

Matthew B. Dwyer
Antónia Lopes (Eds.)

LNCs 4422

Fundamental Approaches to Software Engineering

10th International Conference, FASE 2007
Held as Part of the Joint European Conferences
on Theory and Practice of Software, ETAPS 2007
Braga, Portugal, March/April 2007, Proceedings

European Joint Conferences on
Theory
And
Practice of
Software
2007



Springer

TP 311.5-53
F981
2007

Matthew B. Dwyer Antónia Lopes (Eds.)

Fundamental Approaches to Software Engineering

10th International Conference, FASE 2007
Held as Part of the Joint European Conferences
on Theory and Practice of Software, ETAPS 2007
Braga, Portugal, March 24 - April 1, 2007
Proceedings



Springer



E2007003183

Volume Editors

Matthew B. Dwyer
University of Nebraska
Lincoln, NE 68588, USA
E-mail: dwyer@cse.unl.edu

Antónia Lopes
University of Lisbon
1749-016 Lisboa, Portugal
E-mail: mal@di.fc.ul.pt

Library of Congress Control Number: 2007922338

CR Subject Classification (1998): D.2, F.3, D.3

LNCS Sublibrary: SL 1 – Theoretical Computer Science and General Issues

ISSN 0302-9743
ISBN-10 3-540-71288-7 Springer Berlin Heidelberg New York
ISBN-13 978-3-540-71288-6 Springer Berlin Heidelberg New York

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.

Springer is a part of Springer Science+Business Media

springer.com

© Springer-Verlag Berlin Heidelberg 2007
Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India
Printed on acid-free paper SPIN: 12032075 06/3142 5 4 3 2 1 0

Foreword

ETAPS 2007 is the tenth instance of the European Joint Conferences on Theory and Practice of Software, and thus a cause for celebration.

The events that comprise ETAPS address various aspects of the system development process, including specification, design, implementation, analysis and improvement. The languages, methodologies and tools which support these activities are all well within its scope. Different blends of theory and practice are represented, with an inclination towards theory with a practical motivation on the one hand and soundly based practice on the other. Many of the issues involved in software design apply to systems in general, including hardware systems, and the emphasis on software is not intended to be exclusive.

History and Prehistory of ETAPS

ETAPS as we know it is an annual federated conference that was established in 1998 by combining five conferences [Compiler Construction (CC), European Symposium on Programming (ESOP), Fundamental Approaches to Software Engineering (FASE), Foundations of Software Science and Computation Structures (FOSSACS), Tools and Algorithms for Construction and Analysis of Systems (TACAS)] with satellite events.

All five conferences had previously existed in some form and in various colocated combinations: accordingly, the prehistory of ETAPS is complex. FOSSACS was earlier known as the Colloquium on Trees in Algebra and Programming (CAAP), being renamed for inclusion in ETAPS as its historical name no longer reflected its contents. Indeed CAAP's history goes back a long way; prior to 1981, it was known as the Colloque de Lille sur les Arbres en Algebre et en Programmation. FASE was the indirect successor of a 1985 event known as Colloquium on Software Engineering (CSE), which together with CAAP formed a joint event called TAPSOFT in odd-numbered years. Instances of TAPSOFT, all including CAAP plus at least one software engineering event, took place every two years from 1985 to 1997 inclusive. In the alternate years, CAAP took place separately from TAPSOFT.

Meanwhile, ESOP and CC were each taking place every two years from 1986. From 1988, CAAP was colocated with ESOP in even years. In 1994, CC became a "conference" rather than a "workshop" and CAAP, CC and ESOP were thereafter all colocated in even years.

TACAS, the youngest of the ETAPS conferences, was founded as an international workshop in 1995; in its first year, it was colocated with TAPSOFT. It took place each year, and became a "conference" when it formed part of ETAPS 1998. It is a telling indication of the importance of tools in the modern field of informatics that TACAS today is the largest of the ETAPS conferences.

The coming together of these five conferences was due to the vision of a small group of people who saw the potential of a combined event to be more than the sum of its parts. Under the leadership of Don Sannella, who became the first ETAPS steering committee chair, they included: Andre Arnold, Egidio Astesiano, Hartmut Ehrig, Peter Fritzsón, Marie-Claude Gaudel, Tibor Gyimothy, Paul Klint, Kim Guldstrand Larsen, Peter Mosses, Alan Mycroft, Hanne Riis Nielson, Maurice Nivat, Fernando Orejas, Bernhard Steffen, Wolfgang Thomas and (alphabetically last but in fact one of the ringleaders) Reinhard Wilhelm.

