

Sven Casteleyn • Florian Daniel  
Peter Dolog • Maristella Matera

# Engineering Web Applications

 Springer

Sven Casteleyn  
Vrije Universiteit Brussel  
Department of Computer Science  
Web and Information Systems  
Engineering Lab  
Pleinlaan 2  
1050 Brussels  
Belgium  
Sven.Casteleyn@vub.ac.be

Florian Daniel  
Università di Trento  
Dipartimento di Ingegneria e Scienza  
dell'Informazione  
Via Sommarive, 14  
38100 Povo (TN)  
Italy  
daniel@disi.unitn.it

Peter Dolog  
Aalborg University  
Intelligent Web and Information Systems  
Department of Computer Science  
Selma Lagerlöfs Vej 300  
9220 Aalborg  
Denmark  
dolog@cs.aau.dk

Maristella Matera  
Politecnico di Milano  
Dipartimento di Elettronica  
e Informazione (DEI)  
Piazza Leonardo da Vinci, 32  
20133 Milano  
Italy  
matera@elet.polimi.it

ISBN 978-3-540-92200-1 e-ISBN 978-3-540-92201-8  
DOI 10.1007/978-3-540-92201-8  
Springer Dordrecht Heidelberg London New York

Library of Congress Control Number: 2009929716

ACM Computing Classification (1998): D.2, H.3.5, K.6, J.1

© Springer-Verlag Berlin Heidelberg 2009

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilm or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable to prosecution under the German Copyright Law.

The use of general descriptive names, registered names, trademarks, 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.

*Cover design:* KünkelLopka GmbH

Printed on acid-free paper

Springer is part of Springer Science+Business Media ([www.springer.com](http://www.springer.com))

To our families and partners

---

## Preface

The Web is nowadays omnipresent: we use it at home for private reasons, and we use it at work for professional reasons; we use it for fun (e.g., gaming) and for serious interactions (e.g., home banking), via fixed stations and via mobile devices, and these are just few of the motivations for and the contexts in which we exploit such a powerful medium. The Web has indeed probably become the number one reason for private PCs at home, and the most important kind of “business card” for companies and institutions. Very likely, each of us has already tried at least once online applications such as [Amazon.com](http://Amazon.com) for buying books or CDs, [Ikea.com](http://Ikea.com) for buying furniture, and, of course, [Google.com](http://Google.com) for searching Web sites. Similarly, most of us can no longer imagine a travel planning without the flight booking and hotel reservation systems that are accessible over the Web. We could cite many other examples where the Web is playing a major role, but we believe there is no need for further convincing the reader that the Web has become an indispensable instrument to the most of us.

While the potential, contents, and features offered via the Web are fascinating and attracting an ever growing number of people, there is also a steadily increasing number of people who are interested in developing applications for the Web. If one likes the Web, there is nothing better than developing an own Web site or Web application. Yet, depending on the result one aims to achieve, writing a good application for the Web might be an intricate and complex endeavor that typically requires profound knowledge of the way the Web works.

This book is about engineering Web applications, that is, about developing Web applications according to sound principles, models, and methods. There are many books about Web development available on the market. Most of them focus on specific programming aspects (e.g., data design, presentation design, or Web services), programming languages (e.g., PHP, Java, .NET, JavaScript) or on HTML/XML development. Then, there are many so-called edited books, which assemble independent contributions by multiple authors that, together, cover some aspects of Web development. With this book, we

aim to provide a comprehensive book that covers the whole development life cycle of Web applications, that does not focus too much on specific technologies, and that offers an integrated view on all the addressed topics, also thanks to the adoption of models providing high-level abstractions.

Writing such a book was not an easy task. Bringing together the ideas, knowledge, and personal beliefs of four authors with different backgrounds and experiences was indeed challenging. Uncountable discussions via email and lots of Skype phone conferences were necessary to reach this final version of the book, while we could still go on (and actually do) with new discussions on additional topics and ideas. However, in order to come to a conclusion, writing a book also means taking decisions and keeping deadlines. We sincerely tried to stick to our internal calendar, but only seldom we succeeded. The tones in emails and on the phone were sometimes even harsh, yet fair, but eventually we could always come to an agreement on how to improve what had been written so far and to proceed. Writing a book is also this, arguing and defending ideas, but we are convinced the book benefited from each discussion and, hence, that it was worth to spend the energy we invested into each discussion.

The present version of the book represents the result of about two years of work. Though integrated, the book reflects the characteristics of each author, either because one gave more emphasis to details and technical aspects and another paid more attention to modeling aspects, or simply because some parts have influences from software engineering and others from data engineering or model-driven development. We however think this book provides a good balance between our respective backgrounds and “cultures” and – as outlined in the introduction of this book – we think that it provides a variety of readers with interesting and stimulating contents.

As for the acknowledgments, we would like to stress that many people contributed to the publication of this book. We want to thank them all.

