

Intelligent Systems Reference Library

Volume 111

Series editors

Janusz Kacprzyk, Polish Academy of Sciences, Warsaw, Poland
e-mail: kacprzyk@ibspan.waw.pl

Lakhmi C. Jain, University of Canberra, Canberra, Australia;
Bournemouth University, UK;
KES International, UK
e-mails: jainlc2002@yahoo.co.uk; Lakhmi.Jain@canberra.edu.au

About this Series

The aim of this series is to publish a Reference Library, including novel advances and developments in all aspects of Intelligent Systems in an easily accessible and well structured form. The series includes reference works, handbooks, compendia, textbooks, well-structured monographs, dictionaries, and encyclopedias. It contains well integrated knowledge and current information in the field of Intelligent Systems. The series covers the theory, applications, and design methods of Intelligent Systems. Virtually all disciplines such as engineering, computer science, avionics, business, e-commerce, environment, healthcare, physics and life science are included.

More information about this series at <http://www.springer.com/series/8578>

Eman El-Sheikh · Alfred Zimmermann
Lakhmi C. Jain
Editors

Emerging Trends in the Evolution of Service-Oriented and Enterprise Architectures

Editors

Eman El-Sheikh
Center for Cybersecurity
University of West Florida
Pensacola, FL
USA

Alfred Zimmermann
Hochschule Reutlingen
Reutlingen
Germany

Lakhmi C. Jain
KES International
Leeds
UK

and

University of Canberra
Canberra, ACT
Australia

and

Bournemouth University
Poole
UK

ISSN 1868-4394 ISSN 1868-4408 (electronic)
Intelligent Systems Reference Library
ISBN 978-3-319-40562-9 ISBN 978-3-319-40564-3 (eBook)
DOI 10.1007/978-3-319-40564-3

Library of Congress Control Number: 2016942895

© Springer International Publishing Switzerland 2016

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made.

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG Switzerland

Foreword

Almost 25 years ago Henderson and Venkatraman were writing “*Even though the information technology has evolved from its traditional orientation and administrative support toward a more strategic role within an organization, there is still a glaring lack of fundamental frameworks within which to understand the potential of IT for tomorrow’s organizations*” (IBM Systems Journal 32(1), 1993). Targeting to master this challenging issue, they developed a model, strategic alignment model, and derived four perspectives of alignment with specific impacts for guiding management practices in order to “*leverage IT for transforming organizations.*”

More recent technologies and paradigms (such as cloud computing, big data, IoT) show that not the ownership of IT resources but their strategic management is the foundation for sustainable competitive advantage, as it was earlier defended by Mata, Fuerst, and Barney (MIS Quarterly, 1995).

A decade ago, Ross, Weill, and Robertson in their book “Enterprise Architecture as Strategy: Creating a Foundation for Business Execution” (2006) illustrated through numerous companies worldwide, how constructing the right enterprise architecture enhances profitability and time to market, improves strategy execution, and even lowers IT costs.

Enterprise architecture (EA) aimed (i) to understand the interactions and all kinds of articulations between business and IT, (ii) to define how to align business components and IT components, as well as business strategy and IT strategy, and more particularly (iii) to develop and support a common understanding and sharing of those purposes of interest. EA is also used to map the enterprise goals and strategy to the enterprise’s resources (actors, assets, and IT supports) and to manage the evolution of this mapping.

Services are the governing principle for EA. Nearly all newly created EAs are service-oriented. Service-oriented enterprise architecture (SoEA) easily integrates widespread technological approaches such as SOA or emerging ones as cloud computing because they also use service as structuring and governing paradigm. The scope of SoEA is much broader than the scope of the SOA and also includes services not accessible through software such as business services and infrastructure

services. Services of different purposes and granularities may be interconnected in service (value) nets to provide higher-level services.

Today, foundations of social computing influence EA in new ways. The senior management defines organizational structures no longer alone, but weak ties that are initiated by individuals superimpose the organization. Innovation is no longer a process guided by an elite, but can be initiated by every member of an organization. Decisions are no longer only made by experts, but are also results of collaborative processes. Big data technologies allow to process data with higher velocity, variety, and volume and to create new information flows and data services within EAs.

EA is positioned as a coordination and steering mechanism and as an instrument to support the strategic direction of digital enterprises, which new frontiers require permeability and which new structures require elasticity. The service paradigm and the underlying mechanisms offer an accelerator for nurturing the elasticity of EAs and that of the enterprises themselves, to allow them to survive in evolving business ecosystems. In this context, service ecosystems offer a new land of application for the Nash equilibrium.

