Martín Abadi
Luca de Alfaro (Eds.)

LNCS 3653

CONCUR 2005 – Concurrency Theory

16th International Conference, CONCUR 2005
San Francisco, CA, USA, August 2005
Proceedings

Springer

Martín Abadi Luca de Alfaro (Eds.)

CONCUR 2005 – Concurrency Theory

16th International Conference, CONCUR 2005
San Francisco, CA, USA, August 23-26, 2005
Proceedings

Springer

Volume Editors

Martín Abadi
Luca de Alfaro
University of California at Santa Cruz
School of Engineering
Santa Cruz, CA 95064, USA
E-mail: {abadi, luca}@soe.ucsc.edu

Library of Congress Control Number: 2005930640

CR Subject Classification (1998): F.3, F.1, D.3, D.1, C.2

ISSN 0302-9743
ISBN-10 3-540-28309-9 Springer Berlin Heidelberg New York
ISBN-13 978-3-540-28309-6 Springer Berlin Heidelberg New York

Springer is a part of Springer Science+Business Media

springeronline.com

Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India
Printed on acid-free paper SPIN: 11539452 06/3142 5 4 3 2 1 0

Lecture Notes in Computer Science 3653

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

Lecture Notes in Computer Science

For information about Vols. 1–3526

please contact your bookseller or Springer

Vol. 3654: S. Jajodia, D. Wijesekera (Eds.), Data and Applications Security XIX. X, 353 pages. 2005.

Vol. 3653: M. Abadi, L.de Alfaro (Eds.), CONCUR 2005 – Concurrency Theory. XIV, 578 pages. 2005.

Vol. 3649: W.M.P. van der Aalst, B. Benatallah, F. Casati, F. Curbera (Eds.), Business Process Management. XII, 472 pages. 2005.

Vol. 3639: P. Godefroid (Ed.), Model Checking Software. XI, 289 pages. 2005.

Vol. 3638: A. Butz, B. Fisher, A. Krüger, P. Olivier (Eds.), Smart Graphics. XI, 269 pages. 2005.

Vol. 3634: L. Ong (Ed.), Computer Science Logic. XI, 567 pages. 2005.

Vol. 3633: C. Bauzer Medeiros, M. Egenhofer, E. Bertino (Eds.), Advances in Spatial and Temporal Databases. XIII, 433 pages. 2005.

Vol. 3632: R. Nieuwenhuis (Ed.), Automated Deduction – CADE-20. XIII, 459 pages. 2005. (Subseries LNAI).

Vol. 3627: C. Jacob, M.L. Pilat, P.J. Bentley, J. Timmis (Eds.), Artificial Immune Systems. XII, 500 pages. 2005.

Vol. 3626: B. Ganter, G. Stumme, R. Wille (Eds.), Formal Concept Analysis. X, 349 pages. 2005. (Subseries LNAI).

Vol. 3625: S. Kramer, B. Pfahringer (Eds.), Inductive Logic Programming. XIII, 427 pages. 2005. (Subseries LNAI).

Vol. 3624: C. Chekuri, K. Jansen, J.D.P. Rolim, L. Trevisan (Eds.), Approximation, Randomization and Combinatorial Optimization. XI, 495 pages. 2005.

Vol. 3623: M. Liśkiewicz, R. Reischuk (Eds.), Fundamentals of Computation Theory. XV, 576 pages. 2005.

Vol. 3621: V. Shoup (Ed.), Advances in Cryptology – CRYPTO 2005. XI, 568 pages. 2005.

Vol. 3620: H. Muñoz-Avila, F. Ricci (Eds.), Case-Based Reasoning Research and Development. XV, 654 pages. 2005. (Subseries LNAI).

Vol. 3619: X. Lu, W. Zhao (Eds.), Networking and Mobile Computing. XXIV, 1299 pages. 2005.

