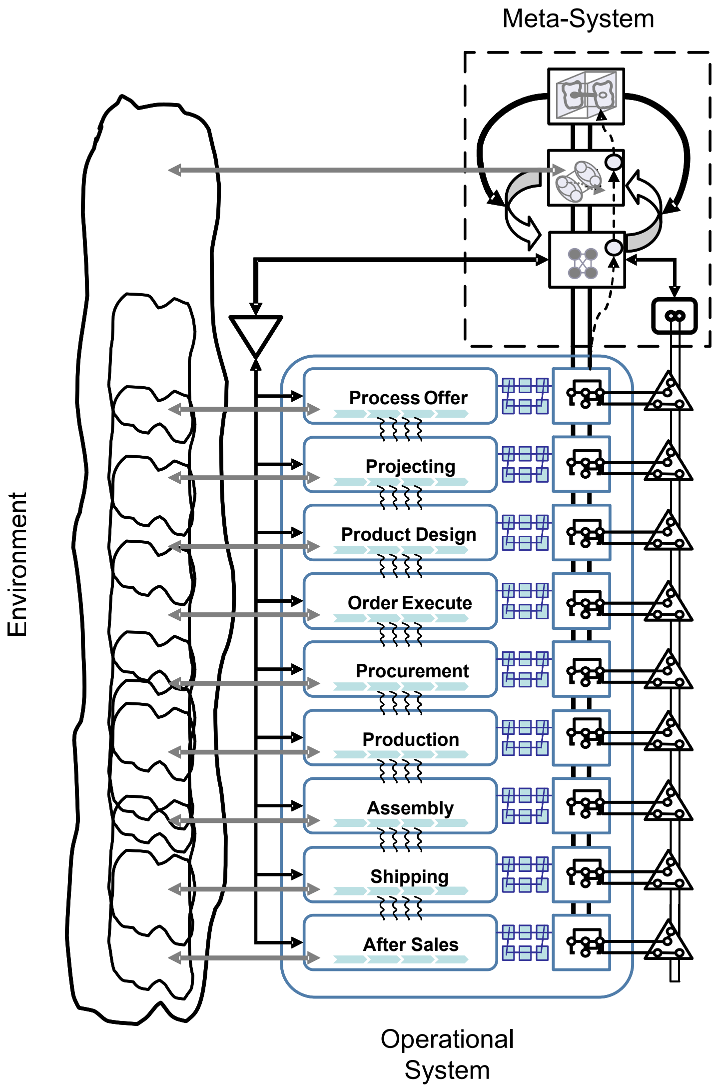

Fig. 2. Viable Production System [23] [24]

The application of the VSM broadens the limited stand alone process view by a further dimension. While the process model arranges the key processes and flow of information among one other, it is able to map the monitoring, control and disturbance functions within the VSM [23][24].

The advantage of the VPS is the stringent orientation on the order processing in conjunction with the current examination of the process and control level. Hence, the opportunity of a holistic embodiment is provided. The corporate application of the VPS is still a challenge to be dealt with. Another focus of research interest for this survey is provided by the anastomotic reticulum. Within the VSM, the anastomotic reticulum serves as the direct connection between the operational units. Information, energy and material can be transmitted through the respective channels of the net in order to fulfil the operational aims. An anastomotic reticulum is a model of a neuronal net in which every neuron listens and speaks to many [25]. This means that the various connections of a network are compound in such a manner that it is no longer possible to detect how the information has passed the network. Comparable to a river delta it is impractical to determine where one particle comes from and goes to. It seems unfeasible to track a single particle in the water. Information streams in management or social systems appear with the same attitude [18].

Whereas the residual channels of the VSM serve for variety engineering and control mechanisms, the anastomotic reticulum is the main connection in terms of a systems purpose. Therefore, this network is an essential research object when dealing with the order processing without considering a certain control mechanism.

The VPS concentrates on the control systems of an order process and is engaged in the information flow of the meta-system. The connections between the meta-system and operational system are on focus as well as the channels within the meta-system. This research tries to bridge the gap within the VPS and centres its work on the information flows between the operational systems which is neither covered in the VPS and VSM at present.

4 Results and Conclusion

The challenge for enterprises of being efficient and effective in using their IT infrastructure is gaining more and more importance. Yet a promising approach to evaluate potential benefits in advance is missing. In the field of profitability analysis of order processing in spread production structures the difficulty lies more within the estimation of benefits rather than in the estimation of the efforts. The monetary analysis of benefit potentials is so far limited to quantitative dimensions, while the qualitative aspects stay neglected or analyzed on a general level only.

As the mediate potentials of benefit at harmonization projects have a high total ratio, the validation of the effects on a monetary key figure for those systems is highly relevant. The interdependencies between the dimensions of benefit were so far only analyzed isolated and without regarding of cross-sites effects. Functional chains analyzed so far do not give a detailed description of the influencing mechanisms, apart from quantifying positive or negative influences. By that it can be stated that a systematic, scientifically founded derivation of the benefit potentials of harmonized data objects has not been performed yet. A corresponding option to assess potential benefits efficiently and exemplify their interdependencies is missing as well. Complexity could be identified as the main causes for this failure.

The VPS in general and the anastomotic reticulum in particular frame a suitable approach to meet the evolving requirements. The anastomotic reticulum can be specified due to the transmitted types and the mode of connection. Information, energy and material are the distinguishable types which are interchanged by the operational units. The mode of connection is determined by the specified Systems 1, where human or technological channels can be differentiated. Especially the technological channels can be developed as machines, conveyors, programmes, applications, emails, information systems, power lines, faxes and many more.

