State-of-the-Art Survey

LNCS 9400

Betty H.C. Cheng · Benoit Combemale
Robert B. France · Jean-Marc Jézéquel
Bernhard Rumpe (Eds.)

Globalizing Domain-Specific Languages

International Dagstuhl Seminar
Dagstuhl Castle, Germany, October 5–10, 2014
Revised Papers

Springer

Lecture Notes in Computer Science 9400

Commenced Publication in 1973
Founding and Former Series Editors:
Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

[CCF+15a] B. H. C. Cheng, B. Combemale, R. B. France, J.-M. Jézéquel, B. Rumpe (Eds.):
Globalizing Domain-Specific Languages.
In: International Dagstuhl Seminar, Dagstuhl Castle, Germany, LNCS 9400, Springer, 2015.
www.se-rwth.de/publications

More information about this series at http://www.springer.com/series/7408

Betty H.C. Cheng · Benoit Combemale
Robert B. France · Jean-Marc Jézéquel
Bernhard Rumpe (Eds.)

Globalizing Domain-Specific Languages

International Dagstuhl Seminar
Dagstuhl Castle, Germany, October 5 10, 2014
Revised Papers

Springer

Editors
Betty H.C. Cheng
Michigan State University
East Lansing, MI
USA

Jean-Marc Jézéquel
IRISA, Université de Rennes 1
Rennes
France

Benoit Combemale
IRISA, Université de Rennes 1
Rennes
France

Bernhard Rumpe
RWTH Aachen University
Aachen
Germany

Robert B. France (†)
Colorado State University
Fort Collins, CO
USA

ISSN 0302-9743 ISSN 1611-3349 (electronic)
Lecture Notes in Computer Science
ISBN 978-3-319-26171-3 ISBN 978-3-319-26172-0 (eBook)
DOI 10.1007/978-3-319-26172-0

Library of Congress Control Number: 2015953257

LNCS Sublibrary: SL2 Programming and Software Engineering

Springer Cham Heidelberg New York Dordrecht London

Printed on acid-free paper

Springer International Publishing AG Switzerland is part of Springer Science+Business Media
(www.springer.com)

Foreword

Dismantling the "Tower of Babel"

The design and construction of complex technical systems such as cyber-physical systems has always been a difficult process due to the sheer number and diversity of design decisions that need to be made. What makes this particularly challenging is the fact that many of these design choices are interdependent, so that selecting a particular alternative constrains the choices available for other decisions. This issue is becoming more vexing as the number of potential technical alternatives increases with technical progress while, at the same time, there is an ever-growing demand for more sophisticated system functionality. To make this intricate task manageable, engineers have throughout history relied on the trusted "divide and conquer" technique; that is, first decomposing a complex problem to be solved into more manageable sub-problems, then solving each of them individually, and, finally, combining the resulting solutions into a single integrated system. Depending on the size and complexity of the system under consideration, the same approach may have to be applied at multiple hierarchically nested levels.

A fundamental weakness of this approach is that any decomposition of the original problem is itself a critical design choice that invariably has repercussions on many key downstream design decisions. Exacerbating this is the fact that the decomposition decision has to be made early, when least is known about the problem and possible solutions. Consequently, it is not uncommon to see that, as development progresses and problem understanding grows, engineers begin to realize that their chosen decomposition is suboptimal and that others would have been more suitable. Unfortunately, all too often this realization comes too late because significant time, resources, and effort may have already been expended developing the system based on the original decomposition, meaning that any major re-engineering would be either impractical or prohibitively expensive.

To minimize the risk of inappropriate decompositions, it is necessary for the design and development teams to gain insight and experience with the problem on hand as early as possible. Clearly, since the system to be developed does not exist until it is implemented, another age-old engineering technique is used: the use of models to represent the intended design of components yet to be built. These engineering models can take many different forms, including renderings that only exist as ideas in designers heads. However, to be truly useful, an engineering model must take on a concrete form so that it can be communicated to other stakeholders as well as analyzed for suitability. Formal models in particular are desirable since they can be analyzed by formal (i.e., mathematical or logical) means, which, if the analyses are conducted correctly, are more likely to yield correct and, hence, more trustworthy results. Moreover, if the models are realized on a computer, many of the mechanistic aspects of the analysis procedure can be automated.

