

*Commenced Publication in 1973*

Founding and Former Series Editors:

Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

## Editorial Board

David Hutchison

*Lancaster University, UK*

Takeo Kanade

*Carnegie Mellon University, Pittsburgh, PA, USA*

Josef Kittler

*University of Surrey, Guildford, UK*

Jon M. Kleinberg

*Cornell University, Ithaca, NY, USA*

Alfred Kobsa

*University of California, Irvine, CA, USA*

Friedemann Mattern

*ETH Zurich, Switzerland*

John C. Mitchell

*Stanford University, CA, USA*

Moni Naor

*Weizmann Institute of Science, Rehovot, Israel*

Oscar Nierstrasz

*University of Bern, Switzerland*

C. Pandu Rangan

*Indian Institute of Technology, Madras, India*

Bernhard Steffen

*TU Dortmund University, Germany*

Madhu Sudan

*Microsoft Research, Cambridge, MA, USA*

Demetri Terzopoulos

*University of California, Los Angeles, CA, USA*

Doug Tygar

*University of California, Berkeley, CA, USA*

Gerhard Weikum

*Max Planck Institute for Informatics, Saarbruecken, Germany*

Viktória Zsók Zoltán Horváth  
Rinus Plasmeijer (Eds.)

# Central European Functional Programming School

4th Summer School, CEFP 2011  
Budapest, Hungary, June 14-24, 2011  
Revised Selected Papers

 Springer

## Volume Editors

Viktória Zsók

Eötvös Loránd University, Faculty of Informatics  
Department of Programming Languages and Compilers  
Pázmány Péter Sétány 1/C, 1117 Budapest, Hungary  
E-mail: zsv@inf.elte.hu

Zoltán Horváth

Eötvös Loránd University, Faculty of Informatics  
Department of Programming Languages and Compilers  
Pázmány Péter Sétány 1/C, 1117 Budapest, Hungary  
E-mail: hz@inf.elte.hu

Rinus Plasmeijer

Radboud University, Computer and Information Sciences Institute  
Heyendaalseweg 135, 6525 AJ Nijmegen, The Netherlands  
E-mail: rinus@cs.ru.nl

ISSN 0302-9743

ISBN 978-3-642-32095-8

DOI 10.1007/978-3-642-32096-5

e-ISSN 1611-3349

e-ISBN 978-3-642-32096-5

Springer Heidelberg Dordrecht London New York

Library of Congress Control Number: 2012942467

CR Subject Classification (1998): D.1.1, D.1.3, D.2, D.3.2

LNCS Sublibrary: SL 1 – Theoretical Computer Science and General Issues

© Springer-Verlag Berlin Heidelberg 2012

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable to prosecution under the German Copyright Law.

The use of general descriptive names, registered names, trademarks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

*Typesetting:* Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

# Preface

This volume presents the revised lecture notes of selected talks given at the fourth Central European Functional Programming School, CEFP 2011, held during June 14–24, in Budapest (Hungary) at Eötvös Loránd University, Faculty of Informatics.

The summer school was organized in the spirit of the advanced programming schools. CEFP involves an ever-growing number of students, researchers, and teachers from across Europe, providing opportunities especially for students from Central, and Eastern European countries.

The intensive program offered a creative, inspiring environment for presentations and exchange of ideas on new specific programming topics. The lectures covered a wide range of distributed and multicore functional programming subjects.

We are very grateful to the lecturers and researchers for the time and effort they devoted to their talks and lecture notes. The lecture notes were each carefully checked by reviewers selected from experts on functional programming. The papers were revised by the lecturers based on the reviews. This revision process guaranteed that only high-quality papers were accepted for the volume.

The last two papers in the volume are selected papers of the PhD Workshop organized for the participants of the summer school.

We would like to express our gratitude for the work of all the members of the Program Committee and the Organizing Committee.

The website for the summer school can be found at: <http://plc.inf.elte.hu/cefp/>.

March 2012

Viktória Zsók  
Zoltán Horváth  
Rinus Plasmeijer

# Organization

CEFP 2011 was organized by Eötvös Loránd University, Budapest, Hungary, and Pannonia Tourist Service, Budapest, Hungary.

## Sponsoring Institutions

The summer school was supported by the:

- Erasmus Intensive Programme (IP) Project No. ERA-IP2010/11 10/0242-E/4006
- CEEPUS program via the CEEPUS CII-HU-19 Network
- Ericsson Hungary
- Morgan Stanley Hungary

The scientific editorial process of the summer school proceedings was supported by the European Union and co-financed by the European Social Fund (Grant Agreement no. TAMOP 4.2.1/B-09/1/KMR-2010-0003).

# Table of Contents

A Programming Tutor for Haskell . . . . .	1
<i>Johan Jeuring, Alex Gerdes, and Bastiaan Heeren</i>	
Defining Multi-user Web Applications with iTasks . . . . .	46
<i>Rinus Plasmeijer, Peter Achten, Bas Lijnse, and Steffen Michels</i>	
Reasoning about I/O in Functional Programs . . . . .	93
<i>Andrew Butterfield</i>	
Eden — Parallel Functional Programming with Haskell . . . . .	142
<i>Rita Loogen</i>	
Single Assignment C (SAC): High Productivity Meets High Performance . . . . .	207
<i>Clemens Grelck</i>	
Reasoning about Multi-process Systems with the Box Calculus . . . . .	279
<i>Greg Michaelson and Gudmund Grov</i>	
Parallel and Concurrent Programming in Haskell . . . . .	339
<i>Simon Marlow</i>	
Feldspar: Application and Implementation . . . . .	402
<i>Emil Axelsson and Mary Sheeran</i>	
Static Analysis of Complex Software Systems Implemented in Erlang . . .	440
<i>Melinda Tóth and István Bozó</i>	
Extending Little Languages into Big Systems . . . . .	499
<i>Gábor Páli</i>	
Some New Approaches in Functional Programming Based on Categories . . . . .	517
<i>Viliam Slodičák, Pavol Macko, and Valerie Novitzká</i>	
<b>Author Index</b> . . . . .	<b>533</b>