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Verified Software: Theories, Tools, Experiments

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Volume Editors

Bertrand Meyer
ETH Zurich, Department of Computer Science
Clausiusstr. 59, 8092 Zurich, Switzerland
E-mail: bertrand.meyer@inf.ethz.ch

Jim Woodcock
University of York, Department of Computer Science
Heslington, York YO10 5DD, UK
E-mail: jim@cs.york.ac.uk

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Preface

A Step Towards Verified Software

Worries about the reliability of software are as old as software itself; techniques for allaying these worries predate even James King's 1969 thesis on "A program verifier." What gives the whole topic a new urgency is the conjunction of three phenomena: the blitz-like spread of software-rich systems to control ever more facets of our world and our lives; our growing impatience with deficiencies; and the development—proceeding more slowly, alas, than the other two trends—of techniques to ensure and verify software quality.

In 2002 Tony Hoare, one of the most distinguished contributors to these advances over the past four decades, came to the conclusion that piecemeal efforts are no longer sufficient and proposed a "Grand Challenge" intended to achieve, over 15 years, the production of a *verifying compiler*: a tool that while processing programs would also guarantee their adherence to specified properties of correctness, robustness, safety, security and other desirable properties. As Hoare sees it, this endeavor is not a mere research project, as might normally be carried out by one team or a small consortium of teams, but a momentous endeavor, comparable in its scope to the successful mission to send a man to the moon or to the sequencing of the human genome. It requires a cogent agenda with both scientific and engineering components; support from the scientific community and from governments; and the collaboration of many groups, spread across many countries and including many specialties, for the advancement of a common goal.

VSTTE — the first conference on Verified Software: Theories, Tools, Experiments —(http://vstte.ethz.ch) was the launching event for this undertaking. Held at ETH Zurich in October of 2005, the conference gathered about 100 participants, the elite of software verification from a dozen countries. The conference was by invitation only. Although of course not every top expert could be invited, and not all who were invited could come, the attendee list makes up a sample of the best work currently being pursued in software verification. The present volume is the record of this memorable event.

We have not just gathered the position papers contributed by most of the participants. Attendees of scientific conferences know well that the benefit does not just come from formal paper presentations; question-and-answer sessions after talks are another prime source of insights, especially with participants as distinguished as those of VSTTE. In an effort to increase the attraction of this book for readers who were not in Zurich, we recorded the discussions and include the transcripts here (with the exclusion of some sessions with no associated paper). To preserve the spontaneity of these exchanges, we have kept the editing to a minimum, essentially removing a few superfluous comments. (Because the process took some time, it also serves as our excuse for the delay between the conference and the present publication.) We hope that you will enjoy the added value of this material, and perhaps even that you will at times feel like you are actually attending a live VSTTE session, including the occasional inaudible comment.

From "Exclusive ors" to Conjunction

The field of software verification has long been marked by competition between approaches, often resulting in binary oppositions—view A vs. view B. The oppositions still exist, and help define a rough multi-dimensional classification of the techniques represented at VSTTE and elsewhere; in attempting this classification, however, we should note that the variants along each dimension are increasingly recognized as complementary rather than exclusive. Software verification is sufficiently hard that a Grand Challenge effort must glean help from every good idea.

The first distinction pits *management*-oriented approaches against those based on *technology*. VSTTE was technology-oriented and this volume emphasizes the latter kind, but you will find occasional references to project management, the political context, model-driven development, process models and the like. Bad management can be as effective as bad technology in destroying software quality. In the rest of this discussion we limit ourselves to technical aspects.

A thick line has long divided proponents of *constructive* approaches to software construction from people who understand "verification" in the same way Reagan did in his reaction to Gorbachev's arms-reduction promises: "Trust, but *verify*." This division can also be called "a priori vs. a posteriori": build the software right, in the Dijkstra tradition of *A Discipline of Programming*, continued today by such techniques as proof-supported refinement, well represented in this volume; or scrutinize the result, with the help of powerful tools, for possible quality violations. This is an example of where opposition tends nowadays to yield to convergence: we need the best techniques to produce software that will have no bugs; and the best techniques to find any bugs that, all these efforts notwithstanding, still slip through the cracks.

Also prominent in this volume is the contrast between authors who concern themselves mostly with *specification*, often to the point of dismissing the advances of modern programming languages, and those who work at the implementation level, using these very programming languages as their basic tool. Even that conflict is not as irreducible as it sounds, since effective approaches using specification languages must go all the way to implementation, and advances in programming languages bring them to a level of abstraction not so far removed from the realm of specification.

The next opposition is between *static* approaches, which work on the basis of the software text only, and *dynamic* ones which require its execution. Examples of the first category are static analysis and proofs; the primary example of the second is testing. Although VSTTE did not prominently feature work on testing, this approach has made significant progress in recent years, and researchers are increasingly recognizing what software practitioners have known for years: that testing is today, and will remain for a long time, a key part of almost any effort to produce quality software.

Among static approaches, you will note the contrast between *full proofs* of correctness, which for any significant software system must command the support of powerful computer-based proof systems (the authors of several of the most famous of these tools were present at VSTTE and contributed to this volume), and *static analysis*, a term that generally describes ascertaining more partial properties of the software. Static analysis uses tools too, sometimes even the same theorem provers.