While computer-based models can help provide more trustworthy analysis results, they do not on their own solve the problem of design decision inter-dependencies unless, of course, the models themselves are linked in appropriate ways. How to link models, particularly models of different subsystems, is one of the primary themes of this volume. Until we had computer-based subsystem models, the only way to link models was through textual reference or human recall methods that have proven highly error prone at best. With the use of computer-supported hyperlinking it is possible to make such links not only more reliable but, even more importantly, more meaningful. This is because it is possible for them to account in various ways for the specific semantics of the model elements that are being linked. Thus, a hyperlink between a software component in a model of the software and an element representing a processor in a model of the intended hardware platform can be customized to capture the specific nature of the software deployment relationship. With that information it might be possible, for example, to compute whether or not the processor is sufficiently powerful to support that software component.

But, even with such computer-aided support, one major problem remains: what if the models whose elements are to be linked are specified using different modeling languages? This is much more than just a syntactical issue: different modeling languages may be based on very different semantic foundations. For example, time in one language may be modeled as a continuous quantity whereas it may be discrete in another. Or, one language may be used to model software while another represents the thermal aspects of a system two radically different domains based on very different paradigms and different ontologies. Yet, although the various languages used in the design of a complex system deal with different phenomena, they all describe components of the same system, including some that are simultaneously present in multiple models but in different forms.

How should this heterogeneity of paradigms and languages be handled? What is the nature of these “semantically aware” hyperlinks? The salient approaches proposed here may come as a surprise to some, particularly given the use of the term “globalization”, which might in the minds of some people connote an Esperanto-like homogenization and unification. What we see, instead, is a more subtle and a much more pragmatic approach based on integration rather than replacement. Even a superficial analysis on how much has been invested in existing technologies and languages reveals that it would be impractical to replace them with some new “universal” language and toolset combination even if we could realistically devise one. The history of technological progress teaches us that most viable technical disciplines are constantly evolving, sprouting new offshoots (i.e., new sub-disciplines) along the way. Each of these is a specialization of another specialization, all of it driven by the need to reason concisely and yet accurately about domain-specific concerns and phenomena. This leads to an ever-increasing number of domain-specific modeling paradigms and languages. Without doubt, this trend will never cease. Consequently, “globalization” as used in this volume means co-existence, and more specifically, collaboration at the system level.

Needless to say, such solutions to this “Tower of Babel” syndrome are not new, yet we have failed to deal with it effectively in the past. So, what has changed to give us hope that we finally have a realistic crack at overcoming it now? It is my conjecture that this is mostly due to the recent emergence of (or, more precisely, the beginnings of) a general theory of modeling languages. This was prompted by the standardization of a few key modeling languages including notably UML and SysML. While neither of these can be held up as a paragon of technical perfection, their very aws (ambiguity, redundancy, lack of precision, etc.) inspired a strong research movement to understand how they can be improved. This seems to have provided the necessary catalyst, which, combined with other recent technological advances, such as ever more powerful computing and communications systems and new generations of computer-based tools, has created the basis for radically new ways of engineering complex technical systems. That is, when these methods and associated technologies reach maturity, engineers will be able to make much more informed design choices much more rapidly, through extensive yet efficient design space exploration. Such dramatic qualitative leaps occur rarely, since much of today's technical progress tends to occur in small increments. This is why I am so excited about the work presented in this volume; I fully expect that it will serve as a core reference source both for researchers and practitioners for many years to come.

In closing, I take this opportunity to pay homage to an exceptional individual, an inspirational leader, a dear friend, and a true gentleman, Dr. Robert France. Sadly, Robert passed away earlier this year, but not until he contributed in fundamental ways to the organization of the Dagstuhl workshop whose results are presented in this volume. However, Robert's contribution to the budding field of model-based software engineering goes far beyond that. He was without doubt one of its true pioneers and will always be fondly remembered as such. One of the initiators of the MoDELS conference series which has become the premier technical venue for publishing and discussing both research and practical work in the domain—Robert was also the founding editor of the *Journal of Software and Systems Modeling* (SoSym) the mainline scientific publication for model-based papers. A patient but persistent man with high technical standards, Robert always strived for cooperation and synergy, drawing all of us working on models and modeling into a diverse and yet unified force, giving thus greater weight to our work and our messages. He worked tirelessly, not hesitating in his efforts even after he was diagnosed with a fatal disease. Thus let this volume be a tribute to this lovely and important human being, to whom we all owe much.