BEER has stated that a specific survey of the anastomotic reticulum is not practical due to its nature. Taking the examples from above into account, it is obvious that a post-correlation how all the different types proceed and the identification of the sender or receiver is clearly too complicated. For that reason containment is necessary in terms of the research topics' focus. Due to the absence of material and energy in business processes only information needs to be taken into account as a transmitted type. The containment of the mode of action turns out to be more precise than a separation into human or technological channel. Because the VPS and this research focuses on the harmonization potentials regarding IT-supported order processing activities, all information systems which have a relevant impact on the business process have to be distinguished. These distinguishable information systems build the so called primary systems (e.g. ERP-Systems, etc.). All other modes of connections which do not count as information systems by definition are gathered as the so called secondary systems (e.g. email applications, etc.). Hence, the object of research requires the distinction between the several information systems known as primary systems and secondary systems. Latter have not to be splitted further.

It is not necessary to determine how information finds its way from a sender to a receiver. Due to the conjunction of the business process analysis concept and recent applied information technology systems, the potential sender and receiver can be identified independently from time constraints. The nature of the anastomotic reticulum can be examined due to the selective choice of relevant observation objects. The relation between certain information and level of information can be studied by a comparison of the different information systems and secondary channels. Consequently, the reticulum has to be understood as the localization of enterprises harmonization potential.

This finding is the missing link which inhibited a holistic assessment of the harmonization potential so far. On the one hand the identification, categorization and assessment of potential benefits and costs become possible. On the other hand the consideration of the functional interdependencies between the various benefit dimensions ensures valid results.

References

1. Kernler, H.: PPS der 3. Generation: Grundlagen, Methoden, Anregungen. Hüthig, Heidelberg (1995)
2. Krcmar, H.: Informationsmanagement. Springer, Berlin (1997)
3. Schuh, G., Friedli, T., Kurr, M.A.: Kooperationsmanagement. Hanser, München (2005)
4. Arnold, B.: Strategische Lieferantenintegration. Dissertation Technische Universität Berlin. Deutscher Universitäts-Verlag, Wiesbaden (2004)
5. Lee, H.L.: Creating value through Supply Chain Integration. Supply Chain Management Review 4(4), 30–36 (2000)
6. Ihde, G.: Lieferantenintegration. In: Kern, W., Schröder, H.-H., Weber, J. (eds.) Handwörterbuch der Produktionswirtschaft: Enzyklopädie der Betriebswirtschaftslehre VIII, pp. 1086–1095. Schäffer-Poeschel Verlag, Stuttgart (1996)

7. Schuh, G.: Referenzstrategien in einer vernetzten Welt. In: Milberg, J., Schuh, G. (eds.) Erfolg in Netzwerken, pp. 17–34. Springer, Berlin (2002)
8. Schönsleben, P., Luczak, H., Nienhaus, J., Weidemann, M., Schnetzler, M., Roesgen, R.: Supply Chain Management: Monitoring-Lösungen auf dem Vormarsch. IT-Management 5, 10–17 (2003)
9. Busch, A., Lange, H., Langemann, T.: Marktstudie zum Collaborative Supply Chain Management. Heinz Nixdorf Institut, Paderborn (2002)
10. Möbus, D., Richter, G.: Stammdatenstrategie: Nur ein IT Thema? `http://www.cio.de/_misc/article/printoverview/index.cfm?pid=181&pk=851640&op=lst`
11. Rautenstrauch, T.: SCM-Integration in heterarchischen Unternehmensnetzwerken. In: Busch, A., Dangelmaier, W. (eds.) Integriertes Supply Chain Management, pp. 341–361. Gabler, Wiesbaden (2002)
12. Beer, S.: Kybernetik und Management. Fischer, Frankfurt (1959)
13. Schuh, G.: Produktionsplanung und –steuerung. Springer, Heidelberg (2006)
14. Retter, G.: Ein prozessorientiertes Wirtschaftlichkeitsanalyseverfahren zur Bewertung von Informationssystemen anhand strategischer Wirkungen. Dissertation RWTH Aachen (1996)
15. Ulrich, H.: Die Betriebswirtschaftslehre als anwendungsorientierte Sozialwissenschaft. In: Geist, N., Köhler, R. (eds.) Die Führung des Betriebes, Poeschel, Stuttgart, pp. S1–S15 (1981)
16. Hill, W., Fehlbaum, R., Ulrich, P.: Organisationslehre 1: Ziele, Instrumente und Bedingungen der Organisation sozialer Systeme, Haupt, Bern (1994)
17. Spiess, M.: Eine Methode zur Nutzenerfassung von Teleservice. Dissertation RWTH Aachen (2003)
18. Beer, S.: Brain of Firm. Wiley, Chichester (1981)
19. Beer, S.: Heart of Enterprise. Wiley, Chichester (1979)
20. Beer, S.: Diagnosing the system for organizations. Wiley, Chichester (1995)
21. Linß, H.: Integrationsabhängige Nutzeffekte der Informationsverarbeitung: Vorgehensmodell und empirische Ergebnisse. Deutscher Universitäts-Verlag, Wiesbaden (1995)
22. Schmidt, C.: Konfiguration überbetrieblicher Koordinationsprozesse in der Auftragsabwicklung des Maschinen- und Anlagenbaus, Dissertation RWTH Aachen (2008)
23. Brosze, T., Bauhoff, F., Stich, V.: High Resolution Supply Chain Management – Resolution of the polylemma of production by information transparency and organizational integration. In: Proceedings of the International IFIP TC 5, WG 5.7 Conference on Advances in Production Management Systems (APMS 2009). University of Bordeaux 1, Bordeaux (2009)
24. Brosze, T.: High Resolution Supply Chain Management. Unternehmen der Zukunft 10(1), 15–17
25. McCulloch, W.S.: Embodiments of Mind. MIT Press, Boston (1988)
26. Geyer, A.: The challenge of sustainable manufacturing – four scenarios 2015-2020. In: International Summer Academy on Technology Studies – Corporate Sustainability (2007)
27. Schuh, G.: Effiziente Auftragsabwicklung mit myOpenFactory. Hanser, München (2008)
28. Schmidt, C., Meyer, M.: Plug and do business – ERP of the next generation for efficient order processing in dynamic business networks. International Journal of Internet and Enterprise Management (IJIEM) 2(2), 152–162