This is one more distinction that tends to get blurred, as the successes of partial static analysis continue to expand the scope and ambition of the properties they assess.

The distinction between static and dynamic approaches might seem to defy such blurring; but that too would be a wrong guess. The testing community's long-time differences with the advocates of proofs are fading out; a successor conference series of VSTTE, Tests And Proofs (TAP, http://tap.ethz.ch), launched at ETH Zurich in 2007, explores this new convergence. Also significant is the growing popularity of *model checking*, a technique that has enjoyed considerable successes in recent years, first with hardware verification and now with software. Model checking is similar to exhaustive testing in that it attempts to explore all execution paths of a program; but it does so on a simplified version of the program (to make the search tractable) and uses advanced proof techniques to limit the search space and make the results significant. One may further contrast model checking with *abstract interpretation*, also used successfully in large industrial projects; here too, some of the key contributors to both approaches were active participants in the conference and this book.

Competition turning into cooperation, "exclusive or" replaced by "and," initial contradictions revealing complementarity the deeper one digs: this could be the theme of the present book. By exploring the authors' often contrasted contributions, you will discover both the multiplicity of viewpoints that exist today in the field of software verification and the numerous common themes and solutions that justify Tony Hoare's injunction: to join forces and all get to work together.

Acknowledgments. Many people made VSTTE and this volume possible. As Program Chair, Natarajan Shankar composed and orchestrated the event. We are of course particularly grateful to the authors, panelists and other participants who contributed their best work.

ETH Zurich (as part of its 150th anniversary celebrations) contributed a generous donation; so did Microsoft Research. We are particularly indebted to Professor Meinrad Eberle, coordinator of the ETH 150th anniversary, and Dr. Andrew Herbert, Managing Director of the Microsoft Research center in Cambridge.

ETH provided superb infrastructure and services, allowing in particular the recording of sessions as reflected in this book. The organizing team from the Chair of Software Engineering—Claudia Günthart, Bernd Schoeller, Ilinca Ciupa, Andreas Leitner, Manuel Oriol, Werner Dietl, Adam Darvas, Farhad Mehta, Luc de Louw and a number of student helpers—was essential to the preparation of the conference and its smooth operation, including the recordings. The grueling task of transcribing these recordings was performed with remarkable efficiency by Patrick Schönbach. Claudia Günthart helped put the book in its final form.

Our primary debt is to the two conference Chairs, Tony Hoare and Jay Misra, for not only conceiving the vision but also relentlessly pursuing its realization down to the most practical details, with an energy that never ceases to amaze us all. We hope that readers of this book will feel some of that energy, and share some of the excitement that pervaded every session of the VSTTE conference.

February 2008

Bertrand Meyer
Jim Woodcock

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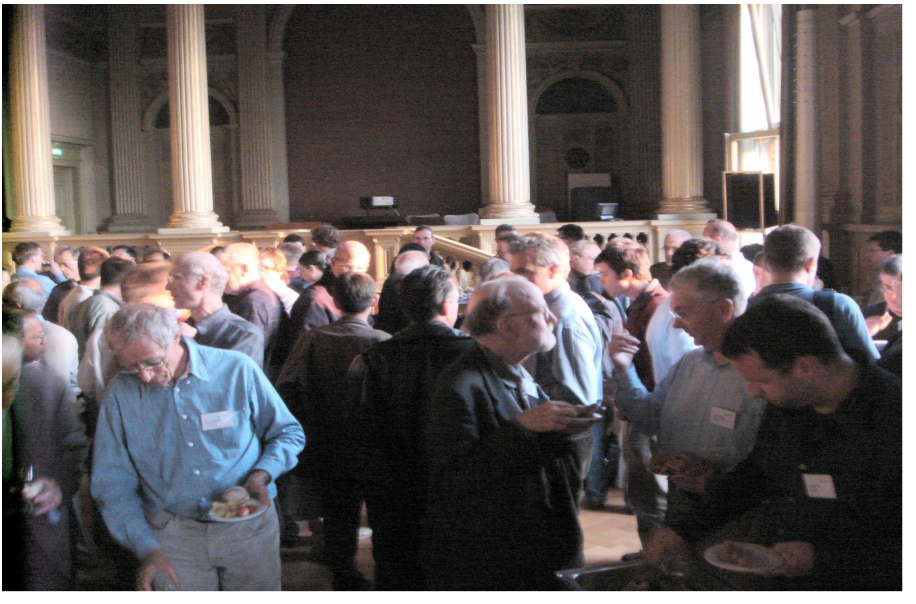
Tony Hoare, opening session

Rajeev Joshi, Joseph Kiniry, Greg Nelson, Natarajan Shankar, Jay Misra, Tony Hoare, closing panel



Welcome party in the historic Semper-Aula of the ETH

Panagiotis Manolios, Wolfgang Paul, Amir Pnueli

Cliff Jones, Connie Heitmeyer

Anthony Hall, Rod Chapman
in the "VSTTE Express" (chartered train to Üetliberg for conference dinner)

Jay Misra, Niklaus Wirth, Tony Hoare

Photographs by Bertrand Meyer

Participants

Jean-Raymond Abrial, ETH Zurich, Switzerland
Rajeev Alur, University of Pennsylvania, USA
Myla Archer, Naval Research Laboratory, USA
Ralph Back, Abo Akademi University, Finland
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David Basin, ETH Zurich, Switzerland
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