ETAPS today is a loose confederation in which each event retains its own identity, with a separate programme committee and proceedings. Its format is open-ended, allowing it to grow and evolve as time goes by. Contributed talks and system demonstrations are in synchronized parallel sessions, with invited lectures in plenary sessions. Two of the invited lectures are reserved for “unifying” talks on topics of interest to the whole range of ETAPS attendees. The aim of cramming all this activity into a single one-week meeting is to create a strong magnet for academic and industrial researchers working on topics within its scope, giving them the opportunity to learn about research in related areas, and thereby to foster new and existing links between work in areas that were formerly addressed in separate meetings.

ETAPS 1998–2006

The first ETAPS took place in Lisbon in 1998. Subsequently it visited Amsterdam, Berlin, Genova, Grenoble, Warsaw, Barcelona, Edinburgh and Vienna before arriving in Braga this year. During that time it has become established as the major conference in its field, attracting participants and authors from all over the world. The number of submissions has more than doubled, and the numbers of satellite events and attendees have also increased dramatically.

ETAPS 2007

ETAPS 2007 comprises five conferences (CC, ESOP, FASE, FOSSACS, TACAS), 18 satellite workshops (ACCAT, AVIS, Bytecode, COCV, FESCA, FinCo, GT-VMT, HAV, HFL, LDTA, MBT, MOMPES, OpenCert, QAPL, SC, SLA++P, TERMGRAPH and WITS), three tutorials, and seven invited lectures (not including those that were specific to the satellite events). We received around 630 submissions to the five conferences this year, giving an overall acceptance rate of 25%. To accommodate the unprecedented quantity and quality of submissions, we have four-way parallelism between the main conferences on Wednesday for the first time. Congratulations to all the authors who made it to the final programme! I hope that most of the other authors still found a way of participating in this exciting event and I hope you will continue submitting.

ETAPS 2007 was organized by the Departamento de Informática of the Universidade do Minho, in cooperation with

- European Association for Theoretical Computer Science (EATCS)
- European Association for Programming Languages and Systems (EAPLS)
- European Association of Software Science and Technology (EASST)
- The Computer Science and Technology Center (CCTC, Universidade do Minho)
- Camara Municipal de Braga
- CeSIUM/GEMCC (Student Groups)

The organizing team comprised:

- João Saraiva (Chair)
- José Bacelar Almeida (Web site)
- José João Almeida (Publicity)
- Luís Soares Barbosa (Satellite Events, Finances)
- Victor Francisco Fonte (Web site)
- Pedro Henriques (Local Arrangements)
- José Nuno Oliveira (Industrial Liaison)
- Jorge Sousa Pinto (Publicity)
- António Nestor Ribeiro (Fundraising)
- Joost Visser (Satellite Events)

ETAPS 2007 received generous sponsorship from Fundação para a Ciência e a Tecnologia (FCT), Enabler (a Wipro Company), Cisco and TAP Air Portugal.

Overall planning for ETAPS conferences is the responsibility of its Steering Committee, whose current membership is:

Perdita Stevens (Edinburgh, Chair), Roberto Amadio (Paris), Luciano Baresi (Milan), Sophia Drossopoulou (London), Matt Dwyer (Nebraska), Hartmut Ehrig (Berlin), José Fiadeiro (Leicester), Chris Hankin (London), Laurie Hendren (McGill), Mike Hinchey (NASA Goddard), Michael Huth (London), Anna Ingólfssdóttir (Aalborg), Paola Inverardi (L'Aquila), Joost-Pieter Katoen (Aachen), Paul Klint (Amsterdam), Jens Knoop (Vienna), Shriram Krishnamurthi (Brown), Kim Larsen (Aalborg), Tiziana Margaria (Göttingen), Ugo Montanari (Pisa), Rocco de Nicola (Florence), Jakob Rehof (Dortmund), Don Sannella (Edinburgh), João Saraiva (Minho), Vladimiro Sassone (Southampton), Helmut Seidl (Munich), Daniel Varro (Budapest), Andreas Zeller (Saarbrücken).

I would like to express my sincere gratitude to all of these people and organizations, the programme committee chairs and PC members of the ETAPS conferences, the organizers of the satellite events, the speakers themselves, the many reviewers, and Springer for agreeing to publish the ETAPS proceedings. Finally, I would like to thank the organizing chair of ETAPS 2007, João Saraiva, for arranging for us to have ETAPS in the ancient city of Braga.

Edinburgh, January 2007

Perdita Stevens
ETAPS Steering Committee Chair

Preface

Software engineering is a complex enterprise spanning many sub-disciplines. At its core are a set of technical and scientific challenges that must be addressed in order to set the stage for the development, deployment, and application of tools and methodologies in support of the construction of complex software systems. The International Conference on Fundamental Approaches to Software Engineering (FASE) — as one of the European Joint Conferences on Theory and Practice of Software (ETAPS) — focuses on those core challenges. FASE provides the software engineering research community with a forum for presenting well-founded theories, languages, methods, and tools arising from both fundamental research in the academic community and applied work in practical development contexts.