Vol. 3615: B. Ludäscher, L. Raschid (Eds.), Data Integration in the Life Sciences. XII, 344 pages. 2005. (Subseries LNBI).

Vol. 3608: F. Dehne, A. López-Ortiz, J.-R. Sack (Eds.), Algorithms and Data Structures. XIV, 446 pages. 2005.

Vol. 3607: J.-D. Zucker, L. Saitta (Eds.), Abstraction, Reformulation and Approximation. XII, 376 pages. 2005. (Subseries LNAI).

Vol. 3606: V. Malyshkin (Ed.), Parallel Computing Technologies. XII, 470 pages. 2005.

Vol. 3603: J. Hurd, T. Melham (Eds.), Theorem Proving in Higher Order Logics. IX, 409 pages. 2005.

Vol. 3602: R. Eigenmann, Z. Li, S.P. Midkiff (Eds.), Languages and Compilers for High Performance Computing. IX, 486 pages. 2005.

Vol. 3599: U. Aßmann, M. Aksit, A. Rensink (Eds.), Model Driven Architecture. X, 235 pages. 2005.

Vol. 3598: H. Murakami, H. Nakashima, H. Tokuda, M. Yasumura, Ubiquitous Computing Systems. XIII, 275 pages. 2005.

Vol. 3597: S. Shimojo, S. Ichii, T.W. Ling, K.-H. Song (Eds.), Web and Communication Technologies and Internet-Related Social Issues - HSI 2005. XIX, 368 pages. 2005.

Vol. 3596: F. Dau, M.-L. Mugnier, G. Stumme (Eds.), Conceptual Structures: Common Semantics for Sharing Knowledge. XI, 467 pages. 2005. (Subseries LNAI).

Vol. 3595: L. Wang (Ed.), Computing and Combinatorics. XVI, 995 pages. 2005.

Vol. 3594: J.C. Setubal, S. Verjovski-Almeida (Eds.), Advances in Bioinformatics and Computational Biology. XIV, 258 pages. 2005. (Subseries LNBI).

Vol. 3592: S. Katsikas, J. Lopez, G. Pernul (Eds.), Trust, Privacy and Security in Digital Business. XII, 332 pages. 2005.

Vol. 3587: P. Perner, A. Imiya (Eds.), Machine Learning and Data Mining in Pattern Recognition. XVII, 695 pages. 2005. (Subseries LNAI).

Vol. 3586: A.P. Black (Ed.), ECOOP 2005 - Object-Oriented Programming. XVII, 631 pages. 2005.

Vol. 3584: X. Li, S. Wang, Z.Y. Dong (Eds.), Advanced Data Mining and Applications. XIX, 835 pages. 2005. (Subseries LNAI).

Vol. 3583: R.W. H. Lau, Q. Li, R. Cheung, W. Liu (Eds.), Advances in Web-Based Learning – ICWL 2005. XIV, 420 pages. 2005.

Vol. 3582: J. Fitzgerald, I.J. Hayes, A. Tarlecki (Eds.), FM 2005: Formal Methods. XIV, 558 pages. 2005.

Vol. 3581: S. Miksch, J. Hunter, E. Keravnou (Eds.), Artificial Intelligence in Medicine. XVII, 547 pages. 2005. (Subseries LNAI).

Vol. 3580: L. Caires, G.F. Italiano, L. Monteiro, C. Palamidessi, M. Yung (Eds.), Automata, Languages and Programming. XXV, 1477 pages. 2005.

Vol. 3579: D. Lowe, M. Gaedke (Eds.), Web Engineering. XXII, 633 pages. 2005.

Vol. 3578: M. Gallagher, J. Hogan, F. Maire (Eds.), Intelligent Data Engineering and Automated Learning - IDEAL 2005. XVI, 599 pages. 2005.

Vol. 3577: R. Falcone, S. Barber, J. Sabater-Mir, M.P. Singh (Eds.), Trusting Agents for Trusting Electronic Societies. VIII, 235 pages. 2005. (Subseries LNAI).