Pragmatic Interoperability: A Systematic Review of Published Definitions

Camlon H. Asuncion and Marten J. van Sinderen

Center for Telematics and Information Technology (CTIT), University of Twente
P.O. Box 217, 7500 AE Enschede, The Netherlands
{c.h.asuncion,m.j.vansinderen}@utwente.nl

Abstract. Enabling the interoperability between applications requires agreement in the format and meaning (syntax and semantics) of exchanged data including the ordering of message exchanges. However, today's researchers argue that these are not enough to achieve a complete, effective and meaningful collaboration – the use of data (pragmatics) is important as well. Pragmatic interoperability requires mutual understanding in the use of data between collaborating systems. However, we observe that the notion of pragmatic interoperability is still largely unsettled, as evidenced by the various proposed definitions and the lack of a canonical understanding. Therefore, our objective is to contribute to a more thorough understanding of this concept through a *systematic review* of published definitions. Our results show that, indeed, various interpretations of pragmatic interoperability exist. Categorizing the derivable concepts from these definitions, we see two broad groups: *system* level and *business* level. Within each of these individual levels, we see some degree of agreement among the definitions. However, comparing the definitions across these levels, we observe no general agreement. At the system level, pragmatic interoperability essentially means sharing the same understanding of the intended and actual use of exchanged system message in a given context. At the business level, pragmatic interoperability goes beyond service use by considering also the compatibility of business intentions, business rules, organizational policies, and the establishment and maintenance of trust and reputation mechanisms between collaborating business parties.

Keywords: pragmatic interoperability, definitions, systematic review.

1 Introduction

Since the beginning of the 1980s, research towards the interoperability of enterprise applications has been steadily increasing [2]. The continued emergence and advances in networking, computing technologies and standards have stimulated this interest. On the one hand, organizations are exploring interoperability to build partnerships that add value to their products and services, and help explore new business opportunities. On the other hand, these advances also provide opportunities for organizations to new enable partnerships in ways that were not previously possible [8].

P. Bernus, G. Doumeingts, and M. Fox (Eds.): EAI2N 2010, IFIP AICT 326, pp. 164–175, 2010.

Interoperability means allowing one system to perform the operation of another [2]. Until now, interoperability has been understood in a largely layered fashion. A meaningful interoperation between enterprises can be achieved fully if it exists in all layers simultaneously: inter-enterprise coordination, business process integration, semantic application integration, syntactical application integration, and physical integration [3].

Currently, however, there are also researchers who advocate the importance of interoperability at the *pragmatic* layer. Using results from our research, we tentatively define pragmatic interoperability as the compatibility between the intended versus the actual effect of message exchange [7]. Thus, at the message level, mere agreement between the meanings (or semantics) of exchanged data and the structure (or syntax) which codifies these messages are not enough to achieve complete, effective, and meaningful collaboration. How data is used (or pragmatics) is also important and must, therefore, be mutually understood between collaborating systems.

However, we observe that the definition of pragmatic interoperability is still largely unsettled. Unlike syntactic and semantic interoperability definitions, a variety of pragmatic interoperability definitions are currently proposed, and there seems to be a lack of a canonical understanding. We argue that solutions not founded on a common understanding of pragmatic interoperability may lead to incompatible solutions. As we are currently developing a solution, we find it imperative to first explore the concept of pragmatic interoperability.

We expect to contribute to this understanding through a systematic review of published definitions. Although we aim at achieving consensus in this area, with the support from both the industry and academia, it is not the objective of this paper to propose a single definition but to gather existing definitions and review their key differences and similarities. To the best of our knowledge, no such review has yet been made. We hope that this paper can serve as a starting point towards a possible improvement in the understanding and communication between individuals and organizations working in pragmatic interoperability research, and ultimately, to aid in developing future solutions.

The rest of the paper is structured as follows: Section 2 describes the background to the concepts behind interoperability and pragmatic interoperability. Section 3 describes the review process we used to systematically gather published definitions. Next, Section 4 presents the search and analysis results that compares key concepts, similarities and differences of the identified definitions. Section 5 provides some analysis and discussion. Finally, Section 6 presents our conclusion and future work.

2 Background

By way of background, we briefly introduce the key terminologies of interoperability and pragmatic interoperability.

Interoperability. Several definitions of interoperability exist. The IEEE defines it as: "*the ability of two or more systems or components to exchange information and to use the information that has been exchanged*"[10]. ISO defines it as "*the capability to communicate, execute programs, or transfer data among various functional units in a* *manner that requires the user to have little or no knowledge of the unique characteristics of those units*"[11]. The Open Group defines it as "*the ability of systems to provide and receive services from other systems and to use the services so interchanged to enable them to operate effectively together*"[12]. Researchers in enterprise interoperability define it as: "*the ability for two systems to understand one another and to use functionality of one another*"[2]. And, in the context of Service Oriented Architectures: "*the ability of the software systems to use each other's software services*"[7]. Summarizing, interoperability allows some form of interaction between two or more systems so as to achieve some goal without having to know the uniqueness of the interacting systems [7].

Pragmatic interoperability. At this stage, we briefly introduce pragmatic interoperability based on our own research so as to give some background information.

Merriam-Webster's dictionary defines *pragmatics* or *pragmatism* as *to do*, *to act,* or *to be practical* from the word's Greek etymology *pragmatikos* or *pragma*.