In 2007, FASE continued in the strong tradition of FASE 2006 by drawing a large and varied number of submissions from the community — 141 in total. Each submission was reviewed by at least three technical experts from the Program Committee with many papers receiving additional reviews from the broader research community. Each paper was discussed during a 10-day “electronic” meeting. In total, the 26 members of the Program Committee, along with 101 additional reviewers, produced more than 500 reviews. We sincerely thank each of them for the effort and care taken in reviewing and discussing the submissions.

The Program Committee selected a total of 30 papers — an acceptance rate of 21%. Accepted papers addressed topics including model-driven development, distributed systems, specification, service-oriented systems, testing, software analysis, and design. The technical program was complemented by the invited lectures of Jan Bosch on “Software Product Families: Towards Compositionality” and of Bertrand Meyer on “Contract-Driven Development.”

FASE 2007 was held in Braga (Portugal) as part of the tenth meeting of ETAPS — for some history read the Foreword in this volume. While FASE is an integral part of ETAPS, it is important to note the debt FASE owes to ETAPS and its organizers. FASE draws significant energy from its synergistic relationships with the other ETAPS meetings, which gives it a special place in the software engineering community. Perdita Stevens and the rest of the ETAPS Steering Committee have provided extremely helpful guidance to us in organizing FASE 2007 and we thank them. João Saraiva and his staff did a wonderful job as local organizers and as PC chairs we appreciate how smoothly the meeting ran due to their efforts.

In closing, we would like to thank the authors of all of the FASE submissions and the attendees of FASE sessions for their participation and we look forward to seeing you in Budapest for FASE 2008.

January 2007

Matthew B. Dwyer
Antónia Lopes

Organization

Program Committee

Luciano Baresi (Politecnico di Milano, Italy)
Yolanda Berbers (Katholieke Universiteit Leuven, Belgium)
Carlos Canal (University of Málaga, Spain)
Myra Cohen (University of Nebraska, USA)
Ivica Crnkovic (Mälardalen University, Sweden)
Arie van Deursen (Delft University of Technology, The Netherlands)
Juergen Dingel (Queen's University, Canada)
Matt Dwyer (University of Nebraska, USA) Co-chair
Harald Gall (University of Zurich, Switzerland)
Holger Giese (University of Paderborn, Germany)
Martin Grosse-Rhode (Fraunhofer-ISST, Germany)
Anthony Hall (Independent Consultant, UK)
Reiko Heckel (University of Leicester, UK)
Patrick Heymans (University of Namur, Belgium)
Paola Inverardi (Universidad of L'Aquila, Italy)
Valérie Issarny (INRIA-Rocquencourt, France)
Natalia Juristo (Universidad Politecnica de Madrid, Spain)
Kai Koskimies (Tampere University of Technology, Finland)
Patricia Lago (Vrije Universiteit, The Netherlands)
Antónia Lopes (University of Lisbon, Portugal) Co-chair
Mieke Massink (CNR-ISTI, Italy)
Carlo Montangero (University of Pisa, Italy)
Barbara Paech (University of Heidelberg, Germany)
Leila Ribeiro (Federal University of Rio Grande do Sul, Brazil)
Robby (Kansas State University, USA)
Catalin Roman (Washington University, USA)
Sebastian Uchitel (Imperial College, UK and University of Buenos Aires, Argentina)
Jianjun Zhao (Shanghai Jiao Tong University, China)

Referees

M. Aiguier	A. Bazzan	A. Bucchiarone
M. Akerholm	D. Bisztray	S. Bygde
V. Ambriola	T. Bolognesi	D. Carrizo
J. Andersson	Y. Bontemps	G. Cignoni
P. Asirelli	J. Bradbury	V. Clerc
M. Autili	A. Brogi	A. Corradini

M. Caporuscio
 R. Coreeia
 S. Costa
 M. Crane
 C. Cuesta
 O. Dieste
 D. Di Ruscio
 G. De Angelis
 A. de Antonio
 R.C. de Boer
 F. Dotti
 F. Durán
 K. Ehrig
 M.V. Espada
 A. Fantechi
 R. Farenhorts
 M.L. Fernandez
 X. Ferre
 L. Foss
 M. Fischer
 B. Fluri
 M. Fredj
 J. Fredriksson
 S. Gnesi
 Q. Gu
 R. Hedayati
 S. Henkler
 M. Hirsch

M. Katara
 J.P. Katoen
 F. Klein
 P. Knab
 P. Kosiuczenko
 S. Larsson
 D. Latella
 B. Lisper
 M. Loreti
 Y. Lu
 F. Lüders
 R. Machado
 G. Mainetto
 S. Mann
 E. Marchetti
 C. Matos
 S. Meier
 Á. Moreira
 A.M. Moreno
 H. Muccini
 J.M. Murillo
 J. Niere
 J. Oberleitner
 A.G. Padua
 H. Pei-Breivold
 P. Pelliccione
 A. Pierantonio
 E. Pimentel