September 2015 Bran Selić

Preface

This book is a result of the 2014 Dagstuhl seminar no. 14412 entitled “Globalizing Domain-Specific Languages.”[1] This Dagstuhl seminar provided a forum in which discussion was focused on the problem of developing complex software systems that span multiple domains of expertise. In the software and system modeling community, research on domain-specific languages (DSLs) aims at providing technologies for developing languages and tools allowing domain experts to efficiently develop system solutions in a particular domain. Unfortunately, the lack of support for explicitly relating concepts expressed in different DSLs made it difficult for developers to reason about information spread across models describing different system aspects. Supporting coordinated use of DSLs leads to what we call the *globalization of domain-specific languages*.

The goal of the seminar was to develop a research initiative that broadens the DSL research focus beyond the development of independent DSLs to one that supports globalized DSLs, that is, DSLs that facilitate coordination of work across different domains of expertise. In the globalized DSLs vision, integrated DSLs provide the means for teams working on systems that span many specialized domains and concerns to determine how their work on a particular aspect influences work on other aspects.

September 2015

Betty H.C. Cheng
Benoit Combemale
Robert B. France
Jean-Marc Jézéquel
Bernhard Rumpe

[1] http://www.dagstuhl.de/14412

Organization

Organizers

Betty H.C. Cheng	Michigan State University - East Lansing, USA
Benoit Combemale	University of Rennes and Inria, France
Robert B. France	Colorado State University, USA
Jean-Marc Jezequel	University of Rennes, France
Bernhard Rumpe	RWTH Aachen, Germany

Participants

Colin Atkinson
Cedric Brun
Barrett Bryant
Benoit Caillaud
Betty H.C. Cheng
Tony Clark
Siobhn Clarke
Benoit Combemale
Julien Deantoni
Thomas Degueule
Robert B. France
Ulrich Frank
Jean-Marc Jezequel
Gabor Karsai
Ralf Lämmel
Marjan Mernik
Pieter J. Mosterman
Oscar Nierstrasz
Bernhard Rumpe
Martin Schindler
Friedrich Steimann
Eugene Syriani
Janos Sztipanovits
Juha-Pekka Tolvanen
Antonio Vallecillo
Mark van den Brand
Markus Völter

Sponsoring Initiatives

The GEMOC Initiative, see http://gemoc.org
The ReMoDD Initiative, see http://www.cs.colostate.edu/remodd

Tribute to Robert B. France

At the time of finalizing this book, we were devastated to learn of the passing of Prof. Robert B. France, on the evening of Sunday, February 15, 2015. His passing was painless, after a battle against cancer. He was 54 years old. Robert B. France was one of the initiators of the Dagstuhl seminar no. 14412, fully devoted in the organization, even during the seminar itself, while already suffering from his illness. We dedicate this book to his memory.

Robert s Scientific Life

Robert started his scientific life at the University of the West Indies, St. Augustine, Trinidad and Tobago in the Caribbean. He graduated in 1984 and began working as a computer specialist in a project called USAID Census in the St. Vincent office of a US company. In 1986, he moved on to the Massey University in Palmerston, New Zealand, where he received his PhD in Computer Science in 1990. From 1990 to 1992, he worked as a postdoctoral fellow at the University of Maryland, Institute for Advanced Computer Studies, USA.

Robert was appointed as an assistant professor at the Computer Science and Engineering Department, Florida Atlantic University in Boca Raton, Florida, and stayed there for six years (1992 1998). In 1999, he moved to the Colorado State University (CSU) in Fort Collins as tenured Associate Professor and was promoted to Full Professor in 2004.

In the period 2006 2007, Robert spent his sabbatical year at Lancaster University in the UK and at IRISA/Inria in Rennes, France. He also made a number of extended scientific visits: to the University of Nice in 2009 and 2012, to SINTEF, Norway, in 2009 and 2011, and the University of Pau in 2003. From 2011, he held a position as visiting Adjunct Professor at the University of the West Indies. In his visits and travels, he was often accompanied by his wife, Sheriffa.