The new challenges for the “design by reuse” of modern IT solutions (recommended to be built in shorter cycles), in accordance with SOA and EA frameworks, impose in turn new challenges to the “design for reuse.” The latter should (i) handle the potential components (services), in terms of abilities to satisfy functional business requirements in manyfold contexts and also (ii) deal with new capabilities for mastering nonfunctional requirements, such as flexibility, maintainability, and trustworthiness, which may themselves be variable in different contexts.

The twelve chapters of this book all together present challenging issues and hot topics related to the emerging trends in the evolution of service-oriented and enterprise architectures, as the evolution of EAs and systems, the flexibility, the maintainability, the security of the underlying software solutions and infrastructures, the digital transformation, the capability management, the forecasting of service demands, the conciliation of resilient and stable parts of EA, which are essential for the integrity of transactions and reliability of systems, with a fast-speed-architecture offering channels that are pivotal for the customer experience. As advocated by one of the contributors, “*Digital Transformation sets a new challenge for the enterprise architect: she has now not just to align the IT with the demands from the business but to enable and even invent new business opportunities. So the architecture capability of an organization gets an active part in shaping the business*”.

Selmin Nurcan
University Paris 1 Panthéon-Sorbonne

Preface

This research oriented book presents emerging trends in the evolution of Service-Oriented and Enterprise architectures. New architectures and methods of both business and IT are integrating services to support mobility systems, Internet of Things, Ubiquitous Computing, collaborative and adaptive business processes, Big Data, and Cloud ecosystems. They inspire current and future digital strategies and create new opportunities for the digital transformation of next digital products and services. Service-Oriented Architectures (SOA) and Enterprise Architectures (EA) have emerged as useful frameworks for developing interoperable, large-scale systems, typically implementing various standards, like Web Services, REST, and Microservices. Managing the adaptation and evolution of such systems presents a great challenge. Service-Oriented Architectures enable flexibility through loose coupling, both between the services themselves and between the IT organizations that manage them. Enterprises evolve continuously by transforming and extending their services, processes and information systems. Enterprise Architectures provide a holistic blueprint to help define the structure and operation of an organization with the goal of determining how an organization can most effectively achieve its objectives. This book presents several novel approaches to address the challenges of the service-oriented evolution of digital enterprise and software architectures.

The book is directed to the researchers, postgraduate, graduate and undergraduate students, professors and practitioners who are interested in the service-oriented evolution of digital enterprise and software architectures.

We are grateful to the contributors and reviewers for their very valuable expertise and contributions without which this book would not have existed. We wish to show our appreciation to Springer-Verlag for their support right from the concept development to the final typesetting phase of this book.

The unconditional support provided by our universities is acknowledged.

USA

Germany

Australia

Eman El-Sheikh

Alfred Zimmermann

Lakhmi C. Jain

Contents

1	Evolution of Service-Oriented and Enterprise Architectures: An Introduction	1
	Eman El-Sheikh, Alfred Zimmermann and Lakhmi C. Jain	
1.1	Introduction	1
	References	3
2	Approaches to the Evolution of SOA Systems	5
	Norman Wilde, Bilal Gonen, Eman El-Sheikh and Alfred Zimmermann	
2.1	Introduction	5
2.2	Perspectives on Software Evolution	6
2.2.1	Design for Evolvability	7
2.2.2	Support for Evolution	7
2.3	Design for Evolvability Approaches to SOA	8
2.4	Support for Evolution Approaches to SOA	10
2.4.1	Code Level Approaches to SOA Evolution	10
2.4.2	Service Interaction Level Approaches to SOA Evolution	11
2.4.3	Model Level Approaches to SOA Evolution	13
2.5	Emerging Trends	16
2.5.1	Microservices and Design for Evolvability	16
2.5.2	Knowledge-Based Support	16
2.6	Concluding Remarks	18
	References	18
3	Flexible and Maintainable Service-Oriented Architectures with Resource-Oriented Web Services	23
	Michael Gebhart, Pascal Giessler and Sebastian Abeck	
3.1	Introduction	23
3.2	Fundamentals	25
3.2.1	SOAP	25
3.2.2	REST	26