M. Pinto
 M. Pinzger
 P. Poizat
 S. Punnekkat
 G. Reif
 G. Salaün
 A.M. Schettini
 P.Y. Schobbens
 M.I.S. Segura
 P. Selonen
 L. Semini
 S. Sentilles
 M. Solari
 T. Systa
 M. ter Beek
 G. Thompson
 M. Tichy
 M. Tivoli
 E. Tuosto
 F. Turini
 A. Vallecillo
 S. Vegas
 A. Vilgarakis
 R. Wagner
 H.Q. Yu
 A. Zarras
 A. Zuendorf

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

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

University of Dortmund, Germany

Madhu Sudan

Massachusetts Institute of Technology, MA, USA

Demetri Terzopoulos

University of California, Los Angeles, CA, USA

Doug Tygar

University of California, Berkeley, CA, USA

Moshe Y. Vardi

Rice University, Houston, TX, USA

Gerhard Weikum

Max-Planck Institute of Computer Science, Saarbruecken, Germany

Lecture Notes in Computer Science

For information about Vols. 1–4310

please contact your bookseller or Springer

Vol. 4429: R. Lu, J.H. Siekmann, C. Ullrich (Eds.), *Cognitive Systems*. X, 161 pages. 2007. (Sublibrary LNAI).

Vol. 4424: O. Grumberg, M. Huth (Eds.), *Tools and Algorithms for the Construction and Analysis of Systems*. XX, 738 pages. 2007.

Vol. 4422: M.B. Dwyer, A. Lopes (Eds.), *Fundamental Approaches to Software Engineering*. XV, 440 pages. 2007.

Vol. 4420: S. Krishnamurthi, M. Odersky (Eds.), *Compiler Construction*. XIV, 233 pages. 2007.

Vol. 4415: P. Lukowicz, L. Thiele, G. Tröster (Eds.), *Architecture of Computing Systems - ARCS 2007*. X, 297 pages. 2007.

Vol. 4414: S. Hochreiter, R. Wagner (Eds.), *Bioinformatics Research and Development*. XVI, 482 pages. 2007. (Sublibrary LNBI).

Vol. 4405: L. Padgham, F. Zambonelli (Eds.), *Agent-Oriented Software Engineering VII*. XII, 225 pages. 2007.

Vol. 4403: S. Obayashi, K. Deb, C. Poloni, T. Hiroyasu, T. Murata (Eds.), *Evolutionary Multi-Criterion Optimization*. XIX, 954 pages. 2007.

Vol. 4397: C. Stephanidis, M. Pieper (Eds.), *Universal Access in Ambient Intelligence Environments*. XV, 467 pages. 2007.

Vol. 4396: J. García-Vidal, L. Cerdà-Alabern (Eds.), *Wireless Systems and Mobility in Next Generation Internet*. IX, 271 pages. 2007.

Vol. 4394: A. Gelbukh (Ed.), *Computational Linguistics and Intelligent Text Processing*. XVI, 648 pages. 2007.

Vol. 4393: W. Thomas, P. Weil (Eds.), *STACS 2007*. XVIII, 708 pages. 2007.

Vol. 4392: S.P. Vadhan (Ed.), *Theory of Cryptography*. XI, 595 pages. 2007.

Vol. 4390: S.O. Kuznetsov, S. Schmidt (Eds.), *Formal Concept Analysis*. X, 329 pages. 2007. (Sublibrary LNAI).

Vol. 4389: D. Weyns, H.V.D. Parunak, F. Michel (Eds.), *Environments for Multi-Agent Systems III*. X, 273 pages. 2007. (Sublibrary LNAI).

Vol. 4385: K. Coninx, K. Luyten, K.A. Schneider (Eds.), *Task Models and Diagrams for Users Interface Design*. XI, 355 pages. 2007.

Vol. 4384: T. Washio, K. Satoh, H. Takeda, A. Inokuchi (Eds.), *New Frontiers in Artificial Intelligence*. IX, 401 pages. 2007. (Sublibrary LNAI).

Vol. 4383: E. Bin, A. Ziv, S. Ur (Eds.), *Hardware and Software, Verification and Testing*. XII, 235 pages. 2007.

Vol. 4381: J. Akiyama, W.Y.C. Chen, M. Kano, X. Li, Q. Yu (Eds.), *Discrete Geometry, Combinatorics and Graph Theory*. XI, 289 pages. 2007.

Vol. 4380: S. Spaccapietra, P. Atzeni, F. Fages, M.-S. Hacid, M. Kifer, J. Mylopoulos, B. Pernici, P. Shvaiko, J. Trujillo, I. Zaihrayeu (Eds.), *Journal on Data Semantics VIII*. XV, 219 pages. 2007.

Vol. 4378: I. Virbitskaite, A. Voronkov (Eds.), *Perspectives of Systems Informatics*. XIV, 496 pages. 2007.