Special thanks go to Stefano Ceri and Mike Carey, who gave us the possibility to publish the book in the renowned series “Data Centric Systems and Applications”. Many thanks go to Ralph Gerstner by Springer for assisting and guiding us during the whole production process. We are also deeply indebted to the reviewers and the manuscript copy editor; their comments and annotations effectively helped us improve the book in both language and content.

Finally, we would like to thank our families, partners, and friends for encouraging (and also tolerating!) us during the writing of this book.

Brussels, Trento, Aalborg, Milan  
May 2009

*Sven Casteleyn*  
*Florian Daniel*  
*Peter Dolog*  
*Maristella Matera*

---

# Contents

<b>1</b>	<b>Introduction</b> .....	1
1.1	The Web Engineering Scenario .....	2
1.2	Structure of the Book .....	5
1.3	Intended Audience .....	7
<b>2</b>	<b>Technologies</b> .....	9
2.1	The HyperText Transfer Protocol (HTTP) .....	10
2.2	The HyperText Markup Language (HTML) .....	11
2.2.1	Cascading Style Sheets (CSSs) .....	13
2.3	The eXtensible Markup Language (XML) .....	14
2.3.1	Well-Formed XML Documents .....	15
2.3.2	Valid XML Documents .....	16
2.3.3	Namespaces .....	18
2.3.4	Presenting XML Documents .....	20
2.3.5	An XML Application: XHTML .....	22
2.4	Dynamic HTML and Client-Side Business Logic .....	23
2.4.1	Common Scripting Languages .....	23
2.4.2	Dynamic HTML .....	24
2.4.3	Client-Side Business Logic and AJAX .....	25
2.4.4	Embedded Applications .....	27
2.4.5	Embedded Multimedia Objects .....	28
2.5	Dynamic Web Pages and Server-Side Business Logic .....	29
2.5.1	Common Gateway Interface (CGI) .....	29
2.5.2	Web Server Extensions .....	33
2.5.3	Multitiered Architectures .....	44
2.5.4	How to Access Data .....	46
2.6	Web Services and Remote Business Logic .....	49
2.6.1	The Web Service Description Language (WSDL) .....	50
2.6.2	The Simple Object Access Protocol (SOAP) .....	50
2.6.3	The Service-Oriented Architecture (SOA) .....	51
2.6.4	Service Orchestration and Choreography .....	52

2.6.5	RESTful Services . . . . .	53
2.7	Summary . . . . .	54
2.8	Further Readings . . . . .	54
<b>3</b>	<b>The Development Process . . . . .</b>	<b>57</b>
3.1	Decomposing the Software Development Process . . . . .	58
3.1.1	Activities in Software Development . . . . .	58
3.1.2	Actors in Software Development . . . . .	60
3.2	Structuring the Software Development Process . . . . .	61
3.2.1	The Waterfall Model . . . . .	61
3.2.2	The Spiral Model . . . . .	61
3.2.3	The Unified Model . . . . .	63
3.2.4	Other Models . . . . .	64
3.3	Web-Specific Software Development Processes . . . . .	64
3.3.1	The Online Evolution Model . . . . .	65
3.3.2	Web-Specific Actors . . . . .	67
3.4	Examples of Web-Specific Development Processes . . . . .	68
3.4.1	The WebML Model . . . . .	68
3.4.2	WSDM . . . . .	71
3.4.3	The OOHDM Model . . . . .	75
3.5	Summary . . . . .	77
3.6	Further Readings . . . . .	78
<b>4</b>	<b>Requirements Engineering . . . . .</b>	<b>81</b>
4.1	Web Requirements Engineering Concepts . . . . .	82
4.1.1	Software Requirements with Relevance to the Web . . . . .	82
4.1.2	Requirements Engineering Processes . . . . .	85
4.2	Organization Requirements Analysis . . . . .	88
4.2.1	Value-Based Requirements Analysis . . . . .	89
4.2.2	Business Information Flow Analysis . . . . .	92
4.2.3	Goals Analysis . . . . .	94
4.2.4	Business Process and Task Analysis . . . . .	97
4.2.5	Audience Analysis . . . . .	102
4.3	Application Domain Analysis . . . . .	106
4.4	Navigation and Interaction Analysis . . . . .	109
4.4.1	Navigation Relationships . . . . .	109
4.4.2	High-Level Interaction and Navigation Units . . . . .	111
4.5	Summary . . . . .	113
4.6	Further Readings . . . . .	113
<b>5</b>	<b>Web Application Design . . . . .</b>	<b>115</b>
5.1	Design Concepts . . . . .	116
5.1.1	Design Principles . . . . .	117
5.1.2	Design Process . . . . .	119
5.2	Workflow Design . . . . .	120