In Information Systems research, most studies that apply pragmatism seem to draw their theoretical foundation from the Theory of Signs (Semiotics) of Charles Morris [5] where he discusses human interpretation over (non-)linguistic signs. Morris sees Semiotics (in Greek: interpreter of signs) as that which is comprised of three basic components: *syntactics* (or syntax), *semantics*, and *pragmatics*. Syntax deals with the abstract study of signs and their formal relation to one another *without* regard to their meaning and use. Semantics reifies syntactic elements of signs by adding meaning but *not* use. Finally, pragmatics encapsulates both syntax and semantics for the purposeful *use* of signs [1]. Specifically in Morris' terms: syntax is that which acts as a sign (the *sign vehicle*), semantics is that which the sign refers to (the *designatum*), and pragmatics is the effect of the sign on the interpreter (the *interpretant*) [5, p.3].

Pragmatic principles in linguistic communication also apply to the interoperability of systems. In order to allow systems to interoperate, the *communication* between them must therefore take place achieved through *message exchange*. Messages contain *data* that represent the *properties or values* about the *entities or phenomena* of the message's *subject domain* (i.e. that part of the world that the message is about).

However, it is not always the case that collaborating systems have a common manner of codifying, understanding, and using the data that is exchanged. The difference can also be viewed in three layers: syntactic, semantic, and pragmatic.

- To ensure *syntactic interoperability*, collaborating systems should have a compatible way of structuring data during exchange; i.e., the manner in which data is be codified using a grammar or vocabulary is compatible.
- To ensure *semantic interoperability*, the meaning of the syntactic elements should be understood by collaborating systems; i.e.; they share the same meaning of the data in relation to the entity or phenomena it represents in the real world.
- Finally, to ensure *pragmatic interoperability*, message sent by a system causes the *effect* intended by that system; i.e., the intended effect of the message is understood by the collaborating systems. Pragmatic interoperability can only be achieved if systems are also syntactically and semantically interoperable [7].

3 Review Process

To allow for a rigorous search of definitions, we use the *procedures for adopting systematic reviews* proposed by Kitchenham [4]. A systematic review consists of a research protocol which details the rationale of the survey, research questions, search strategy, selection criteria, synthesis and analysis of the extracted data. Such a review procedure is appropriate for our purpose since, as Kitchenham argues, it summarizes existing evidence, identifies gaps in current research and areas for further investigation, and provides a background in which to position new research objectives. In our case, we summarize current evidence in pragmatic interoperability research by surveying their definitions and identifying gaps for further research through an analysis of their similarities and differences. Figure 1 describes the review process graphically.

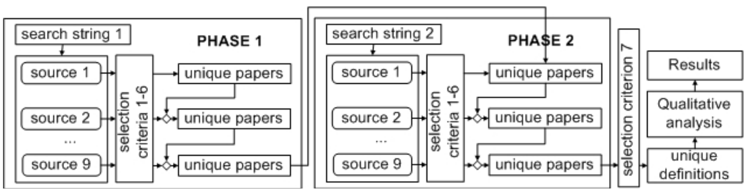

Fig. 1. Summary of the review process

We design the research to proceed in two phases. For each phase, we use a different search string (one broad and one narrow) to search for relevant papers. The search strings are used consistently over the same set of electronic indexing sources. From the hits returned by each source, we use a set of predefined *selection criteria* to manually identify papers that were both unique and relevant. To obtain only unique papers, we exclude a paper that has already been identified from a previously searched source regardless of the phase (i.e. they have the same paper title). Additionally, we manually looked into the references of selected papers which cite other authors to identify more definitions of pragmatic interoperability. We do this repeatedly – applying the same selection criteria –until no other referenced paper seem relevant. Finally, from the set of unique papers identified, we perform a qualitative analysis to draw key concepts and categories. The search was conducted from November 17, 2009 to January 31, 2010. One of us prepared the review protocol independently while the other reviewed and criticized it before the actual search began.

Research questions. Kitchenham[4] suggests that the structures of research questions should be divided into *population*, *intervention* and *outcomes*. We treat the population in our review as those pragmatic interoperability definitions proposed by various authors. Our intervention involves extraction, synthesis, and analysis of key concepts from these definitions. The outcome that is of interest to us is the similarities and differences between these definitions. Our research questions are thus: (i) What proposed definitions describing the notion of pragmatic interoperability can be found in the existing literature? (ii) What are the key concepts in these definitions? (iii) In what ways are the definitions similar or different?

Search strategy. We conduct the search in two phases. The *first phase* searches for relevant papers as exhaustively as possible. We do this by using a search string whose main keywords included synonyms and word class variations. A preliminary search helped identify synonyms using the main keywords "*pragmatic*" and "*interoperability*", with additional help from a dictionary and thesaurus. For example, together with the main keyword "*interoperability*" we include its noun, adjective and verb forms; however, we do not add synonyms to the keyword "*pragmatic*" but add only its noun variation. The phase 1 search string is thus:

```
(pragmatic OR pragmatism) AND (interoperate OR
interoperability OR interoperable OR interoperation
OR integrate OR integration OR collaborate OR
collaboration OR cooperate OR cooperation OR connect
OR connection OR communicate OR communication OR
exchange OR coalition)
```

The goal of the *second phase* is to make the search more restrictive, narrow and focused. The phase 2 search string is thus:

```
pragmatic AND interoperability
```

For each phase, we apply the search strings consistently over nine electronic indexing sources (searched in the following order): (i) *Google Scholar* (scholar.google.com), (ii) *Scopus* (www.scopus.com), (iii) *ISI Web of Knowledge* (apps.isiknowledge.com), (iv) *CiteseerX* (citeseerx.ist.psu.edu), (v) *Compendex* (www.engineeringvillage2.org), (vi) *ScienceDirect* (www.sciencedirect.com), (vii) *IEEEXplore* (ieeexplore.ieee.org), (viii) *ACM Digital Library* (portal.acm.org), and (ix) *Springer Link* (www.springerlink.com), sorting each search result by *relevance*.

