Maura Cerioli (Ed.)

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Fundamental Approaches to Software Engineering

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Held as Part of the Joint European Conferences
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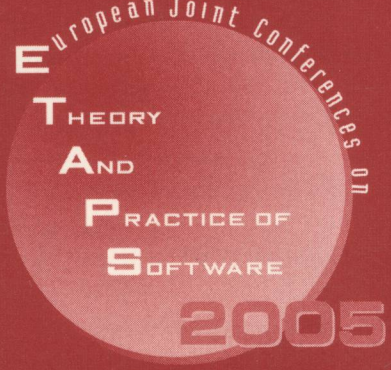
Edinburgh, UK, April 2005, Proceedings



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Foreword

ETAPS 2005 was the eighth instance of the European Joint Conferences on Theory and Practice of Software. ETAPS is an annual federated conference that was established in 1998 by combining a number of existing and new conferences. This year it comprised five conferences (CC, ESOP, FASE, FOSSACS, TACAS), 17 satellite workshops (AVIS, BYTECODE, CEES, CLASE, CMSB, COCV, FAC, FESCA, FINCO, GCW-DSE, GLPL, LDTA, QAPL, SC, SLAP, TGC, UITP), seven invited lectures (not including those that were specific to the satellite events), and several tutorials. We received over 550 submissions to the five conferences this year, giving acceptance rates below 30% for each one. Congratulations to all the authors who made it to the final program! 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.

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.

ETAPS is a loose confederation in which each event retains its own identity, with a separate program 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 2005 was organized by the School of Informatics of the University of Edinburgh, 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 organizing team comprised:

- Chair: Don Sannella
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ETAPS 2005 received support from the University of Edinburgh.

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

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I would like to express my sincere gratitude to all of these people and organizations, the program 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 organizer of ETAPS 2005, Don Sannella. He has been instrumental in the development of ETAPS since its beginning; it is quite beyond the limits of what might be expected that, in addition to all the work he has done as the original ETAPS Steering Committee Chairman and current ETAPS Treasurer, he has been prepared to take on the task of organizing this instance of ETAPS. It gives me particular pleasure to thank him for organizing ETAPS in this wonderful city of Edinburgh in this my first year as ETAPS Steering Committee Chair.

Edinburgh, January 2005

Perdita Stevens
ETAPS Steering Committee Chair

Preface

The conference on Fundamental Approaches to Software Engineering (FASE) is one of the European Joint Conferences on Theory and Practice of Software (ETAPS). As such, it provides a common forum for practitioners and researchers to discuss theories for supporting and improving software engineering practices and their practical application in real contexts.

Contributions were sought targeting both pragmatic concepts and their formal foundations which could lead to new engineering practices and a higher level of reliability, robustness, and evolvability of heterogeneous software federations.

The record submission of 99 research papers and 6 tool demos was the response of the scientific community, with contributions ranging from theoretical aspects, such as graph grammars, graph transformation, agent theory and algebraic specification languages, to applications to industrially used languages, methods, technologies, and tools, including UML, Web services, product lines, component-based development, Java, and Java cards.

The scientific program was complemented by the invited lectures of Gérard Berry on *Esterel v7: from Verified Formal Specification to Efficient Industrial Designs* and of Thomas A. Henzinger on *Checking Memory Safety with Blast.*

The authors of the submissions were from 29 countries, both within Europe (Belgium, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Luxembourg, Macedonia, Portugal, Spain, Sweden, Switzerland, The Netherlands, United Kingdom) and outside (Australia, Brazil, Canada, China, India, Japan, Korea, Pakistan, Russia, Thailand, Tunisia, Turkey, USA). It is a pleasure to note the increasing number of submissions from eastern Europe and from outside Europe altogether, showing that FASE is gaining importance as a world-wide conference.

The help of the Program Committee was invaluable in selecting just 25 papers (3 of them tool demos) from the large number of high-quality submissions, and I take the opportunity to thank warmly all its members and the other referees for supporting the selection process with their precious time.

FASE 2005 was held in Edinburgh, hosted and organized by the School of Informatics of the University of Edinburgh. Next year FASE will take place in Vienna (Austria).

Being part of ETAPS, FASE shares the sponsoring and support described by the ETAPS Chair in the Foreword. Heartfelt thanks are also due to José Fiadeiro and Perdita Stevens for their great efforts in the global ETAPS organization and to Don Sannella and his staff for the wonderful job as local organizers.

Finally, a special thanks to the contributors to and participants of FASE, who in the end are the people making the conference worthwhile.