Vol. 4377: M. Abe (Ed.), *Topics in Cryptology – CT-RSA 2007*. XI, 403 pages. 2006.

Vol. 4376: E. Frachtenberg, U. Schwiegelshohn (Eds.), *Job Scheduling Strategies for Parallel Processing*. VII, 257 pages. 2007.

Vol. 4374: J.F. Peters, A. Skowron, I. Düntsch, J. Grzymala-Busse, E. Orlowska, L. Polkowski (Eds.), *Transactions on Rough Sets VI, Part I*. XII, 499 pages. 2007.

Vol. 4373: K. Langendoen, T. Voigt (Eds.), *Wireless Sensor Networks*. XIII, 358 pages. 2007.

Vol. 4372: M. Kaufmann, D. Wagner (Eds.), *Graph Drawing*. XIV, 454 pages. 2007.

Vol. 4371: K. Inoue, K. Satoh, F. Toni (Eds.), *Computational Logic in Multi-Agent Systems*. X, 315 pages. 2007. (Sublibrary LNAI).

Vol. 4370: P.P. Lévy, B. Le Grand, F. Poulet, M. Soto, L. Darago, L. Toubiana, J.-F. Vibert (Eds.), *Pixelization Paradigm*. XV, 279 pages. 2007.

Vol. 4369: M. Umeda, A. Wolf, O. Bartenstein, U. Geske, D. Seipel, O. Takata (Eds.), *Declarative Programming for Knowledge Management*. X, 229 pages. 2006. (Sublibrary LNAI).

Vol. 4368: T. Erlebach, C. Kaklamanis (Eds.), *Approximation and Online Algorithms*. X, 345 pages. 2007.

Vol. 4367: K. De Bosschere, D. Kaeli, P. Stenström, D. Whalley, T. Ungerer (Eds.), *High Performance Embedded Architectures and Compilers*. XI, 307 pages. 2007.

Vol. 4366: K. Tuyls, R. Westra, Y. Saeys, A. Nowé (Eds.), *Knowledge Discovery and Emergent Complexity in Bioinformatics*. IX, 183 pages. 2007. (Sublibrary LNBI).

Vol. 4364: T. Kühne (Ed.), *Models in Software Engineering*. XI, 332 pages. 2007.

Vol. 4362: J. van Leeuwen, G.F. Italiano, W. van der Hoek, C. Meinel, H. Sack, F. Plášil (Eds.), *SOFSEM 2007: Theory and Practice of Computer Science*. XXI, 937 pages. 2007.

Vol. 4361: H.J. Hoogeboom, G. Păun, G. Rozenberg, A. Salomaa (Eds.), *Membrane Computing*. IX, 555 pages. 2006.