Robert was active at CSU in both organizational and scientific positions for as long as his health allowed him and even helped to organize the Modularity Conference, which took place in Fort Collins in March 2015.

During his scientific life, Robert made a remarkable number of research contributions. His CV (last updated in August 2014) lists:

- 33 journal articles
- 10 book chapters
- One invited paper
- 107 refereed conference papers
- 40 refereed workshop papers
- 13 proceedings and journal editorials

And we know that more papers with his name are still being published. As of March 20, 2015, DBLP lists 236 published entries co-authored by Robert, including informal summaries and SoSyM editorials, and an astonishing list of 223 collaborating authors. Google Scholar lists 387 entries! Since he was an Editor-in-Chief of SoSyM from its inception, Robert was never allowed to publish his work there. Therefore his modeling papers were mostly published at conferences. Otherwise, we are sure that his journal paper count would have been even higher!

In addition to his amazing research productivity and a 16-year labor-intensive commitment to SoSyM, Robert was also an active member of IEEE-CS, ACM, and the OMG. In addition, he served on one of the UML task forces as part of his OMG participation. Robert served as a keynote speaker, invited panelist, panel moderator, invited speaker, summer school lecturer, and, in addition, gave numerous talks at companies and conferences all around the world. He also served as an Associate Editor of *IEEE Computer* (2006 2012) and the *Journal of Software Testing, Verification and Reliability* (2006 2015). Furthermore, he cared deeply about the computer science educational curriculum, serving on the IEEE Computer Society Educational Activities Board (2011 2013). However, his most sustainable scientific service achievement was the role he played in establishing the UML/MODELS conference series. He was the general chair and the local arrangements chair of the first UML/MODELS conference held in Fort Collins in 1999, right after an initial UML workshop in France in 1998. This conference series brought together a research community that eventually made SoSyM the success it is today.

Robert Was an Outstanding Researcher

He was a pioneer in the cross-fertilization of formal methods and informal or semi-formal specification languages used in software engineering. His work provided the scientific foundations of the "integrated methods" which have evolved into a rigorous model-driven engineering (MDE). His contributions in the fields of languages, verification, and modeling have provided the mathematical tools used in the design of critical systems. The exceptional quality of his work on modeling, and his contribution to the object-oriented programming and modeling community, was honored in 2014 with the AITO Dahl-Nygaard Senior Prize, awarded on the occasion of the ECOOP conference. The steering committee of the MODELS conference also awarded him in January 2015 the first MODELS Career award.

Robert Was a Recognized Teacher

Robert was recognized for his teaching skills, his proximity with the students, and his ability to share his vision. Sharing knowledge with students always concerned him. He actively participated in the democratization of computer science education, being a member of the Steering Committee of the "IEEE/ACM Computer Science Curriculum Recommendation, CS2013" and head of the committee "IEEE Curricula." He was responsible for the international program REUSSI, and was a mentor for many researchers around the world and helped them to develop a culture and scientific rigor, as well as appreciating the richness of this job. Since 2014, he was Professor Laureate at Colorado State University (CSU), the highest honor that can be awarded to a teacher, recognizing his qualities.

Robert Was Passionate About the Animation of the Scientific Community

Robert was a founding member of the pUML initiative to define a formal semantics for the UML standard. He organized the first UML conference in 1999 in Denver, and the first edition of the newly renamed MODELS conference in 2005 at Montego Bay, Jamaica. He was also a founding member and editor-in-chief of the *SoSyM Journal*. More recently, he promoted various initiatives to take a new step in MDE through a maturation phase: the ReMoDD initiative, which aims at the creation of a repository of models to build experimental results that are sound and reproducible; and the GEMOC initiative, which aims to develop the foundations, methods, and tools to facilitate the creation, integration, and automated processing of heterogeneous modeling languages.

Robert Was a Child of the Caribbean

Always concerned with providing excellent training, he worked a lot to enable young researchers to access studies, build their academic networks, and benefit from exceptional collaborations. He devoted his energy to allow Caribbean students to access their expected studies. These efforts have become part of the heritage of the Caribbean, awarded in 2014 by the Institute of Caribbean Studies.

Contents