SPRINGER BRIEFS IN COMPUTER SCIENCE

Sandeep Kumar
Niyati Baliyan

Semantic Web-Based Systems

Quality Assessment Models

Springer

SpringerBriefs in Computer Science

Series editors

Stan Zdonik, Brown University, Providence, RI, USA
Shashi Shekhar, University of Minnesota, Minneapolis, MN, USA
Xindong Wu, University of Vermont, Burlington, VT, USA
Lakhmi C. Jain, University of South Australia, Adelaide, SA, Australia
David Padua, University of Illinois Urbana-Champaign, Urbana, IL, USA
Xuemin Sherman Shen, University of Waterloo, Waterloo, ON, Canada
Borko Furht, Florida Atlantic University, Boca Raton, FL, USA
V. S. Subrahmanian, University of Maryland, College Park, MA, USA
Martial Hebert, Carnegie Mellon University, Pittsburgh, PA, USA
Katsushi Ikeuchi, University of Tokyo, Tokyo, Japan
Bruno Siciliano, Università di Napoli Federico II, Napoli, Italy
Sushil Jajodia, George Mason University, Fairfax, VA, USA
Newton Lee, Newton Lee Laboratories, LLC, Burbank, CA, USA

SpringerBriefs present concise summaries of cutting-edge research and practical applications across a wide spectrum of fields. Featuring compact volumes of 50 to 125 pages, the series covers a range of content from professional to academic.

Typical topics might include:

- A timely report of state-of-the art analytical techniques
- A bridge between new research results, as published in journal articles, and a contextual literature review
- A snapshot of a hot or emerging topic
- An in-depth case study or clinical example
- A presentation of core concepts that students must understand in order to make independent contributions

Briefs allow authors to present their ideas and readers to absorb them with minimal time investment. Briefs will be published as part of Springer's eBook collection, with millions of users worldwide. In addition, Briefs will be available for individual print and electronic purchase. Briefs are characterized by fast, global electronic dissemination, standard publishing contracts, easy-to-use manuscript preparation and formatting guidelines, and expedited production schedules. We aim for publication 8–12 weeks after acceptance. Both solicited and unsolicited manuscripts are considered for publication in this series.

More information about this series at http://www.springer.com/series/10028

Sandeep Kumar · Niyati Baliyan

Semantic Web-Based Systems

Quality Assessment Models

Springer

Sandeep Kumar
Department of Computer Science and Engineering
Indian Institute of Technology Roorkee
Roorkee, Uttarakhand
India

Niyati Baliyan
Department of Information Technology
Indira Gandhi Delhi Technical University for Women
New Delhi, Delhi
India

ISSN 2191-5768 ISSN 2191-5776 (electronic)
SpringerBriefs in Computer Science
ISBN 978-981-10-7699-2 ISBN 978-981-10-7700-5 (eBook)
https://doi.org/10.1007/978-981-10-7700-5

Library of Congress Control Number: 2018945453

© The Author(s) 2018
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. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Printed on acid-free paper

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

As a result of dynamic nature of software, the software engineering study and practice has transformed drastically. There have been transitions from a stand-alone application to Web application and a recent development being that of Semantic Web-based applications. Semantic Web is characterized by machine comprehensibility of the content, sharing, and reuse among heterogeneous applications, modular structure of its domain vocabulary, and availability as a service. Owing to the difference in characteristics of such applications, the currently available software quality models are considered to be either inappropriate or incomplete for the assessment of Semantic Web-based applications. Quality evaluation of Semantic Web-based applications is an interesting problem nowadays since they are not solely utilized for information retrieval in a semantic search engine, but being widely employed in the healthcare industry, social networks, e-learning programs, and multimedia processing, among others. Semantic Web applications are a layered cake with ontology at the backbone, description and formal logic in the middle, and the deployment layer at the outermost end. Further, the syntactical composition of ontology as well as its behavior within a Semantic Web-based system or application needs to be assessed. This book initially presents the basic concepts related to the Semantic Web, Semantic Web-based applications, Web applications, ontology and their quality aspects. In addition to various important works reported in this area, our reported works on evaluating the structural quality of modular ontologies and additionally metrics for evaluation of ontology behavior are also summarized. In the presence of multiple Semantic Web applications, offering similar functionality, it is reasonable to evaluate them and make a choice based on the fulfillment of non-functional requirements from them. Further, the quality evaluation of Semantic Web applications deployed on the cloud is summarized, in order to better understand, maintain, integrate, and reuse such applications. This book has been organized as follows. Chapter 1 provides a brief introduction to some of the basic topics related to Semantic Web, ontology, modular ontology, quality, etc. Chapter 2 presents quality assessment of modular ontology. The chapter initially summarizes some works reported in this direction and then discusses one of the models in detail. Chapter 3 discusses the quality evaluation of Semantic Web-based applications as a

whole. Chapter 4 provides a discussion on quality evaluation of Semantic Web applications deployed as service. The primary contribution of this book lies in presenting a single source of information for software engineers in general and ontology engineers in particular in figuring out the best modularization on the basis of goodness of (re)use, irrespective of their types and size. This book can also work as an initial source of information for starting research in this domain. We are hopeful that this book will not only provide a good introductory reference but also give the reader a breadth and depth of this topic.

