

*Commenced Publication in 1973*

Founding and Former Series Editors:

Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

Editorial Board

David Hutchison

*Lancaster University, UK*

Takeo Kanade

*Carnegie Mellon University, Pittsburgh, PA, USA*

Josef Kittler

*University of Surrey, Guildford, UK*

Jon M. Kleinberg

*Cornell University, Ithaca, NY, USA*

Alfred Kobsa

*University of California, Irvine, CA, USA*

Friedemann Mattern

*ETH Zurich, Switzerland*

John C. Mitchell

*Stanford University, CA, USA*

Moni Naor

*Weizmann Institute of Science, Rehovot, Israel*

Oscar Nierstrasz

*University of Bern, Switzerland*

C. Pandu Rangan

*Indian Institute of Technology, Madras, India*

Bernhard Steffen

*TU Dortmund University, Germany*

Madhu Sudan

*Microsoft Research, Cambridge, MA, USA*

Demetri Terzopoulos

*University of California, Los Angeles, CA, USA*

Doug Tygar

*University of California, Berkeley, CA, USA*

Gerhard Weikum

*Max Planck Institute for Informatics, Saarbruecken, Germany*

Marco Bernardo Vittorio Cortellessa  
Alfonso Pierantonio (Eds.)

# Formal Methods for Model-Driven Engineering

12th International School  
on Formal Methods for the Design of Computer,  
Communication, and Software Systems, SFM 2012  
Bertinoro, Italy, June 18-23, 2012  
Advanced Lectures

## Volume Editors

Marco Bernardo  
Università di Urbino "Carlo Bo"  
Dipartimento di Scienze di Base e Fondamenti  
Piazza della Repubblica 13, 61029 Urbino, Italy  
E-mail: marco.bernardo@uniurb.it

Vittorio Cortellessa  
Università dell'Aquila  
Dipartimento di Informatica  
Via Vetoio 1, 67010 Coppito - L'Aquila, Italy  
E-mail: vittorio.cortellessa@univaq.it

Alfonso Pierantonio  
Università dell'Aquila  
Dipartimento di Informatica  
Via Vetoio 1, 67010 Coppito - L'Aquila, Italy  
E-mail: alfonso.pierantonio@univaq.it

ISSN 0302-9743  
ISBN 978-3-642-30981-6  
DOI 10.1007/978-3-642-30982-3  
Springer Heidelberg Dordrecht London New York

e-ISSN 1611-3349  
e-ISBN 978-3-642-30982-3

Library of Congress Control Number: 2012939229

CR Subject Classification (1998): D.2.4, D.2, D.3.1, F.3-4, K.6, C.3

LNCS Sublibrary: SL 2 – Programming and Software Engineering

© Springer-Verlag Berlin Heidelberg 2012

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, re-use of illustrations, recitation, broadcasting, reproduction on microfilms 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.

*Typesetting:* Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

# Preface

This volume presents a set of papers accompanying the lectures of the 12th International School on Formal Methods for the Design of Computer, Communication and Software Systems (SFM).

This series of schools addresses the use of formal methods in computer science as a prominent approach to the rigorous design of the above-mentioned systems. The main aim of the SFM series is to offer a good spectrum of current research in foundations as well as applications of formal methods, which can be of help for graduate students and young researchers who intend to approach the field.

SFM 2012 was devoted to model-driven engineering and covered several topics including modeling languages, model transformations, functional and performance modeling and analysis, and model evolution management.

This volume comprises 11 articles. Selic's paper reviews how UML has changed over time and what new features it can provide that support not only informal lightweight sketching in early phases of development, but also full implementation capability. The paper by Andova, Van Den Brand, Engelen, and Verhoeff discusses the basic aspects of model-driven engineering in combination with textual domain-specific languages developed using the language invention pattern. Cabot and Gogolla present a comprehensive view of OCL and its applications including the use for expressing model transformations, well-formedness rules, and code-generation templates. The paper by Di Ruscio, Eramo, and Pierantonio introduces a classification of model-transformation approaches and languages and illustrates the characteristics of the most prominent ones. Giese, Lambers, Becker, Hildebrandt, Neumann, Vogel, and Wätzoldt show that graph transformations can be employed to engineer solutions for model-driven development, dynamic adaptation, and models at run time. The paper by De Caso, Braberman, Garbervetsky, and Uchitel deals with enabledness-preserving abstractions, which are concise representations of the behavior space for software engineering artifacts such as source code and specifications. Petriu, Alhaj, and Tawhid consider quantitative performance analysis of UML software models annotated with performance attributes according to the MARTE profile and describe a model-transformation chain that enables the integration of performance analysis in a UML-based software development process. Becker's paper gives an overview on the process of model-driven quality analyses with a special focus on issues that arise in fully automated approaches. The paper by Cortellessa, Di Marco, and Trubiani addresses the problem of capturing performance problems in the software design process by means of software performance antipatterns. Brosch, Kappel, Langer, Seidl, Wieland, and Wimmer offer an introduction to the foundations of model versioning, the underlying technologies for processing models and their evolution, and the state of the art in the field. Finally, the paper by Vallecillo, Gogolla, Burgueño, Wimmer, and Hamann presents model-transformation

specification and testing by discussing and classifying some of the existing approaches and introducing a generalization of model-transformation contracts.

We believe that this book offers a useful view of what has been done and what is going on worldwide in the field of formal methods for model-driven engineering. We wish to thank all the speakers and all the participants for a lively and fruitful school. We also wish to thank the entire staff of the University Residential Center of Bertinoro for the organizational and administrative support.

June 2012

Marco Bernardo  
Vittorio Cortellessa  
Alfonso Pierantonio

# Table of Contents

The Less Well Known UML: A Short User Guide .....	1
<i>Bran Selic</i>	
MDE Basics with a DSL Focus .....	21
<i>Suzana Andova, Mark G.J. van den Brand, Luc J.P. Engelen, and Tom Verhoeff</i>	
Object Constraint Language (OCL): A Definitive Guide .....	58
<i>Jordi Cabot and Martin Gogolla</i>	
Model Transformations .....	91
<i>Davide Di Ruscio, Romina Eramo, and Alfonso Pierantonio</i>	
Graph Transformations for MDE, Adaptation, and Models at Runtime .....	137
<i>Holger Giese, Leen Lambers, Basil Becker, Stephan Hildebrandt, Stefan Neumann, Thomas Vogel, and Sebastian Wätzoldt</i>	
Abstractions for Validation in Action .....	192
<i>Guido de Caso, Victor Braberman, Diego Garbervetsky, and Sebastian Uchitel</i>	
Software Performance Modeling .....	219
<i>Dorina C. Petriu, Mohammad Alhaj, and Rasha Tawhid</i>	
Model Transformations in Non-functional Analysis .....	263
<i>Steffen Becker</i>	
Software Performance Antipatterns: Modeling and Analysis .....	290
<i>Vittorio Cortellessa, Antiniscia Di Marco, and Catia Trubiani</i>	
An Introduction to Model Versioning .....	336
<i>Petra Brosch, Gerti Kappel, Philip Langer, Martina Seidl, Konrad Wieland, and Manuel Wimmer</i>	
Formal Specification and Testing of Model Transformations .....	399
<i>Antonio Vallecillo, Martin Gogolla, Loli Burqueño, Manuel Wimmer, and Lars Hamann</i>	
<b>Author Index</b> .....	<b>439</b>