Genoa, January 2005 Maura Cerioli

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Esterel v7: From Verified Formal Specification to Efficient Industrial Designs

Gérard Berry

Chief Scientist, Esterel Technologies Member, Academie des Sciences

Synchronous languages were developed in the mid-80's specifically to deal with embedded systems. They are based on mathematical semantics and support formal compilation to classical software or hardware languages as well as formal verification. Esterel v7 is a major industrial evolution of the original Esterel synchronous language, mostly directed to complex hardware applications. The language is supported by the Esterel Studio integrated development environment, which provides a smooth path from verifiable executable specification to efficient circuit synthesis. The graphical Safe States Machines derived from Esterel are also used in the SCADE tool which is widely used for safety-critical software applications in avionics.

Through the examples of Esterel v7 and SCADE, we discuss the impact and evolution of formal methods for actual industrial design. In particular, we discuss some issues that are central for actual applications but are usually either not considered as such or viewed as too difficult to handle in research or R&D projects. We demonstrate that the difference between industrial success and failure often lies in precisely these aspects.

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Checking Memory Safety with Blast*

Dirk Beyer[1], Thomas A. Henzinger[1,2], Ranjit Jhala[3], and Rupak Majumdar[4]

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[4] University of California, Los Angeles

Abstract. BLAST is an automatic verification tool for checking temporal safety properties of C programs. Given a C program and a temporal safety property, BLAST statically proves that either the program satisfies the safety property or the program has an execution trace that exhibits a violation of the property. BLAST constructs, explores, and refines abstractions of the program state space based on lazy predicate abstraction and interpolation-based predicate discovery. We show how BLAST can be used to statically prove memory safety for C programs. We take a two-step approach. First, we use CCURED, a type-based memory safety analyzer, to annotate with run-time checks all program points that cannot be proved memory safe by the type system. Second, we use BLAST to remove as many of the run-time checks as possible (by proving that these checks never fail), and to generate for the remaining run-time checks execution traces that witness them fail. Our experience shows that BLAST can remove many of the run-time checks added by CCURED and provide useful information to the programmer about many of the remaining checks.

1 Introduction

Invalid memory access is a major source of program failures. If a program statement dereferences a pointer that points to an invalid memory cell, the program is either aborted by the operating system or, often worse, the program continues to run with an undefined behavior. To avoid the latter, one can perform checks before every memory access at run time. For some programming languages (e.g., Java) this is done automatically by the compiler/run-time environment. For the language C, neither the compiler nor the run-time environment enforces memory-safety policies. CCURED [7, 24] is a program-transformation tool for C which transforms any given C program to a memory-safe version. CCURED uses a type-based program analysis to prove as many memory accesses as possible

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memory safe, and it inserts run-time checks before the remaining memory accesses. The resulting, "cured" C program is memory safe in the sense that it alarms the user if the program was about to execute an unsafe operation. Despite the manyfold advantages of this approach, it has two drawbacks: first, the run-time checks consume additional processor time, and second, the checks give late feedback, just before the program aborts.

We address these two points by combining CCured with a more powerful, path-sensitive program analysis. The additional analysis is performed by the model checker Blast [19]. For each memory access that the type-based analysis of CCured fails to prove safe, we invoke the more precise, more expensive analysis of Blast. There are three possible outcomes. First, Blast may be able to prove that the memory access is safe (even though CCured was not able to prove this). In this case, no run-time check needs to be inserted, thus reducing the overhead in the cured program. Second, Blast may be able to generate an execution trace to an invalid pointer dereference at the considered control location, i.e., an execution trace along which the run-time check inserted by CCured would fail. This may expose a program bug, which can, based on the error trace provided by Blast, then be fixed by the programmer. Third, Blast may time-out attempting to check whether or not a given memory access is always safe. In this case, the run-time check inserted by CCured remains in the cured program. It is important to note that Blast, even though often more powerful than CCured, is not invoked by itself, but only after a type-based pointer analysis fails. This is because where successful, the CCured analysis is more efficient, and it may also succeed in cases that overwhelm the model checker. However, the combination of CCured and Blast guarantees memory-safe programs with less run-time overhead than the use of CCured alone, and it provides useful compile-time feedback about memory-safety violations to the programmer.

Blast performs an abstract reachability analysis to check if a given error location of a C program can be visited during program execution. All paths of the program are checked symbolically and abstractly, by tracking only some relevant facts (called *predicates*) about program variables, instead of the full program state. If a path to the error location is found, the path may be due to the imprecision in the abstraction (a so-called *spurious* counterexample) or it may correspond to a feasible program path (a *genuine* counterexample). In the former case, additional relevant predicates are discovered automatically to remove the spurious error trace. The process is repeated, by tracking an increasing number of predicates, until either a genuine error trace (program bug) is found, or the abstraction is precise enough to prove the absence of error traces. This scheme of counterexample-guided predicate abstraction refinement was first implemented for verifying software by the Slam project [3]. Blast improves on the general scheme in two main ways. First, relevant predicates are discovered locally and independently at each program location as interpolants between the past and the future fragments of a spurious error trace [15]. Second, the discovered new predicates are added and tracked locally only in those parts of an abstract reachability tree where the spurious error trace occurred (*lazy abstraction*) [18]. This