Selection criteria. For each search phase, we devise and apply the same set of *selection criteria* to retrieve papers. The criteria include, *in general*: (i) limited to journals, conferences (proceedings), workshop papers, including technical reports, theses, and books or book chapters; (ii) written in English; (iii) regardless of publication date; (iv) within the computer science discipline; (v) *in particular*, it must explicitly contain text that defines (or attempts to define, propose, suggest, or describe) pragmatic interoperability found either in the abstract or body of the paper; (vi) proposed by original author(s); and (vii) in the case of similar definitions by the same (set of) original author(s), the most informative and descriptive definition (so not necessarily the latest). We used the first six criteria to extract candidate papers from the nine sources and the final criterion to arrive at the final set of definitions from the candidate papers for qualitative analysis.

Qualitative Analysis. From the total set of selected unique definitions, we analyze their differences and similarities using *open coding* – a component of the *constant comparative method of analysis* proposed by Strauss and Corbin [9]. Open coding is the process of analyzing data (which in our case are texts containing the definitions) by *conceptualizing* and *categorizing* them. Conceptualization requires breaking down, examining, comparing and *labeling* data according to some discrete happenings, ideas, events, or other phenomena. Categories *group* concepts which pertain to a similar phenomenon at a more abstract level. We use a qualitative analysis software called NVivo 8 [5] from QSR International to facilitate the coding process and to perform additional analysis. One of us performed the actual coding while the other reviewed and criticized the results.

4 Results

All in all, we identify 101 relevant and unique papers. From these, 43 papers are from the first phase, and 58 from the second. The 101 papers are unique in the sense that they do not have the same titles. However, it may be the case that they may have the same, or slightly similar, definitions from the same (set of) author(s). Thus, by applying the final selection criterion (*c.f.* Section 3), we arrive at the final set of unique definitions from 44 papers. These papers are the basis for the qualitative analysis using open coding that later followed. Table 1 shows the comparison between the *key concepts* derived from definitions of the selected 44 papers. The proposed categorizations of these concepts are discussed in Section 5.

Table 1. Summary of open coding analysis[1]

Authors	Year	System level			Business level					
		Message intention	Message exchange	Message use	Context	Business requirements	Business collaboration	Business use	Business trust	Business willingness
Pokraev [7]	2009	✓	✓	✓						
Roukolainen [13]	2009					✓	✓		✓	✓
Seo, et al. [14]	2009	✓	✓	✓	✓					
Mingxin, et al. [15]	2009	✓	✓	✓						
Liu [16]	2009	✓	✓	✓	✓					
Bravo, et al. [17]	2009	✓	✓	✓	✓					
Sheping, et al. [18]	2009	✓	✓	✓	✓					
Vilches-Blázquez, et al. [19]	2009				✓					
Tolk, et al. [20]	2008		✓	✓	✓					
Boxer, et al. [21]	2008	✓	✓	✓	✓					
Leuchter, et al. [21]	2008	✓	✓	✓						
Dehmoobad, et al. [23]	2008					✓	✓	✓		
Ballari, et al. [24]	2008	✓	✓	✓						
Ruohomaa [25]	2007					✓	✓		✓	✓
de Moor [26]	2007				✓					
Elkin, et al. [27]	2007				✓					
Dagienė, et al. [28]	2007	✓	✓	✓						
Rukanova, et al. [29]	2006					✓	✓	✓		
Legner, et al. [30]	2006				✓	✓	✓	✓		
Paterson, et al. [31]	2006	✓	✓	✓						
Tamani, et al. [32]	2006	✓	✓	✓	✓					
Agerri, et al. [32]	2005	✓	✓	✓	✓					
Wenzel, et al. [34]	2005				✓	✓	✓	✓		
Schade, et al. [35]	2005	✓	✓	✓	✓					
Artyshchev, et al. [36]	2005	✓	✓	✓	`					
Bazijanec, et al. [37]	2005	✓	✓	✓						

[1] Due to lack of space, the list of selected definition and its summary are given in http://wwwhome.cs.utwente.nl/~asuncionch/research/pi/pi_definition_search_results.htm

Table 1. (*continued*)

Bentahar [38]	2005	✓	✓	✓						
Chun, et al. [39]	2004	✓	✓	✓	✓					
Goossenaerts [40]	2004	✓	✓		✓					
Karasavvas, et al. [41]	2004	✓	✓	✓						
Hofmann [42]	2004	✓	✓	✓	✓					
Zimmerman [43]	2003	✓	✓	✓						
Singh [44]	2000	✓	✓		✓					
Phillips, et al. [45]	2002				✓	✓	✓	✓		
Euzenat [46]	2001				✓					
Huber, et al. [47]	2000		✓	✓						
Labrou, et al. [48]	1999	✓	✓	✓						
Ingenerf [49]	1999		✓	✓	✓					
Wang, et al. [50]	1999	✓	✓						✓	
Bradshaw, et al. [51]	1999	✓	✓	✓	✓					
Cerri [52]	1999	✓	✓	✓						
Gristock [53]	1998				✓					
Gitt [54]	1989	✓	✓	✓						
Werner [55]	1988	✓	✓		✓					

5 Discussion

Although, in general, we see no agreement among the definitions, we observe that if the definitions are grouped broadly into two categories – *system* and *business levels* – then we some reasonable agreement. By system level, we mean that the interaction is mostly between applications through the exchange of messages. By business level, we mean that the collaboration is mostly between organizations, business units, business processes, or even human actors [30]. Our results also show that much research emphasis has been given towards the system level and only a little at the business level (e.g. [13,23,25,29,30,34,45]).