- Vol. 4360: W. Dubitzky, A. Schuster, P.M.A. Sloot, M. Schroeder, M. Romberg (Eds.), Distributed, High-Performance and Grid Computing in Computational Biology. X, 192 pages. 2007. (Sublibrary LNBI).
- Vol. 4358: R. Vidal, A. Heyden, Y. Ma (Eds.), Dynamical Vision. IX, 329 pages. 2007.
- Vol. 4357: L. Buttyán, V. Gligor, D. Westhoff (Eds.), Security and Privacy in Ad-Hoc and Sensor Networks. X, 193 pages. 2006.
- Vol. 4355: J. Julliand, O. Kouchnarenko (Eds.), B 2007: Formal Specification and Development in B. XIII, 293 pages. 2006.
- Vol. 4354: M. Hanus (Ed.), Practical Aspects of Declarative Languages. X, 335 pages. 2006.
- Vol. 4353: T. Schwentick, D. Suciu (Eds.), Database Theory – ICDT 2007. XI, 419 pages. 2006.
- Vol. 4352: T.-J. Cham, J. Cai, C. Dorai, D. Rajan, T.-S. Chua, L.-T. Chia (Eds.), Advances in Multimedia Modeling, Part II. XVIII, 743 pages. 2006.
- Vol. 4351: T.-J. Cham, J. Cai, C. Dorai, D. Rajan, T.-S. Chua, L.-T. Chia (Eds.), Advances in Multimedia Modeling, Part I. XIX, 797 pages. 2006.
- Vol. 4349: B. Cook, A. Podelski (Eds.), Verification, Model Checking, and Abstract Interpretation. XI, 395 pages. 2007.
- Vol. 4348: S.T. Taft, R.A. Duff, R.L. Brukardt, E. Ploederer, P. Leroy (Eds.), Ada 2005 Reference Manual. XXII, 765 pages. 2006.
- Vol. 4347: J. Lopez (Ed.), Critical Information Infrastructures Security. X, 286 pages. 2006.
- Vol. 4346: L. Brim, B. Haverkort, M. Leucker, J. van de Pol (Eds.), Formal Methods: Applications and Technology. X, 363 pages. 2007.
- Vol. 4345: N. Maglaveras, I. Chouvarda, V. Koutkias, R. Brause (Eds.), Biological and Medical Data Analysis. XIII, 496 pages. 2006. (Sublibrary LNBI).
- Vol. 4344: V. Gruhn, F. Oquendo (Eds.), Software Architecture. X, 245 pages. 2006.
- Vol. 4342: H. de Swart, E. Orłowska, G. Schmidt, M. Roubens (Eds.), Theory and Applications of Relational Structures as Knowledge Instruments II. X, 373 pages. 2006. (Sublibrary LNAI).
- Vol. 4341: P.Q. Nguyen (Ed.), Progress in Cryptology - VIETCRYPT 2006. XI, 385 pages. 2006.
- Vol. 4340: R. Prodan, T. Fahringer, Grid Computing. XXIII, 317 pages. 2007.
- Vol. 4339: E. Ayguadé, G. Baumgartner, J. Ramanujam, P. Sadayappan (Eds.), Languages and Compilers for Parallel Computing. XI, 476 pages. 2006.
- Vol. 4338: P. Kalra, S. Peleg (Eds.), Computer Vision, Graphics and Image Processing. XV, 965 pages. 2006.
- Vol. 4337: S. Arun-Kumar, N. Garg (Eds.), FSTTCS 2006: Foundations of Software Technology and Theoretical Computer Science. XIII, 430 pages. 2006.
- Vol. 4336: V.R. Basili, H.D. Rombach, K. Schneider, B. Kitchenham, D. Pfahl, R.W. Selby, Empirical Software Engineering Issues. XVII, 194 pages. 2007.
- Vol. 4335: S.A. Brueckner, S. Hassas, M. Jelasity, D. Yamins (Eds.), Engineering Self-Organising Systems. XII, 212 pages. 2007. (Sublibrary LNAI).
- Vol. 4334: B. Beckert, R. Hähnle, P.H. Schmitt (Eds.), Verification of Object-Oriented Software. XXIX, 658 pages. 2007. (Sublibrary LNAI).
- Vol. 4333: U. Reimer, D. Karagiannis (Eds.), Practical Aspects of Knowledge Management. XII, 338 pages. 2006. (Sublibrary LNAI).
- Vol. 4332: A. Bagchi, V. Atluri (Eds.), Information Systems Security. XV, 382 pages. 2006.
- Vol. 4331: G. Min, B. Di Martino, L.T. Yang, M. Guo, G. Ruenger (Eds.), Frontiers of High Performance Computing and Networking – ISPA 2006 Workshops. XXXVII, 1141 pages. 2006.
- Vol. 4330: M. Guo, L.T. Yang, B. Di Martino, H.P. Zima, J. Dongarra, F. Tang (Eds.), Parallel and Distributed Processing and Applications. XVIII, 953 pages. 2006.
- Vol. 4329: R. Barua, T. Lange (Eds.), Progress in Cryptology - INDOCRYPT 2006. X, 454 pages. 2006.
- Vol. 4328: D. Penkler, M. Reitspiess, F. Tam (Eds.), Service Availability. X, 289 pages. 2006.
- Vol. 4327: M. Baldoni, U. Endriss (Eds.), Declarative Agent Languages and Technologies IV. VIII, 257 pages. 2006. (Sublibrary LNAI).
- Vol. 4326: S. Göbel, R. Malkewitz, I. Iurgel (Eds.), Technologies for Interactive Digital Storytelling and Entertainment. X, 384 pages. 2006.
- Vol. 4325: J. Cao, I. Stojmenovic, X. Jia, S.K. Das (Eds.), Mobile Ad-hoc and Sensor Networks. XIX, 887 pages. 2006.
- Vol. 4323: G. Doherty, A. Blandford (Eds.), Interactive Systems. XI, 269 pages. 2007.
- Vol. 4322: F. Kordon, J. Sztipanovits (Eds.), Reliable Systems on Unreliable Networked Platforms. XIV, 317 pages. 2007.
- Vol. 4320: R. Gotzhein, R. Reed (Eds.), System Analysis and Modeling: Language Profiles. X, 229 pages. 2006.
- Vol. 4319: L.-W. Chang, W.-N. Lie (Eds.), Advances in Image and Video Technology. XXVI, 1347 pages. 2006.
- Vol. 4318: H. Lipmaa, M. Yung, D. Lin (Eds.), Information Security and Cryptology. XI, 305 pages. 2006.
- Vol. 4317: S.K. Madria, K.T. Claypool, R. Kannan, P. Uppuluri, M.M. Gore (Eds.), Distributed Computing and Internet Technology. XIX, 466 pages. 2006.
- Vol. 4316: M.M. Dalkilic, S. Kim, J. Yang (Eds.), Data Mining and Bioinformatics. VIII, 197 pages. 2006. (Sublibrary LNBI).
- Vol. 4314: C. Freksa, M. Kohlhase, K. Schill (Eds.), KI 2006: Advances in Artificial Intelligence. XII, 458 pages. 2007. (Sublibrary LNAI).
- Vol. 4313: T. Margaria, B. Steffen (Eds.), Leveraging Applications of Formal Methods. IX, 197 pages. 2006.
- Vol. 4312: S. Sugimoto, J. Hunter, A. Rauber, A. Morishima (Eds.), Digital Libraries: Achievements, Challenges and Opportunities. XVIII, 571 pages. 2006.
- Vol. 4311: K. Cho, P. Jacquet (Eds.), Technologies for Advanced Heterogeneous Networks II. XI, 253 pages. 2006.