3.2.3	Quality Model	27
3.3	Scenario	28
3.4	Quality Indicators for Resource-Oriented Web Services	29
3.4.1	Unique Categorization	30
3.4.2	Loose Coupling	32
3.4.3	Discoverability.	34
3.4.4	Autonomy	36
3.5	Conclusion and Outlook	37
	References.	38
4	Knowledge Elicitation and Conceptual Modeling to Foster Security and Trust in SOA System Evolution	41
	John W. Coffey, Arthur Baskin and Dallas Snider	
4.1	Introduction	41
4.2	Security and Trust in SOA Federations	42
4.3	Concept Maps, Knowledge Models, and Knowledge Modeling	44
4.4	Studies in Knowledge Modeling for SOA Security and Trust	45
4.4.1	Developing a Security Assurance Case Through Knowledge Modeling	45
4.4.2	Assessing Trust Needs for a SOA Federation	48
4.5	Discussion	55
4.6	Conclusions	56
	References.	57
5	The Fractal Nature of SOA Federations: A Real World Example	59
	Arthur Baskin, Robert Reinke and John W. Coffey	
5.1	Introduction	60
5.2	The Historical Context of This Work	62
5.3	Literature on SOA Federations, SOA Elements, Algorithms and Data Persistence	63
5.4	Three Levels of Abstraction for SOA Federations	65
5.5	Dimensions of Our SOA World at Each Level of Abstraction: Real World Example	66
5.5.1	Enterprise Federation.	67
5.5.2	Desktop Federation	70
5.5.3	Tool Federation	72
5.6	Fractal Issues We Have Identified.	76
5.6.1	Finiteness Limits Drive the Need for Structure	76
5.6.2	SOA Federations Favor Some Structural Patterns Over Others.	78
5.6.3	SOA Federations Favor Late Binding	81

5.6.4	SOA Federations Contain Mixed Initiative Dialogs	82
5.6.5	SOA Federations Depend upon the Explicit Management of Trust, Reliability, and Authoritative Source	84
5.7	Conclusions	86
	References.	87
6	Leveraging Analytics for Digital Transformation of Enterprise Services and Architectures	91
	Alfred Zimmermann, Rainer Schmidt, Kurt Sandkuhl, Eman El-Sheikh, Dierk Jugel, Christian Schweda, Michael Möhring, Matthias Wißotzki and Birger Lantow	
6.1	Introduction	92
6.2	Digitization of Products and Services	94
6.3	Digital Enterprise Architecture	96
6.4	Decision Case Management	98
6.5	Collaborative Decision Processes	102
6.6	Decision Analytics	103
6.7	Semantic Support for Architectural Analytics	105
6.8	Conclusions and Future Work	108
	References.	108
7	A Framework to Support Digital Transformation	113
	Oliver F. Nandico	
7.1	Changed Role of IT and the Enterprise Architecture in the Times of Digital Transformation.	113
7.1.1	Changed Role of the Architect	113
7.1.2	Services as Atomic Building Blocks of the Architecture.	114
7.1.3	Time Is the Most Limited Resource	114
7.1.4	Agile Approach Necessary	114
7.1.5	Need for a Lightweight Enterprise Architecture Framework	115
7.1.6	Overview of This Article.	115
7.2	Digital Transformation and the Consequences for a Respective Framework.	116
7.3	The Lightweight Enterprise Architecture Framework—A Very Focused Customization of TOGAF	117
7.4	Drivers of Digital Transformation Provide a Foundation for Architecture Guidelines and Principles	118
7.5	Issues to Be Addressed for Digital Transformation by a Lightweight Enterprise Architecture Framework.	120

7.6	The Viewpoints of the Lightweight Enterprise Architecture Framework	125
7.6.1	Viewpoints at Enterprise Level	126
7.6.2	Viewpoints at Project Level.	129
7.7	The Challenge for the Architect of a Digital Transformation Program	137
	References.	137
8	A Two-Speed Architecture for the Digital Enterprise.	139
	Oliver Bossert	
8.1	Introduction	139
8.2	The Digital Era.	140
8.3	Fundamentals of a Two-Speed Architecture	144
8.3.1	Implications for Enterprise Architecture	145
8.4	The Building Blocks of Digital-Enterprise Architecture	147
8.5	Organizational and Process Implications.	148
8.6	Conclusion	150
	References.	150
9	Capability-Driven Development	151
	Hasan Koç, Jan-Christian Kuhr, Kurt Sandkuhl and Felix Timm	
9.1	Introduction	151
9.2	Problem Investigation: The Need for Capability-Driven Development.	153
9.2.1	Flexible Business Services in Utility Industries.	153
9.2.2	Adaptive E-Government Services	155
9.2.3	Industrial Requirements.	155
9.3	Background and Related Work.	156
9.3.1	Notion of Capability in CDD and EAM Capabilities	157
9.3.2	Context Modelling.	158
9.3.3	Overview of Capability Design Methods.	159
9.3.4	Summary.	161
9.4	Capability-Driven Development	162
9.4.1	CDD Method.	163
9.4.2	CDD Implementation.	165
9.5	Real-World Use Case: Utility Industry	167
9.5.1	Background and Motivation	167
9.5.2	Use Case Scenario.	168
9.5.3	Capability Model.	170
9.5.4	Clearing Center	171
9.6	Summary and Recommendations	174
	References.	175