At the **system level**, four key concepts consistently arise: *message intention*, *message exchange*, *message use*, and *context*.

- A message is sent with some intention. Some authors use the term 'goals' [39,40], purpose [16], 'needs' [40], 'preferences' [18], 'desired actions' [42], or 'reasoning behind the message' [35]. A message intention contains what the sender expects the effect of the message will be or the intended use of data on the receiver.
- To realize the sender's message intention, the message must first be sent to the receiver in some automated way. This requires that message exchange must therefore take place. This is important as interoperability, by definition, requires communication between systems. We observe that all definitions at the system level consider this to be an important concept, whether stated explicitly or implicitly.
- Message use is about how a receiver interprets the intention of the communicated information on message receipt. Some authors call this generally as the *effect* the message has on the receiver (e.g. [7,31]). The actual effect of the message must thus be compatible with its desired intention. This demands from the receiver thorough understanding of the intention of the received message; i.e., the intended interpretation and use are clear (e.g. [14,16,17,18,20] among others).

- The importance of context in the use, interpretation and understanding of the message is regarded by most authors as a core concept in pragmatic interoperability. It should not be the case that messages are used arbitrarily; a message has to be used in a certain context. The complete pragmatic meaning of a message varies, depending on the context in which it is used (e.g. [20,16,14,30,32]). Therefore, to achieve pragmatic interoperability, at least at the system level, the intention of the message and its use in a given context are understood by the collaborating parties; i.e., context is mutually shared [20]. Although some authors closely relate use and context (e.g. [20,16,14,32]), we separate them here as some authors are unclear as to their relation (e.g. [7,21,28,31]).

  We notice also that there seems to be a lack of discussion and agreement as to what constitutes context in terms of its properties and dimensions in relation to pragmatic interoperability. Some authors do provide insights. Liu [16] says context is "*where communication takes place. [It is] constantly and dynamically formed, deformed, configured and re-configured, and that […] different behaviors can result [in] different results under different context[s]*". Tolk [20] describes context as "*both the state that the system is in at the time the [data] element is being employed, as well as a specification of the particular system process that will employ the [data] element. If any of these things change (either the system state, or the particular process), then the meaning of the element might be different*".

Thus, summarizing, some authors believe that pragmatic interoperability, at the system level, is achieved if collaborating systems share the same intention of message use (e.g. [17,21]). Other authors emphasize the role of context beyond message use; i.e., pragmatic interoperability is achieved if collaborating systems share not only the same understanding of the intended use of data, but also the same context in which the message is (to be) applied (e.g. [14,20]). In a broader sense, we can consider that message use and the context where the use occurs together constitute the expected effect that must be both understood by collaborating systems (e.g. [7,16,31]).

At the **business level**, four main key concepts seem to arise consistently: *business requirements*, *business collaboration*, *business use*, and *context*.

- Business requirements encompass the business's autonomic intentions expressed through business rules, organizational policies [13], definition of responsibilities [23] and required business processes, specifications of the roles, and the definition of security services and authorization [34] needed for collaboration. The business requirements not only emphasize what the collaboration is about but also what the underlying business intentions are [29,45].
- Like message exchange at the system level, business collaboration at the business level is also a prerequisite of pragmatic interoperability. This not only deals with continuous communication between business parties [32] but also entails negotiation [13,32] (e.g. expressed through collaboration contracts [13] including the execution and monitoring of responsibilities and agreements (such as through Service Level Agreements)[23]).
- Business use is an indication of how business parties use their shared services [23], how communicated information is received, interpreted [29], understood and used by partners [29,30], including who executes the communicated information [45].

- Similar to the system level, some argue that a shared understanding of background or context between the collaborating parties is also important to establish pragmatic interoperability at the business level. Context here includes the different professional, social, or cultural backgrounds of the collaborating business parties [32] relevant to the communication, or the sharing of the same physical space, same timeframe, and capabilities of collaborating parties [53].
- Aside from the four concepts outlined earlier, other authors also emphasize *trust*, *reputation* and *willingness* of collaborating partners as equally important prerequisites for pragmatic interoperability that must be established before and maintained during the collaboration [13,25,50]. Trust management looks at whether business parties trust one other enough to want to start a collaboration. Furthermore, the trust needed to start the collaboration may evolve over time and may be different for new parties joining. Business parties may also belong to different cultural norms and may follow different legislation that dictate how trust is to be established between them [25].

Thus, summarizing, pragmatic interoperability at the business level exists if there is compatibility between the business requirements of collaborating parties expressed through their business intentions, business rules, and organizational policies [13]. Collaborating parties should also have a shared understanding of the services they offer [30] and the context in which these services are to be used [32,29]. Beyond these, they should also establish beforehand and maintain during collaboration trust, willingness, and reputation-related issues [13,29].

6 Conclusion and Future Work

This paper explores the notion of pragmatic interoperability as it is understood today. As the understanding of the term is still largely unsettled, this paper aims to contribute to a more thorough understanding of the term through a systematic review of currently published definitions.

Our results show that, indeed, various interpretations of pragmatic interoperability exist. Categorizing the concepts from these definitions, we see two broad groups: system level and business level. Within these individual levels, we see some degree of agreement among the definitions. However, comparing the definitions across these levels, we observe no general agreement. At the system level, pragmatic interoperability involves sharing a common understanding and expectation in the use of data in a particular context (where context of use is much emphasized). At the business level, pragmatic interoperability entails a shared understanding of the use of services offered as applied in a given context. Beyond service use, collaborating parties should be compatible in terms of business intentions, business rules, organizational policies, including the establishment and maintenance of the trust and reputation mechanisms.

