David Sands (Ed.)

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Programming Languages and Systems

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Held as Part of the Joint European Conferences
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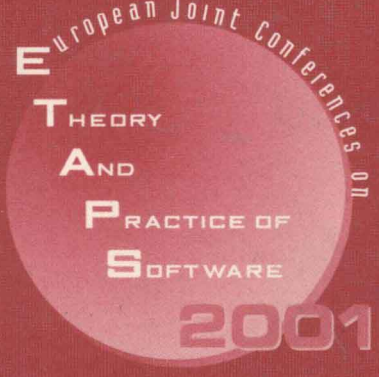
Genova, Italy, April 2001, Proceedings



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Foreword

ETAPS 2001 was the fourth 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 (FOSSACS, FASE, ESOP, CC, TACAS), ten satellite workshops (CMCS, ETI Day, JOSES, LDTA, MMAABS, PFM, RelMiS, UNIGRA, WADT, WTUML), seven invited lectures, a debate, and ten 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 program 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 2001 was hosted by the Dipartimento di Informatica e Scienze dell'Informazione (DISI) of the Università di Genova and was organized by the following team:

Egidio Astesiano (General Chair)
Eugenio Moggi (Organization Chair)
Maura Cerioli (Satellite Events Chair)
Gianna Reggio (Publicity Chair)
Davide Ancona
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with the assistance of Convention Bureau Genova. Tutorials were organized by Bernhard Rumpe (TU München). Overall planning for ETAPS conferences is the responsibility of the ETAPS Steering Committee, whose current membership is:

Egidio Astesiano (Genova), Ed Brinksma (Enschede), Pierpaolo Degano (Pisa), Hartmut Ehrig (Berlin), José Fiadeiro (Lisbon), Marie-Claude Gaudel (Paris), Susanne Graf (Grenoble), Furio Honsell (Udine), Nigel Horspool (Victoria), Heinrich Hußmann (Dresden), Paul Klint (Amsterdam), Daniel Le Métayer (Rennes), Tom Maibaum (London), Tiziana Margaria (Dortmund), Ugo Montanari (Pisa), Mogens Nielsen (Aarhus), Hanne Riis Nielson (Aarhus), Fernando Orejas (Barcelona), Andreas Podelski (Saarbrücken), David Sands (Göteborg), Don Sannella (Edinburgh), Perdita Stevens (Edinburgh), Jerzy Tiuryn (Warsaw), David Watt (Glasgow), Herbert Weber (Berlin), Reinhard Wilhelm (Saarbrücken)

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the Association for Computing Machinery
the European Association for Programming Languages and Systems
the European Association of Software Science and Technology
the European Association for Theoretical Computer Science

and received generous sponsorship from:

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Università di Genova

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, and finally Springer-Verlag for agreeing to publish the ETAPS proceedings.

January 2001

Donald Sannella
ETAPS Steering Committee chairman

Preface

This volume contains the 28 papers presented at ESOP 2001, the Tenth European Symposium on Programming, which took place in Genova, Italy, April 4–6, 2001. The ESOP series began in 1986, and addresses both practical and theoretical issues in the design, specification, and analysis of programming languages and systems.

The call for ESOP 2001 encouraged papers addressing (but not limited to)

- Programming paradigms (including functional, logic, concurrent, and object-oriented) and their integration;
- Semantics with applications to the development of correct, secure, and efficient software and systems;
- Advanced type systems, program analysis, program transformation.

The volume begins with two invited contributions. The first contribution belongs to ETAPS as a whole, and accompanies the "unifying" ETAPS invited talk given by Luca Cardelli. The second contribution is from the ESOP invited speaker, John Mitchell. The remaining 26 papers were selected by the program committee from the 76 submissions, and include one short paper which accompanied a tool-demo presentation.

Each submission was reviewed by at least three referees, and papers were selected in the latter stages of a two week discussion phase. My thanks to the members of the program committee and other referees for their hard work. Thanks also to Christian Probst for help with the conference management software, and to Don Sannella for steering the ETAPS ship so smoothly.