Vol. 3576: K. Etessami, S.K. Rajamani (Eds.), Computer Aided Verification. XV, 564 pages. 2005.

Vol. 3575: S. Wermter, G. Palm, M. Elshaw (Eds.), Biomimetic Neural Learning for Intelligent Robots. IX, 383 pages. 2005. (Subseries LNAI).

Vol. 3574: C. Boyd, J.M. González Nieto (Eds.), Information Security and Privacy. XIII, 586 pages. 2005.

Vol. 3573: S. Etalle (Ed.), Logic Based Program Synthesis and Transformation. VIII, 279 pages. 2005.

Vol. 3572: C. De Felice, A. Restivo (Eds.), Developments in Language Theory. XI, 409 pages. 2005.

Vol. 3571: L. Godo (Ed.), Symbolic and Quantitative Approaches to Reasoning with Uncertainty. XVI, 1028 pages. 2005. (Subseries LNAI).

Vol. 3570: A. S. Patrick, M. Yung (Eds.), Financial Cryptography and Data Security. XII, 376 pages. 2005.

Vol. 3569: F. Bacchus, T. Walsh (Eds.), Theory and Applications of Satisfiability Testing. XII, 492 pages. 2005.

Vol. 3568: W.-K. Leow, M.S. Lew, T.-S. Chua, W.-Y. Ma, L. Chaisorn, E.M. Bakker (Eds.), Image and Video Retrieval. XVII, 672 pages. 2005.

Vol. 3567: M. Jackson, D. Nelson, S. Stirk (Eds.), Database: Enterprise, Skills and Innovation. XII, 185 pages. 2005.

Vol. 3566: J.-P. Banâtre, P. Fradet, J.-L. Giavitto, O. Michel (Eds.), Unconventional Programming Paradigms. XI, 367 pages. 2005.

Vol. 3565: G.E. Christensen, M. Sonka (Eds.), Information Processing in Medical Imaging. XXI, 777 pages. 2005.

Vol. 3564: N. Eisinger, J. Małuszyński (Eds.), Reasoning Web. IX, 319 pages. 2005.

Vol. 3562: J. Mira, J.R. Álvarez (Eds.), Artificial Intelligence and Knowledge Engineering Applications: A Bioinspired Approach, Part II. XXIV, 636 pages. 2005.

Vol. 3561: J. Mira, J.R. Álvarez (Eds.), Mechanisms, Symbols, and Models Underlying Cognition, Part I. XXIV, 532 pages. 2005.

Vol. 3560: V.K. Prasanna, S. Iyengar, P.G. Spirakis, M. Welsh (Eds.), Distributed Computing in Sensor Systems. XV, 423 pages. 2005.

Vol. 3559: P. Auer, R. Meir (Eds.), Learning Theory. XI, 692 pages. 2005. (Subseries LNAI).

Vol. 3558: V. Torra, Y. Narukawa, S. Miyamoto (Eds.), Modeling Decisions for Artificial Intelligence. XII, 470 pages. 2005. (Subseries LNAI).

Vol. 3557: H. Gilbert, H. Handschuh (Eds.), Fast Software Encryption. XI, 443 pages. 2005.

Vol. 3556: H. Baumeister, M. Marchesi, M. Holcombe (Eds.), Extreme Programming and Agile Processes in Software Engineering. XIV, 332 pages. 2005.

Vol. 3555: T. Vardanega, A.J. Wellings (Eds.), Reliable Software Technology – Ada-Europe 2005. XV, 273 pages. 2005.

Vol. 3554: A. Dey, B. Kokinov, D. Leake, R. Turner (Eds.), Modeling and Using Context. XIV, 572 pages. 2005. (Subseries LNAI).