However, there still remain some key concepts that need to be further explored such as the notion of context in pragmatic interoperability. Although many authors argue favorably of its importance, we observe that there is still a lack of discussion and agreement especially at the business level where treatment is rudimentary. We ask, how should context be understood at either business or system level, and how does one influence the other particularly in pragmatic interoperability?

Additionally, the separation between the business level and system level needs a more thorough investigation in terms of their alignment. How can this alignment be achieved? What potential benefits and challenges can this alignment bring forth? In the end, we argue that to allow businesses to fully take advantage of pragmatic interoperability approaches, the system level and business level should be properly aligned.

At a much wider perspective, are the concepts of pragmatic interoperability presented in this paper currently addressed by solutions, approaches, frameworks or methodologies? If they do, to what extent are they able to do so? Are current languages or notations able to sufficiently express or model pragmatic interoperability requirements and solutions? If not, what new concepts have to be added to these languages or notations? These are just some of the important questions that will drive our future work in pragmatic interoperability research.

References

1. Allywood, J.: A Bird's Eye View of Pragmatics. In: 4th Scandinavian Conf. on Linguistics, pp. 145–159. Odense University Press (1978)
2. Chen, D., Doumeingts, G., Vernadat, F.: Architectures for Enterprise Integration and Interoperability: Past, Present and Future. Computers in Industry 59, 647–659 (2008)
3. Chen, D., Doumeingts, G.: European Initiatives to Develop Interoperability of Enterprise Applications – Basic Concepts, Framework and Roadmap. Annual Reviews in Control 27, 153–162 (2003)
4. Kitchenham, B.A.: Procedures for Performing Systematic Reviews. Technical Report TR/SE-0401, Keele University, and Technical Report 0400011T.1, NICTA (2004)
5. Morris, C.W.: Foundations of the Theory of Signs. University of Chicago Press, Chicago (1938)
6. NVivo v8, QSR International, `http://www.qsrinternational.com/products_nvivo.aspx`
7. Pokraev, S.V.: Model-Driven Semantic Integration of Service-Oriented Applications. PhD thesis, University of Twente (2009)
8. van Sinderen, M.J.: Challenges and Solutions in Enterprise Computing. Enterprise Information Systems 2, 341–346 (2008)
9. Strauss, A., Corbin, J.M.: Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory. Thousand Oaks, California (1998)
10. Institute of Electrical and Electronics Engineers (IEEE): IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries (1990)
11. ISO/IEC 2382-1:1993 Information Technology – Vocabulary – Part 1: Fundamental terms. International Organization for Standardization, ISO (1993)
12. The Open Group, http://www.opengrouporg/architecture/togaf8doc/arch/chap36.html
13. Roukolainen, T.: Modeling Framework for Interoperability Management for Collaborative Computing Environments. Licentiate Thesis, University of Helsinki (2009)
14. Seo, C., Zeigler, B.P.: DEVS Namespace for Interoperable DEVS/SOA. In: 2009 Winter Simulation Conf., pp. 1311–1322 (2009)
15. Mingxin, G., Lily, S.: Dynamic Convergence of Business and IT Systems Through Enterprise Isomorphic Architecture. In: 2009 Int. Conf. on Information Technology and Computer Science, vol. 1, pp. 366–369. IEEE Computer Society, Los Alamitos (2009)

16. Liu, K.: Pragmatic Computing – Semiotic Perspective to Web Services. In: 4th Int. Conf. on E-business and Telecommunications, vol. 23, pp. 3–15. Springer, Berlin (2009)
17. Bravo, M., Alvarado, M.: On the Pragmatic Similarity Between Agent Communication Protocols: Modeling and Measuring. In: On the Move to Meaningful Internet Systems: OTM 2008 Workshops, pp. 128–137. Springer, Berlin (2009)
18. Sheping, Z., Zengzhi, L., Juanli, W.: Negotiation Between Requester and Provider Based on Pragmatics Web Service. In: 2009 WRI Int. Conf. on Communications and Mobile Computing, vol. 3, pp. 583–587. IEEE Computer Society, Los Alamitos (2009)
19. Vilches-Blázquez, L.M., Corcho, O.: A Heuristic Approach to Generate Good-Quality Linked Data About Hydrography. In: 20th Int. Workshop on Database and Expert Systems Application, Linz, Austria, pp. 99–103. IEEE Computer Society, Los Alamitos (2009)
20. Tolk, A., Turnitsa, C., Diallo, S.: Implied Ontological Representation within the Levels of Conceptual Interoperability Model. Intelligent Decision Technologies 2, 3–19 (2008)
21. Boxer, P., Morris, E., Anderson, W., Cohen, B.: Systems-of-Systems Engineering and the Pragmatics of Demand. In: 2nd Annual IEEE Systems Conf., Canada (2008)
22. Leuchter, S., Mühlenberg, D., Schönbein, R.: Agent-Based Web for Information Fusion in Military Intelligence, Surveillance, and Reconnaissance. In: 2008 IEEE Int. Conf. Systems, Man and Cybernetics, pp. 3732–3737. IEEE Computer Society, Los Alamitos (2008)
23. Dehmoobad, A., Sartipi, K.: Minimized Domain Knowledge for SOA-Based Interoperability. In: IEEE Asia-Pacific Services Computing Conf., pp. 500–506 (2008)
24. Ballari, D., Manso-Callejo, M.A., Wachowicz, M.: The Interoperability of Wireless Sensor Networks. In: Sensors 2008, vol. 9, pp. 3635–3651 (2008)
25. Ruohomaa, S.: Trust Management for Inter-enterprise Collaborations. In: Web Proceedings of the I-ESA 2007 Doctoral Symposium, Portugal (2007)
26. de Moor, A.: The Pragmatic Evaluation of Tool System Interoperability. In: 2nd Conceptual Structures Tool Interoperability Workshop, pp. 1–19 (2007)
27. Elkin, P.L., Froehling, D., Bauer, B.A., Wahner-Roedler, D., Rosenbloom, S.T., Bailey, K., Brown, S.H.: Aequus Communis Sententia: Defining Levels of Interoperability. Studies in Health Technology and Informatics 129, 725–729 (2007)
28. Dagienė, V., Kurilovas, E.: Design of Lithuanian Digital Library of Educational Resources and Services: The Problem of interoperability. Information Technologies and Control 36, 402–411 (2007)
29. Rukanova, B., van Slooten, K., Stegwee, R.A.: Towards a Meta-model for Describing Communication: How to Address Interoperability on a Pragmatic Level. In: Enterprise Information Systems VI, pp. 203–210 (2006)
30. Legner, C., Wende, K.: Business Interoperability Framework, `http://www.alexandria.unisg.ch/EXPORT/DL/39432.pdf`
31. Paterson, G.I., Soroka, S.D.: Formative Evaluation of the Clinical Pragmatic Attributes of Components Chosen for a Boundary Infostructure. In: 11th Int. Symp. on Health Information Management Research (2006)
32. Tamani, E., Evripidou, P.: A Pragmatic and Pervasive Methodology to Web Service Discovery. In: OTM 2008 Workshops, pp. 1285–1294. Springer, Berlin (2006)
33. Agerri, R., Alonso, E.: Semantics and Pragmatics for Agent Communication. In: 12th Portuguese Conf. on Artificial Intelligence, pp. 524–535. Springer, Berlin (2005)
34. Wenzel, S., Jessen, U., Bernhard, J.: Classifications and Conventions Structure the Handling of Models within the Digital Factory. Computers in Ind. 56, 334–346 (2005)
35. Schade, U.: Towards the Edge and Beyond: The Role of Interoperability. In: 10th International Command and Control Research and Technology Symposium (2005)