Roorkee, India Sandeep Kumar
New Delhi, India Niyati Baliyan

Acknowledgements

I would like to express my sincere thanks to my institute, Indian Institute of Technology Roorkee, India, for providing me healthy and conducive working environment. I am also thankful to the faculty members of the Department of Computer Science and Engineering, Indian Institute of Technology Roorkee, India, for their constant support and encouragement. I am especially thankful to some of my colleagues there, who are more like friends and give me constant support. I am thankful to my past postgraduate students, especially Shriya Sukalikar and Satish Dalal, whose work helped in some part of this book. I am also thankful to Prof. R. B. Mishra of Indian Institute of Technology, Banaras Hindu University, India, for his guidance. I am also grateful to the editor and the publication team of the Springer. I am really thankful to my wife, sisters, brother, parents-in-law, and my lovely daughter Aastha, who is my life, for their love and blessings. I have no words to mention the support, patience, and sacrifice of my parents. I dedicate this book to God and to my family.

—Sandeep Kumar

I express profound gratitude to God. I also feel extremely thankful to a lot of people who facilitated the start and finish of this book, either directly or indirectly. I thank Dr. Sandeep Kumar, first and foremost for the impetus to write this book. I want to acknowledge my husband for his persistent backing. It is also hard to imagine this book without the blessing of my parents. I thank all my friends and colleagues for being a source of inspiration and love throughout my journey. I want to thank anonymous reviewers for proofreading the chapters and the publishing team.

—Niyati Baliyan

Contents

1 Introduction 1
1.1 Semantic Web 2
1.1.1 Layered Architecture of Semantic Web 4
1.2 Ontology 5
1.2.1 Modular Ontology 10
1.3 Semantic Web Applications 11
1.3.1 Conventional Software Versus Web Applications 11
1.3.2 Web Applications Versus Semantic Web Applications 12
1.4 Semantic Web Application as a Service 13
1.5 Quality 13
1.6 Conclusion and Summary 15
References 15

2 Quality Evaluation of Ontologies 19
2.1 Quality Evaluation of Modular Ontology 20
2.2 Overview of Some Works on Quality Evaluation of Modular Ontology 20
2.3 A Quality Evaluation Model for Modular Ontology 24
2.3.1 Cohesion and Coupling Metrics 25
2.3.2 Complexity Metrics 31
2.3.3 Behavioral Metrics 35
2.4 Validation 38
2.5 Implementation 43
2.6 Conclusion and Summary 47
References 48

3 Quality Evaluation of Semantic Web Applications 51
3.1 Semantic Web Application Quality 52
3.2 Overview of Some Works on Quality Evaluation of Semantic Web Applications 53

3.3 A Quality Evaluation Model for Semantic Web Applications 54
3.3.1 Quality-Based Ranking Using Analytic Hierarchy Process 63
3.3.2 Quality-Based Ranking Using Fuzzy Inference System 67
3.4 Validation 68
3.5 Implementation 71
3.6 Conclusion and Summary 72
References 73

4 Quality Evaluation of Semantic Web Application as a Service 75
4.1 Background and Motivation 76
4.2 A Quality Model for SWAaaS 77
4.3 Validation 81
4.4 Implementation 83
4.5 Conclusion and Summary 85
References 86

Closing Remarks 89

Index 91

About the Authors

Sandeep Kumar (SMIEEE'17) is currently working as an assistant professor in the Department of Computer Science and Engineering, Indian Institute of Technology (IIT) Roorkee, India. He has supervised three Ph.D. theses, about 30 master dissertations, about 15 undergraduate projects and is currently supervising four Ph.D. students. He has published more than 45 research papers in international/national journals and conferences and has also written books/chapters with Springer, USA, and IGI Publications, USA. He has also filed two patents for his work done along with his students. He is the member of the board of examiners and board of studies of various universities and institutions. He has collaborations in industry and academia. He is currently handling multiple national and international research/consultancy projects. He has received NSF/TCPP early adopter award-2014, 2015, ITS Travel Award 2011 and 2013, and others. He is the member of ACM and senior member of IEEE. His name has also been enlisted in major directories such as Marquis Who's Who, IBC. His areas of interest include Semantic Web, Web services, and software engineering. Email: sandeepkumargarg@gmail.com, sgargfec@iitr.ac.in

Niyati Baliyan received her Ph.D. degree from the Computer Science and Engineering Department, Indian Institute of Technology Roorkee, India, in 2016. She topped Gautam Buddha University, Greater Noida, India, during her M.Tech. program in Information and Communication Technology. She has also attained postgraduate certificate with honors in Information Technology from Sheffield Hallam University, UK, where she was an exchange student on scholarship. She has authored and reviewed many chapters, journals, and conference papers. She is currently working as an assistant professor at Indira Gandhi Delhi Technical University for Women, New Delhi, Delhi, India. Prior to this, she has guided four M.E. theses while teaching at Thapar Institute of Engineering and Technology University, Patiala, India. Her research interests include Semantic Web, ontologies, graph theory, and data analytics. Email: niyati.baliyan@gmail.com, niyatibaliyan@igdtuw.ac.in