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Mogens Nielsen
Uffe Engberg (Eds.)

Foundations of Software Science and Computation Structures

5th International Conference, FOSSACS 2002
Held as Part of the Joint European Conferences on Theory and Practice of Software, ETAPS 2002
Grenoble, France, April 2002, Proceedings

European Joint Conferences on Theory And Practice of Software 2002

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Foreword

ETAPS 2002 is the fifth 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 comprises five conferences (FOSSACS, FASE, ESOP, CC, TACAS), thirteen satellite workshops (ACL2, AGT, CMCS, COCV, DCC, INT, LDTA, SC, SFEDL, SLAP, SPIN, TPTS and VISS), eight invited lectures (not including those that are specific to the satellite events), and several tutorials.

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 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 programme committee and independent 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 2002 is organized by Laboratoire Verimag in cooperation with

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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, and finally Springer-Verlag for agreeing to publish the ETAPS proceedings. As organiser of ETAPS'98, I know that there is one person that deserves a special applause: Susanne Graf. Her energy and organizational skills have more than compensated for my slow start in stepping into Don Sannella's enormous shoes as ETAPS Steering Committee chairman. Yes, it is now a year since I took over the role, and I would like my final words to transmit to Don all the gratitude and admiration that is felt by all of us who enjoy coming to ETAPS year after year knowing that we will meet old friends, make new ones, plan new projects and be challenged by a new culture! Thank you Don!

Lisbon, January 2002

José Luiz Fiadeiro
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Preface

The present volume contains the proceedings of the international conference *Foundations of Software Science and Computation Structures (FOSSACS) 2002*, held in Grenoble, France, April 10–12, 2002. FOSSACS is an event of the *Joint European Conferences on Theory and Practice of Software (ETAPS)*. The previous four FOSSACS conferences took place in Lisbon (1998), Amsterdam (1999), Berlin (2000), and Genova (2001).

FOSSACS presents papers, which offer progress in foundational research with a clear significance to Software Sciences. Central objects of interest are the algebraic, categorical, logical, and geometric theories, models, and methods which support the specification, synthesis, verification, analysis, and transformation of sequential, concurrent, distributed, and mobile programs and software systems. This volume contains research contributions to a wide spectrum of topics within this scope, many of which are motivated by recent trends and problems in the practice of software and information technology.

These proceedings contain 29 papers. The first one accompanies the invited lecture *Semantical Evaluations as Monadic Second-Order Compatible Structure Transformations* delivered by Bruno Courcelle, University of Bordeaux. The other 28 are contributed papers, selected from a total of 67 submissions. I would like to sincerely thank all members of the FOSSACS 2002 Program Committee for the excellent job they did in the difficult selection process. Also I would like to thank all the sub-referees for their invaluable contributions to this process.

Thanks also to the co-editor of this volume, Uffe H. Engberg, for his assistance in handling and preparing the files for the publisher. And special thanks to Pawel Sobocinski for his excellent administrative handling of the conference web page, the electronic submissions, the reviewing, and the notification process. Thanks also to Rich Gerber for allowing us to use his conference management system START. And finally thanks to the ETAPS 2002 Organizing Committee chaired by Susanne Graf, and the Steering Committee of ETAPS for their efficient coordination of all the activities leading up to FOSSACS 2002.

Aarhus, January 2002

Mogens Nielsen
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Table of Contents

Invited Paper

Contributed Papers

Semantical Evaluations as Monadic Second-Order Compatible Structure Transformations

Bruno Courcelle

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Abstract. A transformation of structures τ is *monadic second-order compatible* (*MS-compatible*) if every monadic second-order property P can be effectively rewritten into a monadic second-order property Q such that, for every structure S, if T is the transformed structure $\tau(S)$, then $P(T)$ holds iff $Q(S)$ holds.
We will review *Monadic Second-order definable transductions* (*MS-transductions*): they are MS-compatible transformations of a particular form, *i.e.*, defined by monadic second-order (MS) formulas.
The unfolding of a directed graph into a tree is an MS-compatible transformation that is not an MS-transduction.
The MS-compatibility of various transformations of semantical interest follows. We will present three main cases and discuss applications and open problems.

Overview of the Lecture

Our working logical language is *Monadic Second-Order Logic*, *i.e.*, the extension of First-Order Logic with variables denoting sets of elements of the considered structures. It enjoys a number of interesting properties regarding decidability and construction of polynomial algorithms [4].

We consider certain semantical evaluations that can be formalized as transformations of discrete structures like graphs or trees (and not as mappings from terms to values belonging to semantical domains as this is usual in denotational semantics).

Our main concern will be to identify transformations such that the verification of an MS property P, of a structure $T = \tau(S)$ reduces to the verification of an MS property Q of the input structure S, where Q depends only on τ and P and, of course, of the fixed relational signatures of S and T.

In such a case, if the MS theory of an infinite structure S is decidable (which means that there exists an algorithm that decides whether a monadic second-order formula is true or not in S), then so is that of $T = \tau(S)$. We say that τ is *Monadic Second-order compatible* (*MS-compatible*).

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Monadic Second-order definable transductions (*MS-transductions* in short) have been surveyed in [2]. The idea is that $T = \tau(S)$ if T is defined by MS formulas inside the structure formed of k disjoint copies of S (where k and these MS formulas are fixed and constitute the logical specification of τ). That an MS-transduction is MS-compatible is pretty clear for those familiar with the notion of interpretation in model theory.

An obvious consequence of the definition is that the size of the domain of $T = \tau(S)$ is at most k times the size of that of S. In particular the *unfolding* operation which transforms a finite graph into an infinite tree is not an MS-transduction. However, the unfolding operation is MS-compatible [3, 6].

Let us consider some examples and their semantical motivations.

Example 1. The structure S is a finite or infinite *transition system*, *i.e.*, a directed labelled graph, given with a special vertex called the *initial state*. The *unfolding* of S from the initial state is a tree (usually infinite), the tree of finite paths starting from the initial state, that represents the behavior of the transition system.

Example 2. S is here a finite or infinite *directed acyclic graph* representing a finite or infinite term with *shared* subterms. Labels attached to vertices and edges make unambiguous the description of such a term by a graph. *Unsharing*, the operation that reconstructs the term, is a special case of unfolding.

As an example of such a graph, we can take $f \rightrightarrows f \rightrightarrows f \rightrightarrows a$ with f a binary function symbol and a a constant.

It unshares into the term $f(f(f(a,a), f(a,a)), f(f(a,a), f(a,a)))$.

By looking at sizes, one can see that unsharing is not an MS-transduction.

Example 3. S is here a *recursive applicative program scheme*, as those considered in [1], and T is the infinite term called an *algebraic tree*. It is the infinite term resulting from a certain form of unfolding, involving term substitutions. Here is an example, consisting of a single equation:

$$\varphi(x) = f(x, \varphi(g(x))$$

This scheme unfolds into the algebraic tree:

$$f(x, f(g(x), f(g(g(x)), f(g(g(g(x))), \ldots)))).$$

The scheme is actually not given by a graph, but a graph representation fitting our formal framework is easy to build. The transformation from graphs representing schemes (consisting of several mutually recursive equations) with function symbols of bounded arity to algebraic trees is MS-compatible. It follows in particular that the MS theory of an algebraic tree is decidable [3, 5].

Example 4. Hyperalgebraic trees are defined as algebraic trees except that the "unknown functions" in schemes may take parameters of function type. Such schemes have been first investigated by W. Damm [7] and more recently by Knapik et al. [8, 9].