Helmut Seidl (Ed.)

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Foundations of Software Science and Computational Structures

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

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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 Colleque 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 Fritzson, 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:

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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:

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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

The present volume contains the proceedings of the international conference Foundations of Software Science and Computations Structures (FOSSACS) 2007, held in Braga, Portugal, March 26-28, 2007. FOSSACS is an event of the Joint European Conferences on Theory and Practice of Software (ETAPS). The previous nine FOSSACS conferences took place in Lisbon (1998), Amsterdam (1999), Berlin (2000), Genoa (2001), Grenoble (2002), Warsaw (2003), Barcelona (2004), Edinburgh (2005) and Vienna (2006).

FOSSACS presents original papers on foundational research with a clear significance to software science. The Program Committee invited papers on theories and methods to support analysis, synthesis, transformation and verification of programs and software systems. We identified the following topics, in particular: algebraic models, automata and language theory, behavioral equivalences, categorical models, computation processes over discrete and continuous data, infinite state systems computation structures, logics of programs, modal, spatial, and temporal logics, models of concurrent, reactive, distributed, and mobile systems, process algebras and calculi, semantics of programming languages, software specification and refinement, type systems and type theory, fundamentals of security, semi-structured data, program correctness and verification. We ultimately received 103 submissions.

This proceedings volume consists of the abstract of our invited talk together with 25 contributed papers. The contributed papers were selected for publication by the Program Committee during a two-week electronic discussion.

I sincerely thank all the authors of papers submitted to FOSSACS 2007. We were pleased by the number and quality of the submissions. Moreover, I would like to thank the members of the Program Committee for the excellent job they did during the selection process. Clearly, all this would not have been possible without the valuable and detailed reports provided by the sub-reviewers.

To administer submission and evaluation of papers, we relied on the Web-based tool OCS from Dortmund; thanks to Martin Karusseit for his patience and immediate help in cases of emergency. Finally, I would also like to thank the ETAPS 2007 Organizing Committee chaired by João Alexandre Saraiva and the ETAPS Steering Committee for their efficient coordination of all the activities leading up to FOSSACS 2007.

January 2007 Helmut Seidl

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Invited Talk

Contributed Papers

Formal Foundations for Aspects

Radha Jagadeesan

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Abstract. Aspects have emerged as a powerful tool in the design and development of systems. Aspect-orientation ideas are paradigm independent and have been developed for object-oriented, imperative and functional languages.

This talk will discuss a suite of results that aim to level the foundational playing field between aspects and other programming paradigms. In this context, we will argue that aspects are no more intractable than stateful higher order programs.

The talk is based on joint work with Glenn Bruns, Alan Jeffrey, Corin Pitcher and James Riely.

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Sampled Universality of Timed Automata

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Abstract. Timed automata can be studied in not only a dense-time setting but also a discrete-time setting. The most common example of discrete-time semantics is the so called *sampled* semantics (i.e., discrete semantics with a fixed time granularity ε). In the real-time setting, the universality problem is known to be undecidable for timed automata. In this work, we study the universality question for the languages accepted by timed automata with sampled semantics. On the negative side, we show that deciding whether for all sampling periods ε a timed automaton accepts all timed words in ε-sampled semantics is as hard as in the real-time case, i.e., undecidable. On the positive side, we show that checking whether there is a sampling period such that a timed automaton accepts all untimed words in ε-sampled semantics is decidable. Our proof uses clock difference relations, developed to characterize the reachability relation for timed automata in connection with sampled semantics.

1 Introduction

Timed automata [3] are considered as one of the standard models for timed systems. The semantics of these models can be defined over various time domains. The most common one is the set of nonnegative real numbers, giving *dense* time semantics. The dense time semantics allows for the description of how a system behaves at every real-valued time point with arbitrarily fine precision, and thus one needs not consider time granularity in modeling and verification. To study systems which have a fixed granularity of time (e.g., clock cycles), discrete time semantics, and in particular, *sampled* semantics with fixed time step ε are often considered, e.g., [10, 5]. In such a case, the time domain is $\{k \cdot \varepsilon | k \in \mathbb{N}_0\}$, where $\varepsilon = 1/n$ for some $n \in \mathbb{N}$.

In this paper, we study the universality question for the languages accepted by timed automata in sampled semantics. Let A be a timed automaton and $L_\varepsilon(A)$ denote the sampled language accepted by A in the ε-sampled semantics, i.e., the set of timed traces where all events are associated with a timestamp which is $n * \varepsilon$ for some natural number n. More precisely we study the following problems:

1. *Existential timed universality* which is to check whether $L_\varepsilon(\mathcal{A})$ is universal for some sampling period ε.
2. *Universal timed universality* which is to check whether $L_\varepsilon(\mathcal{A})$ is universal for all sampling periods ε.

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