Table of Contents

Invited Contributions

Software Product Families: Towards Compositionality	1
<i>Jan Bosch</i>	
Contract-Driven Development	11
<i>Bertrand Meyer</i>	

Evolution and Agents

EQ-Mine: Predicting Short-Term Defects for Software Evolution	12
<i>Jacek Ratzinger, Martin Pinzger, and Harald Gall</i>	
An Approach to Software Evolution Based on Semantic Change.....	27
<i>Romain Robbes, Michele Lanza, and Mircea Lungu</i>	
A Simulation-Oriented Formalization for a Psychological Theory	42
<i>Paula Salem da Silva and Ana C. Vieira de Melo</i>	

Model Driven Development

Integrating Performance and Reliability Analysis in a Non-Functional MDA Framework	57
<i>Vittorio Cortellessa, Antinisca Di Marco, and Paola Inverardi</i>	
Information Preserving Bidirectional Model Transformations	72
<i>Hartmut Ehrig, Karsten Ehrig, Claudia Ermel, Frank Hermann, and Gabriele Taentzer</i>	
Activity-Driven Synthesis of State Machines	87
<i>Rolf Hennicker and Alexander Knapp</i>	
Flexible and Extensible Notations for Modeling Languages	102
<i>Jimin Gao, Mats Heimdahl, and Eric Van Wyk</i>	

Tool Demonstrations

Declared Type Generalization Checker: An Eclipse Plug-In for Systematic Programming with More General Types	117
<i>Markus Bach, Florian Forster, and Friedrich Steimann</i>	
S2A: A Compiler for Multi-modal UML Sequence Diagrams	121
<i>David Harel, Asaf Kleinbort, and Shahar Maoz</i>	

Distributed Systems

Scenario-Driven Dynamic Analysis of Distributed Architectures 125
George Edwards, Sam Malek, and Nenad Medvidovic

Enforcing Architecture and Deployment Constraints of Distributed
Component-Based Software 140
Chouki Tibermacine, Didier Hoareau, and Reda Kadri

A Family of Distributed Deadlock Avoidance Protocols and Their
Reachable State Spaces 155
César Sánchez, Henny B. Sipma, and Zohar Manna

Specification

Precise Specification of Use Case Scenarios 170
Jon Whittle

Joint Structural and Temporal Property Specification Using Timed
Story Scenario Diagrams 185
Florian Klein and Holger Giese

SDL Profiles – Formal Semantics and Tool Support 200
R. Grammes and R. Gotzhein

Preliminary Design of BML: A Behavioral Interface Specification
Language for Java Bytecode 215
Lilian Burdy, Marieke Huisman, and Mariela Pavlova

Services

A Service Composition Construct to Support Iterative Development 230
Roy Grønmo, Michael C. Jaeger, and Andreas Wombacher

Correlation Patterns in Service-Oriented Architectures 245
Alistair Barros, Gero Decker, Marlon Dumas, and Franz Weber

Dynamic Characterization of Web Application Interfaces 260
Marc Fisher II, Sebastian Elbaum, and Gregg Rothermel

Testing

A Prioritization Approach for Software Test Cases Based on Bayesian
Networks 276
Siavash Mirarab and Ladan Tahvildari

Redundancy Based Test-Suite Reduction 291
Gordon Fraser and Franz Wotawa

Testing Scenario-Based Models	306
<i>Hillel Kugler, Michael J. Stern, and E. Jane Albert Hubbard</i>	
Integration Testing in Software Product Line Engineering: A Model-Based Technique.....	321
<i>Sacha Reis, Andreas Metzger, and Klaus Pohl</i>	

Analysis

Practical Reasoning About Invocations and Implementations of Pure Methods	336
<i>Ádám Darvas and K. Rustan M. Leino</i>	
Finding Environment Guarantees	352
<i>Marsha Chechik, Mihaela Gheorghiu, and Arie Gurfinkel</i>	
Ensuring Consistency Within Distributed Graph Transformation Systems	368
<i>Ulrike Ranger and Thorsten Hermes</i>	
Maintaining Consistency in Layered Architectures of Mobile Ad-Hoc Networks	383
<i>Julia Padberg, Kathrin Hoffmann, Hartmut Ehrig, Tony Modica, Enrico Biermann, and Claudia Ermel</i>	