Vol. 3553: T.D. Hämäläinen, A.D. Pimentel, J. Takala, S. Vassiliadis (Eds.), Embedded Computer Systems: Architectures, Modeling, and Simulation. XV, 476 pages. 2005.

Vol. 3552: H. de Meer, N. Bhatti (Eds.), Quality of Service – IWQoS 2005. XVIII, 400 pages. 2005.

Vol. 3551: T. Härder, W. Lehner (Eds.), Data Management in a Connected World. XIX, 371 pages. 2005.

Vol. 3548: K. Julisch, C. Kruegel (Eds.), Intrusion and Malware Detection and Vulnerability Assessment. X, 241 pages. 2005.

Vol. 3547: F. Bomarius, S. Komi-Sirviö (Eds.), Product Focused Software Process Improvement. XIII, 588 pages. 2005.

Vol. 3546: T. Kanade, A. Jain, N.K. Ratha (Eds.), Audio- and Video-Based Biometric Person Authentication. XX, 1134 pages. 2005.

Vol. 3544: T. Higashino (Ed.), Principles of Distributed Systems. XII, 460 pages. 2005.

Vol. 3543: L. Kutvonen, N. Alonistioti (Eds.), Distributed Applications and Interoperable Systems. XI, 235 pages. 2005.

Vol. 3542: H.H. Hoos, D.G. Mitchell (Eds.), Theory and Applications of Satisfiability Testing. XIII, 393 pages. 2005.

Vol. 3541: N.C. Oza, R. Polikar, J. Kittler, F. Roli (Eds.), Multiple Classifier Systems. XII, 430 pages. 2005.

Vol. 3540: H. Kalviainen, J. Parkkinen, A. Kaarna (Eds.), Image Analysis. XXII, 1270 pages. 2005.

Vol. 3539: K. Morik, J.-F. Boulicaut, A. Siebes (Eds.), Local Pattern Detection. XI, 233 pages. 2005. (Subseries LNAI).

Vol. 3538: L. Ardissono, P. Brna, A. Mitrovic (Eds.), User Modeling 2005. XVI, 533 pages. 2005. (Subseries LNAI).

Vol. 3537: A. Apostolico, M. Crochemore, K. Park (Eds.), Combinatorial Pattern Matching. XI, 444 pages. 2005.

Vol. 3536: G. Ciardo, P. Darondeau (Eds.), Applications and Theory of Petri Nets 2005. XI, 470 pages. 2005.

Vol. 3535: M. Steffen, G. Zavattaro (Eds.), Formal Methods for Open Object-Based Distributed Systems. X, 323 pages. 2005.

Vol. 3534: S. Spaccapietra, E. Zimányi (Eds.), Journal on Data Semantics III. XI, 213 pages. 2005.

Vol. 3533: M. Ali, F. Esposito (Eds.), Innovations in Applied Artificial Intelligence. XX, 858 pages. 2005. (Subseries LNAI).

Vol. 3532: A. Gómez-Pérez, J. Euzenat (Eds.), The Semantic Web: Research and Applications. XV, 728 pages. 2005.

Vol. 3531: J. Ioannidis, A. Keromytis, M. Yung (Eds.), Applied Cryptography and Network Security. XI, 530 pages. 2005.

Vol. 3530: A. Prinz, R. Reed, J. Reed (Eds.), SDL 2005: Model Driven. XI, 361 pages. 2005.

Vol. 3528: P.S. Szczepaniak, J. Kacprzyk, A. Niewiadomski (Eds.), Advances in Web Intelligence. XVII, 513 pages. 2005. (Subseries LNAI).

Vol. 3527: R. Morrison, F. Oquendo (Eds.), Software Architecture. XII, 263 pages. 2005.

Preface

This volume contains the papers presented at CONCUR 2005, the 16th International Conference on Concurrency Theory. The purpose of the CONCUR series of conferences is to bring together researchers, developers, and students in order to advance the theory of concurrency and to promote its applications. This year's conference was in San Francisco, California, from August 23 to August 26.