36. Artyshchev, S., Weigand, H.: Contract-based Interoperability for e-Business Transactions. In: 2005 Interoperability of Enterprise Software and Applications, pp. 173–184. Springer, London (2005)
37. Bazijanec, B., Zaha, J.M., Albani, A., Turowski, K.: Establishing Interoperability of Coordination Protocols in Ad Hoc Inter-Organizational Collaborations. In: 1st INTEROP-ESA 2005, pp. 126–136 (2005)
38. Bentahar, J.: A Pragmatic and Semantic Unified Framework for Agent Communication. PhD Thesis, Laval University, Canada (2005)
39. Chun, S.A., Lee, Y., Geller, J.: Ontological and Pragmatic Knowledge Management for Web Service Composition. In: 9th Int. Conf. on Database Systems for Advanced Applications, pp. 365–373. Springer, Heidelberg (2004)
40. Goossenaerts, J.: Interoperability in the Model Accelerated Society. In: Presentation at the eChallenges Conf., Austria (2004)
41. Karasavvas, K.A., Baldock, R., Burger, A.: Bioinformatics Integration and Agent Technology. J. Biomed. Inform. 37, 205–219 (2004)
42. Hofmann, M.A.: Challenges of Model Interoperation in Military Simulations. Simulation 80, 659–667 (2004)
43. Zimmermann, B.: Integrated Army Modeling and Simulation Data Network. Paper #08, NATO Report RTO-MP-123: C3I and M&S Interoperability, Turkey (2003)
44. Singh, M.P.: A Social Semantics for Agent Communication Languages. In: Issues in Agent Communication, pp. 31–45. Springer, Berlin (2000)
45. Phillips Jr., C.E., Ting, T.C., Demurjian, S.A.: Information Sharing and Security in Dynamic Coalitions. In: 7th ACM Sym. on Access Control Models and Technologies, Monterey, pp. 87–96 (2002)
46. Euzenat, J.: Towards a Principled Approach to Semantic Interoperability. In: Workshop on Ontologies and Information Sharing (2001)
47. Huber, T., Alt, R., Österle, H.: Templates – Instruments for Standardizing ERP Systems. In: 33rd Hawaii Int. Conf. on Science Systems, Maui, Hawaii (2000)
48. Labrou, Y., Finin, T.: History, State of the Art and Challenges for Agent Communication Languages. INFORMATIK - Zeitschrift der schweizerischen Informatik organisationen 7, 17–24 (1999)
49. Ingenerf, J.: Telemedicine and Terminology: Different Needs of Context Information. IEEE Trans. Inf. Technol. Biomed. 3, 92–100 (1999)
50. Wang, I., Liu, C., Conradi, R.: A Multi-Agent Architecture for Cooperative Software Engineering. In: 11th Int. Conf. on Software Engineering and Knowledge Engineering, Germany, pp. 1–22 (1999)
51. Bradshaw, J.M., Greaves, M., Holmback, H., Karygiannis, T., Jansen, W., et al.: Agent for the Masses? IEEE Intelligent Systems, 53–63 (1999)
52. Cerri, S.A.: Shifting the Focus from Control to Communication: the STReams OBjects Environments Model of Communicating Agents. In: Collaboration between Human and Artificial Societies, Coordination and Agent-Based Distributed Computing, pp. 74–101. Springer, Berlin (1999)
53. Gristock, J.J.: Organisational Virtuality: A Conceptual Framework for Communication in Shared Virtual Environments. In: MIT Media Lab/University College London workshop Presence in Shared Virtual Environments, Ipswich (1998)
54. Gitt, W.: Information: The 3rd Fundamental Quantity. Siemens Rev. 6, 36–41 (1989)
55. Werner, E.: Toward a Theory of Communication and Cooperation for Multi-Agent Planning. In: 2nd Conf. Theoretical Aspects of Reasoning About Knowledge, pp. 129–144 (1988)

Author Index