5.3	Data Design .....	123
5.3.1	Information integration engineering .....	126
5.4	Navigation Design .....	127
5.4.1	Site Structure Design .....	127
5.4.2	Navigation Behavior Design .....	136
5.4.3	Web Service Interaction .....	144
5.5	Presentation Design .....	146
5.5.1	Abstract Presentation Design .....	147
5.5.2	Concrete Presentation Design .....	154
5.6	Architecture Design .....	155
5.6.1	Conallen's Web Application Extension for UML .....	155
5.6.2	Web Software Architecture (WebSA) .....	157
5.7	Extensions for Rich Internet Applications .....	161
5.7.1	WebML extensions .....	163
5.7.2	ADRIA extensions .....	165
5.7.3	The RUX method .....	165
5.7.4	OOH4RIA .....	166
5.8	Model-Driven Engineering and Web Engineering .....	166
5.9	Hypertext Models .....	168
5.9.1	Hyperbase Models .....	169
5.9.2	Layered Hypermedia Models .....	169
5.10	Summary .....	172
5.11	Further Readings .....	173
<b>6</b>	<b>Adaptation .....</b>	<b>175</b>
6.1	Localization and Internationalization .....	176
6.1.1	Terminology .....	177
6.1.2	History and Problems Involved .....	177
6.1.3	Hofstede's Cross-Cultural Theory .....	179
6.1.4	Web Design Methods and Localization/Internationalization .....	181
6.2	Personalization, Adaptation, and Context-Awareness .....	185
6.2.1	Terminology .....	185
6.2.2	Methods and Techniques .....	187
6.2.3	Web Design Methods and Adaptation/Personalization .....	188
6.3	Accessibility and Users with Disabilities .....	197
6.3.1	Enabling Accessibility .....	198
6.3.2	The Web Content Accessibility Guidelines .....	199
6.3.3	The Dante Approach .....	203
6.3.4	Web Design Methods and Accessibility .....	204
6.4	Product Line Engineering and Feature Modeling .....	205
6.4.1	Software Product Line Engineering .....	205
6.4.2	Adaptive Web Applications and Software Product Lines .....	208
6.4.3	Domain Analysis in Detail .....	210
6.5	Summary .....	220



6.6	Further Readings . . . . .	221
<b>7</b>	<b>Implementation, Deployment, and Maintenance . . . . .</b>	<b>223</b>
7.1	Implementing the Presentation Layer . . . . .	224
7.1.1	Template-Based Layout . . . . .	224
7.1.2	XSLT at Runtime . . . . .	227
7.1.3	Model-View-Controller Pattern . . . . .	228
7.2	Web Application Frameworks and Engineering Tools . . . . .	230
7.2.1	Web Application Frameworks . . . . .	230
7.2.2	Web Engineering Tools . . . . .	232
7.2.3	Model-driven Engineering and Model Transformation . . . . .	238
7.3	Deployment and Installation . . . . .	240
7.3.1	Choosing a Web Server . . . . .	241
7.3.2	Hosting, Housing, or Own Web Server? . . . . .	243
7.3.3	Registering a Domain Name . . . . .	244
7.3.4	Deploying a Web Application . . . . .	245
7.4	Maintenance and Evolution . . . . .	245
7.4.1	Maintenance of Web Applications . . . . .	246
7.4.2	Evolution of Web Applications . . . . .	248
7.5	The Role of Model-Driven Design and Industry Solutions . . . . .	249
7.6	Summary . . . . .	251
7.7	Further Readings . . . . .	253
<b>8</b>	<b>Quality Assessment . . . . .</b>	<b>255</b>
8.1	The Need for Quality Models . . . . .	256
8.1.1	Quality Perspectives . . . . .	258
8.1.2	Quality Factors Characterizing Web Applications . . . . .	260
8.2	Testing Web Applications . . . . .	262
8.2.1	Functional Testing . . . . .	263
8.2.2	Performance testing . . . . .	267
8.3	Usability Evaluation . . . . .	272
8.3.1	User Testing . . . . .	273
8.3.2	Inspection Methods . . . . .	275
8.3.3	Web Usage Analysis . . . . .	277
8.4	Web Design Methods and Quality Assessment . . . . .	279
8.4.1	Early Assessment of Navigation Models . . . . .	279
8.4.2	Web Application Testing . . . . .	284
8.4.3	Web Usage Analysis . . . . .	284
8.5	Automatic Tools . . . . .	288
8.5.1	Testing Tools . . . . .	288
8.5.2	Usability Evaluation Tools . . . . .	289
8.6	Summary . . . . .	290
8.7	Further Readings . . . . .	291

<b>9 Semantic Web and Web 2.0</b> .....	293
9.1 The Semantic Web .....	294
9.1.1 Semantic Web Technologies .....	296
9.1.2 The Friend Of A Friend Project .....	299
9.1.3 Web Design Methods and the Semantic Web .....	300
9.2 Web 2.0/3.0 .....	305
9.2.1 Social Involvement/Participation .....	306
9.2.2 Technologies for Web 2.0 .....	308
9.2.3 New Technologies and Accessibility .....	311
9.2.4 Web Design Methods and Web 2.0 .....	311
9.2.5 Web 3.0 .....	313
9.3 Summary .....	314
9.4 Further Readings .....	315
<b>References</b> .....	317
<b>Index</b> .....	341