Design

Towards Normal Design for Safety-Critical Systems	398
<i>Derek Mannering, Jon G. Hall, and Lucia Rapanotti</i>	
A Clustering-Based Approach for Tracing Object-Oriented Design to Requirement	412
<i>Xin Zhou and Hui Yu</i>	
Measuring and Characterizing Crosscutting in Aspect-Based Programs: Basic Metrics and Case Studies	423
<i>Roberto E. Lopez-Herrejon and Sven Apel</i>	
Author Index	439

Software Product Families: Towards Compositionality

Jan Bosch

Nokia, Technology Platforms/Software Platforms,
P.O. Box 407, FI-00045 NOKIA GROUP, Finland
Jan.Bosch@nokia.com
<http://www.janbosch.com>

Abstract. Software product families have become the most successful approach to intra-organizational reuse. Especially in the embedded systems industry, but also elsewhere, companies are building rich and diverse product portfolios based on software platforms that capture the commonality between products while allowing for their differences. Software product families, however, easily become victims of their own success in that, once successful, there is a tendency to increase the scope of the product family by incorporating a broader and more diverse product portfolio. This requires organizations to change their approach to product families from relying on a pre-integrated platform for product derivation to a compositional approach where platform components are composed in a product-specific configuration.

Keywords: Software product families, compositionality.

1 Introduction

Over the last decades, embedded systems have emerged as one of the key areas of innovation in software engineering. The increasing complexity, connectedness, feature density and enriched user interaction, when combined, have driven an enormous demand for software. In fact, the size of software in embedded systems seems to follow Moore's law, i.e. with the increased capabilities of the hardware, the software has followed suit in terms of size and complexity. This has led to a constant struggle to build the software of embedded systems in a cost-effective, rapid and high-quality fashion in the face of a constantly expanding set of requirements. Two of the key approaches evolved to handle this complexity have been software architecture and software product families. Together, these technologies have allowed companies to master, at least in part, the complexity of large scale software systems.

One can identify three main trends that are driving the embedded systems industry, i.e. convergence, end-to-end functionality and software engineering capability. The convergence of the consumer electronics, telecom and IT industries has been discussed for over a decade. Although many may wonder whether and when it will happen, the fact is that the convergence is taking place constantly. Different from what the name may suggest, though, convergence in fact leads to a portfolio of increasingly diverging devices. For instance, in the mobile telecom industry, mobile phones have diverged into still picture camera models, video camera models, music

player models, mobile TV models, mobile email models, etc. This trend results in a significant pressure on software product families as the amount of variation to be supported by the platform in terms of price points, form factors and feature sets is significantly beyond the requirements just a few years ago. The second trend is that many innovations that have proven their success in the market place require the creation of an end-to-end solution and possibly even the creation or adaptation of a business eco-system. Examples from the mobile domain include, for instance, ring tones, but the ecosystem initiated by Apple around digital music is exemplary in this context. The consequence for most companies is that where earlier, they were able to drive innovations independently to the market, the current mode requires significant partnering and orchestration for innovations to be successful. The third main trend is that a company's ability to engineer software is rapidly becoming a key competitive differentiator. The two main developments underlying this trend are efficiency and responsiveness. With the constant increase in software demands, the cost of software R&D is becoming unacceptable from a business perspective. Thus, some factor difference in productivity is easily turning into being able or not being able to deliver certain feature sets. Responsiveness is growing in importance because innovation cycles are moving increasingly fast and customers are expecting constant improvements in the available functionality. Web 2.0 [7] presents a strong example of this trend. A further consequence for embedded systems is that, in the foreseeable future, the hardware and software innovation cycles will, at least in part, be decoupled, significantly increasing demands for post-deployment distribution of software.

Due to the convergence trend, the number of different embedded products that a manufacturer aims to bring to market is increasing. Consequently, reuse of software (as well as of mechanical and hardware solutions) is a standing ambition for the industry. The typical approach employed in the embedded systems industry is to build a platform that implements the functionality common to all devices. The platform is subsequently used as a basis when creating new product and functionality specific to the product is built on top of the platform. Several embedded system companies have successfully employed product families or platforms and are now reaching the stage where the scope of the product family is expanding considerably. This requires a transition from a traditional, integration-oriented approach to a compositional approach.

The contribution of this paper is that it analyses the problems of traditional approaches to software product families that several companies are now confronted with. In addition, it presents compositional platforms as the key solution approach to addressing these problems and discusses the technical and organizational consequences.

The remainder of this article is organized as follows. The next section defines the challenges faced by traditional product families when expanding their scope. Subsequently, section 3 presents the notion of compositional product families. The component model underlying composability is discussed in more detail in section 4. Finally, the paper is concluded in section 5.