We received 100 submissions in response to a call for papers. Each submission was assigned to at least three members of the Program Committee; in many cases, reviews were solicited from outside experts. The Program Committee discussed the submissions electronically, judging them on their perceived importance, originality, clarity, and appropriateness to the expected audience. The Program Committee selected 38 papers for presentation. Because of the format of the conference and the high number of submissions, many good papers could not be included. Although submissions were read and evaluated, the papers that appear in this volume may differ in form and contents from the corresponding submissions. It is expected that many of the papers will be further revised and submitted to refereed archival journals for publication.

Complementing the contributed papers, the program of CONCUR 2005 included invited lectures by Rajeev Alur, Luca Cardelli, Dawson Engler, and Christos Papadimitriou. Rajeev Alur's and Dawson Engler's lectures were jointly for CONCUR 2005 and SPIN 2005, one of 11 affiliated workshops that enhanced the program:

- BioCONCUR: Concurrent Models in Molecular Biology
- DisCoVeri: Distributed Algorithms Meet Concurrency Theory
- EXPRESS: Expressivity in Concurrency
- FIT: Foundations of Interface Technology
- FOCLASA: Coordination Languages and Software Architectures
- GETCO: Geometric and Topological Methods in Concurrency
- GT-VC: Graph Transformation for Verification and Concurrency
- INFINITY: Verification of Infinite-State Systems
- MoChArt: Model Checking and Artificial Intelligence
- SecCo: Security Issues in Concurrency
- SPIN: Model Checking of Software

We would like to thank the members of the Program Committee for their hard and expert work. We would also like to thank the CONCUR Steering Committee, the workshop organizers, the external reviewers, the authors, and the local organizers for their contributions to the success of the conference. Finally, we gratefully acknowledge the generous support received from Cisco Systems and from Microsoft Research.

Martín Abadi and Luca de Alfaro

CONCUR Steering Committee

CONCUR 2005 Organization

General Chair

Luca de Alfaro (University of California, Santa Cruz)

Program Committee Chairs

Martín Abadi (University of California, Santa Cruz)
Luca de Alfaro (University of California, Santa Cruz)

Program Committee

Christel Baier (Universität Bonn)
Jos Baeten (Eindhoven University of Technology)
Albert Benveniste (IRISA/INRIA)
Luis Caires (Universidade Nova de Lisboa)
Giuseppe Castagna (CNRS/École Normale Supérieure)
Marsha Chechik (University of Toronto)
Vincent Danos (CNRS/Université Paris VII)
Javier Esparza (University of Stuttgart)
Cédric Fournet (Microsoft Research, Cambridge)
Dimitra Giannakopoulou (NASA Ames Research Center)
Anna Ingólfsdóttir (Aalborg University)
Radha Jagadeesan (DePaul University)
Bengt Jonsson (Uppsala University)
Antonin Kucera (Masaryk University)
Orna Kupferman (Hebrew University)
Cosimo Laneve (Università di Bologna)
Kim Larsen (Aalborg University)
John Mitchell (Stanford University)
Ugo Montanari (Università di Pisa)
Catuscia Palamidessi (INRIA Futurs and LIX)
Prakash Panangaden (McGill University)
Shaz Qadeer (Microsoft Research, Redmond)
Vijay Saraswat (IBM T.J. Watson Research Center)
Vladimiro Sassone (University of Sussex)
Philippe Schnoebelen (CNRS/École Normale Supérieure de Cachan)
Frits Vaandrager (Radboud University Nijmegen)
Mahesh Viswanathan (University of Illinois at Urbana-Champaign)
Igor Walukiewicz (Université Bordeaux)
Glynn Winskel (University of Cambridge)