January 2001 David Sands

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Table of Contents

A Query Language Based on the Ambient Logic

Luca Cardelli[1] and Giorgio Ghelli[2]

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Abstract. The ambient logic is a modal logic proposed to describe the structural and computational properties of distributed and mobile computation. The structural part of the ambient logic is, essentially, a logic of labeled trees, hence it turns out to be a good foundation for query languages for semistructured data, much in the same way as first order logic is a fitting foundation for relational query languages. We define here a query language for semistructured data that is based on the ambient logic, and we outline an execution model for this language. The language turns out to be quite expressive. Its strong foundations and the equivalences that hold in the ambient logic are helpful in the definition of the language semantics and execution model.

1 Introduction

This work arises from the unexpected convergence of studies in two different fields: mobile computation and semistructured data.

Unstructured collections, or unstructured data, are collections that do not respect a predefined schema, and hence need to carry a description of their own structure. These are called *semistructured* when one can recognize in them some degree of homogeneity. This partial regularity makes semistructured collections amenable to be accessed through query languages, but not through query languages that have been designed to access fully structured databases. New languages are needed that are able to tolerate the data irregularity, and that can be used to query, at the same time, both data and structure. Semistructured collections are usually modeled in terms of labeled graphs, or labeled trees [3].

The ambient logic is a modal logic proposed to describe the structural and computational properties of distributed and mobile computation [10]. The logic comes equipped with a rich collection of logical implications and equivalences. The structural part of the ambient logic is, essentially, a logic designed to describe properties of labeled trees. It is therefore a good foundation for query languages for semistructured data, much in the same way as first order logic is a fitting foundation for relational query languages. First order logic is a logic of predicates (i.e. relations) and therefore it is particularly suitable to describe relational data. But, to describe tree-shaped data, we need a more suitable logic: a logic of trees or graphs.

This is an invited paper.

D. Sands (Ed.): ESOP 2001, LNCS 2028, pp. 1–22, 2001.

Here we define a query language for semistructured data that is based on the ambient logic, and we outline an execution model for this language. The language turns out to be quite expressive. Its strong foundations and the equivalences that hold in the ambient logic are helpful in the definition of the language semantics and execution model.

The paper is structured as follows. In this section we present a preview of the query language, and compare it with related proposals. In Section 2 we define the tree data model. In Section 3 we present the logic, upon which the query language, defined in Section 4, is defined. In Section 5 we present the evaluation model. In Section 6 we draw some conclusions.

1.1 A Preview

Consider the following bibliography, expressed in the syntax of our language TQL, which we explain in detail later. Informally, $a[F]$ represents a piece of data labeled a with contents F. The contents can be a collection of similar pieces of data, separated by "|". When the collection is empty, we can omit the brackets, so that, for example, $POPL[\,]$ can be written as $POPL$.

The bibliography below consists of a set of references all labeled *article*. Each entry contains a number of *author* fields, a *title* field, and possibly other fields.

$ARTICLES =$

$article[\ author[Cardelli] \mid author[Gordon] \mid title[Anytime\_Anywhere]$
$\quad \mid conference[POPL] \mid year[2000]$
$\quad \mid keyword[Ambient\_Calculus] \mid keyword[Logic]\ ] \mid$

$article[\ author[Cardelli] \mid title[Wide\_Area\_Computation]$
$\quad \mid booktitle[ICALP] \mid year[1999] \mid pages[403\text{-}444] \mid publisher[SV]\ ] \mid$

$article[\ author[Ghelli] \mid author[Pierce] \mid title[Bounded\_Existentials]$
$\quad \mid journal[TCS] \mid year[1998]\ ]$

Suppose we want to find all the papers in *ARTICLES* where one author is *Cardelli*; then we can write the following query:

$from \quad ARTICLES \vDash .article[X]$
$\quad\quad X \vDash .author[Cardelli]$
$select \quad paper[X]$

The query consists of a list of *matching expressions* contained between *from* and *select*, and a *reconstruction expression*, following *select*. The matching expressions bind X with every piece of data that is reachable from the root *ARTICLES* through an *article* path, and such that a path *author* goes from X to *Cardelli*; the answer is $paper[author[Cardelli] \mid author[Gordon] \mid \ldots] \mid paper[author[Cardelli] \mid title[Wide\ Area\ Computation] \mid \ldots]$, i.e. the first two articles in the databases, with the outer *article* rewritten as *paper*.

This query language is characterized by the fact that a matching expression is actually a logic expression combining matching and logical operators. For example, the following query combines path expressions and logical implication