10	Exploring the Nature of Capability Research	179
	Matthias Wißotzki	
10.1	Introduction	179
10.2	Research Approach	180
10.3	Planning the Review	180
10.3.1	Motivating Research Questions	181
10.3.2	Source Selection	182
10.3.3	Time Frame Selection	182
10.4	Performing the Review	183
10.4.1	Article Selection	183
10.4.2	Data Collection	184
10.5	Review Report	185
10.5.1	Types of Capabilities	190
10.5.2	Descriptive Capability Elements	192
10.5.3	Correlations of Capability Elements	194
10.6	Conclusion and Outlook	197
	References	198
11	Enterprise Architecture Analytics and Decision Support	201
	Rainer Schmidt and Michael Möhring	
11.1	Introduction	201
11.2	Data Sources for Enterprise Architecture Analytics	203
11.2.1	Structured Data	203
11.2.2	Semi-structured Data	204
11.2.3	Unstructured Data	204
11.3	Analyzing Architectural Data	204
11.4	Applications of Big Data and Advanced Analytics in Enterprise Architecture	207
11.4.1	Forecasting the Demand and Prices of EA Services	207
11.4.2	Service Recommendation for Different Customers	209
11.4.3	Analyzes of Unstructured Data	211
11.5	Outlook	214
11.5.1	Graph-Based Data	214
11.5.2	Frameworks for Stream-Based Data Processing	214
11.6	Conclusion	215
	References	215
12	A Guide for Capability Management	219
	Matthias Wißotzki and Anna Sonnenberger	
12.1	Introduction	219
12.2	Strategic Management and Enterprise Architecture	221
12.3	Capability Management	224
12.4	Capability Management Process v3.0	227
12.4.1	BB1—Preparation	228
12.4.2	Catalog Design	240

12.4.3	Detail Development	250
12.4.4	Catalog Governance	256
12.5	Conclusion and Outlook	262
	References.	263
	Author Index.	265

About the Editors



Eman El-Sheikh is professor of computer science and director of the Center for Cybersecurity at the University of West Florida. She received her Ph.D. and M.Sc. in computer science from Michigan State University and her B.Sc. in computer science from the American University of Cairo. Her research interests include artificial intelligence, machine learning, intelligent systems, cybersecurity and software maintenance and evolution. Dr. El-Sheikh has applied her research to various problem domains, including education, health care, finance, software maintenance, and robotics. She has authored over 60 publications and

given over 50 conference presentations in her research areas and enjoys engaging and mentoring undergraduate and graduate students in research activities.



Alfred Zimmermann is a professor of computer science at Reutlingen University, director of the Graduate Cooperative Research School for Services Computing, and the research director of the Herman Hollerith Center, Boeblingen, Germany. His research is focused on digital transformation and digital enterprise architecture in close relationship with services and cloud computing. He graduated in medical informatics at the University of Heidelberg and obtained his Ph.D. in informatics from the University of Stuttgart, Germany. He keeps the academic relations of his home university to the GI—the German Computer Science Society, the ACM—the US Association for Computing Machinery, and the IEEE, where he is a part of specific research groups, programs, and initia-

tives like software architecture, enterprise architecture and management, services computing, and cloud computing. Additionally, he is a visiting professor and honorary professor at international universities: La Plata University—Buenos Aires, the Marmara University, and the Yeditepe University of Istanbul.



Lakhmi C. Jain is a visiting professor at Bournemouth University, UK, and adjunct professor at University of Canberra, Australia.

Dr. Jain founded the KES International for providing a professional community the opportunities for publications, knowledge exchange, cooperation, and teaming. Involving around 5000 researchers drawn from universities and companies worldwide, KES facilitates international cooperation and generates synergy in teaching and research. KES regularly provides networking opportunities for professional community through one of the largest conferences of its kind in the area of KES.

His interests focus on the artificial intelligence paradigms and their applications in complex systems, security, e-education, e-health care, unmanned air vehicles, and intelligent systems.

www.kesinternational.org