External Reviewers

Samy Abbes, Parosh Abdulla, Luca Aceto, Karine Altisen, Rajeev Alur, Paul Camille Attie, Eric Badouel, Michael Baldamus, Paolo Baldan, Emmanuel Beffara, Nick Benton, Bernard Berthomieu, Karthik Bhargavan, Stefano Bistarelli, Bruno Blanchet, Bernard Boigelot, Mikolaj Bojanczyk, Marcello Bonsangue, Michele Boreale, Ahmed Bouajjani, Gérard Boudol, Patricia Bouyer, Claus Brabrand, Tomáš Brázdil, Roberto Bruni, Peter Buchholz, Nadia Busi, Thierry Cachat, Marco Carbone, Rohit Chadha, Thomas Colcombet, Giovanni Conforti, Ricardo Corin, Flavio Corradini, Scott Cotton, Jean-Michel Couvreur, Silvia Crafa, Cas Cremers, Philippe Darondeau, Johan de Kleer, Yannick Delbecque, Yuxin Deng, Rocco De Nicola, Ewen Denney, Josée Desharnais, Erik de Vink, Ellie D'Hondt, Maria Rita di Berardini, Eric Fabre, Ulrich Fahrenberg, Alessandro Fantechi, Harald Fecher, Jérôme Feret, Marcelo Fiore, Emmanuel Fleury, Riccardo Focardi, Wan Fokkink, Pierre Ganty, Simon Gay, Blaise Genest, Mihaela Gheorghiu, Hugo Gimbert, Patrice Godefroid, Jens Chr. Godskesen, Georges Gonthier, Valentin Goranko, Andy Gordon, Daniele Gorla, Roberto Gorrieri, Vineet Gupta, Arie Gurfinkel, Stefan Haar, Frédéric Herbreteau, Thomas Hildebrandt, Dan Hirsch, Loïc Hélouët, Hans Hüttel, Bertrand Jeannet, Ole Jensen, Ken Kahn, Apu Kapadia, Christos Karamanolis, Yannis Kassios, Joost-Pieter Katoen, Lionel Khalil, Josva Kleist, Bartek Klin, Pavel Krčál, Steve Kremer, Jean Krivine, Karl Krukow, Viraj Kumar, Celine Kuttler, Barbara König, Anna Labella, Albert Lai, Yassine Lakhnech, Leslie Lamport, Ivan Lanese, François Laroussinie, Sławomir Lasota, Olivier Laurent, François Laviolette, Jamey Leifer, Didier Lime, Markus Lohrey, Etienne Lozes, Michael Luttenberger, Bas Luttik, Parthasarathy Madhusudan, Matteo Maffei, Andrea Maggiolo Schettini, Pritha Mahata, Ka Lok Man, Richard Mayr, Hernan Melgratti, Paul-André Melliès, José Meseguer, Marius Mikucionis, Michael Mislove, MohammadReza Mousavi, Venkatesh Mysore, Shiva Nejati, Uwe Nestmann, Mogens Nielsen, Marcus Nilsson, Dirk Nowotka, Luke Ong, Simona Orzan, Joel Ouaknine, Joachim Parrow, Corina Pasareanu, Dusko Pavlovic, Radek Pelánek, Paul Pettersson, Henrik Pilegaard, Michele Pinna, Damien Pous, Vinayak Prabhu, Rosario Pugliese, Sriram Rajamani, Julian Rathke, Martin Raussen, Antonio Ravara, Laurent Regnier, Michel Reniers, Arend Rensink, Shamim Ripon, Bill Rounds, Vojtěch Řehák, Mayank Saksena, Simonas Saltenis, Davide Sangiorgi, Zdeněk Sawa, Alan Schmitt, Johann Schumann, Stefan Schwoon, Koushik Sen, Pawel Sobocinski, Ana Sokolova, Jiří Srba, Sam Staton, Alin Stefanescu, Marielle Stoelinga, Oldřich Stražovský, Jan Strejček, Grégoire Sutre, Dejvuth Suwimonteerabuth, David Teller, P.S. Thiagarajan, Simone Tini, Tayssir Touili, Nikola Trčka, Stavros Tripakis, Bruno Tuffin, Emilio Tuosto, Franck van Breugel, Rob van Glabbeek, Michiel van Osch, Daniele Varacca, Abhay Vardhan, Moshe Y. Vardi, Björn Victor, Aymeric Vincent, Ramesh Viswanathan, Hagen Völzer, Tomáš Vojnar, Marc Voorhoeve, Sergei Vorobyov, Ou Wei, Lucian Wischik, Kidane Yemane, Wang Yi, Mingsheng Ying, Francesco Zappa Nardelli, Gianluigi Zavattaro, Axelle Ziegler, W.M. Zuberek

Local Organizers

Bo Adler, Leandro Dias Da Silva, Marco Faella, Jessica Gronski, Teresa La Femina, Axel Legay

Table of Contents

Invited Lectures

Contributed Papers

Static Analysis Versus Model Checking for Bug Finding

Dawson Engler

Computer Systems Laboratory,
Stanford University,
Stanford, CA 94305, U.S.A

Abstract. This talk tries to distill several years of experience using both model checking and static analysis to find errors in large software systems. We initially thought that the tradeoffs between the two was clear: static analysis was easy but would mainly find shallow bugs, while model checking would require more work but would be strictly better — it would find more errors, the errors would be deeper and the approach would be more powerful. These expectations were often wrong. This talk will describe some of the sharper tradeoffs between the two, as well as a detailed discussion of one domain — finding errors in file systems code — where model checking seems to work very well.

M. Abadi and L. de Alfaro (Eds.): CONCUR 2005, LNCS 3653, p. 1, 2005.

The Benefits of Exposing Calls and Returns

Rajeev Alur

University of Pennsylvania

Regular languages have robust theoretical foundations leading to numerous applications including model checking. Context-free languages and pushdown automata have been indispensable in program analysis due to their ability to model control flow in procedural languages, but the corresponding theory is fragile. In particular, non-closure under intersection and undecidability of the language inclusion problem disallows context-free specifications in model checking applications.

In the recently proposed definition of *visibly pushdown languages*, the set of input symbols is partitioned into *calls*, *returns*, and *local* symbols, and the type of the input symbol determines when the pushdown automaton can push or pop or swap. Exposing the matching structure of calls and returns is natural in associating a language with a sequential block-structured program or a document format with nested tags. When calls and returns are exposed in this manner, the language can be defined by a (stackless) finite-state *alternating* automaton that can jump from a call to the matching return. The resulting class of VPLs has many appealing theoretical properties:

Closure Properties: it is closed under a variety of operations such as union, intersection, complementation, renaming, concatenation, and Kleene-$*$;

Robustness: it has multiple equivalent characterizations using context-free grammars, using the monadic second order (MSO) theory over words augmented with a binary matching predicate, and using Myhill-Nerode-like characterization by syntactic congruences;

Decidability: problems such as language inclusion and equivalence are decidable for visibly pushdown automata (VPA);

Determinization: nondeterministic VPAs can be determinized;

Minimization: under some restrictions, deterministic VPAs can be minimized yielding a canonical VPA; and

ω-VPLs: most of the results generalize to the class of languages over infinite words defined by visibly pushdown automata with Büchi acceptance condition.

After reviewing the theory of VPLs, we show how it allows enhancing the expressiveness of specification languages used in software model checking. The *temporal logic of calls and returns* (CaRet) integrates Pnueli-style temporal modalities with Hoare-style reasoning by pre/post conditions, in a single algorithmic framework. Besides the standard global temporal modalities, CaRet admits the *local-next operator* that allows a path to jump from a call to the *matching* return. This operator can be used to specify a variety of non-regular properties such as

M. Abadi and L. de Alfaro (Eds.): CONCUR 2005, LNCS 3653, pp. 2–3, 2005.