



MSCS

Mathematical Structures in Computer Science

*A journal in the applications of categorical, algebraic
and geometric methods in Computer Science*

APRIL 2010 VOLUME 20 NUMBER 2

CAMBRIDGE
UNIVERSITY PRESS

EDITOR-IN-CHIEF

Giuseppe Longo

Laboratoire d'Informatique (CNRS) et DI, Ecole Normale Supérieure, 45, Rue D'Ulm, 75005 Paris (France), e-mail: Giuseppe.Longo@ens.fr

ASSOCIATE EDITORS

P. L. Curien

PPS – Case 7014, Université Paris 7, 2 pl. Jussieu, 75251 Paris, Cedex 05, France
e-mail: curien@pps.jussieu.fr

P. J. Scott

Department of Mathematics, University of Ottawa, 585 King Edward, Ottawa,
Ontario K1N 9B4, Canada
e-mail: scpsg@uottawa.ca

EDITORIAL BOARD

E. Asarin LIAFA, France

G. Berry INRIA, France

R. Cockett Department of Computer Science, University of Calgary

T. Coquand Department of Computer Sciences, Chalmers University of
Technology, Göteborg, Sweden

R. De Nicola Università di Firenze

A. Edalat Department of Computing, Imperial College, London

T. Ehrhard Université Denis Diderot, France

H. Ehrig Technische Universität, Berlin

M. Escardo Computer Science, University of Birmingham

Y. Fu Department of Computer Science, Shanghai Jiaotong University

J. Y. Girard CNRS, Laboratoire de Mathématiques Discrètes, 163 Avenue de
Luminy, case 930 13288 Marseille cedex 9

M. Hasegawa Kyoto University, Japan

F. Honsell Dipartimento di Informatica, Università di Udine, Italy

M. Hyland Department of Mathematics, University of Cambridge

M. Kanovich Queen Mary, University of London

S. Lack University of Western Sydney

R. Milner Computer Laboratory, University of Cambridge

M. Mislove Tulane University

E. Moggi Dipartimento di Informatica e Scienze dell'Informazione, Università
di Genova, Italy

U. Montanari Dipartimento de Informatica, Università di Pisa

C. Palamidessi Ecole Polytechnique, France

T. Paul CNRS and Ecole Normale Supérieure, France

B. Pierce University of Pennsylvania

A. Pitts Computer Laboratory, University of Cambridge

G. D. Plotkin Department of Computer Science, University of Edinburgh

A. Scedrov Department of Mathematics, University of Pennsylvania,
Philadelphia

D. S. Scott School of Computer Science, CMU, Pittsburgh, Pennsylvania

R. A. G. Seely Department of Mathematics, John Abbott College,
Montreal, Quebec

P. Selinger Department of Mathematics & Statistics, Dalhousie University,
Halifax, Canada

A. Simpson University of Edinburgh

C. Stirling University of Edinburgh

G. Winskel Computer Laboratory, University of Cambridge

© CAMBRIDGE UNIVERSITY PRESS 2010

SUBSCRIPTIONS. *MSCS-Mathematical Structures in Computer Science* (ISSN: 0960-1295) is published bimonthly in February, April, June, August, October and December by Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 8RU, UK/Cambridge University Press, 40 West 20th Street, New York, N.Y. 10011-4211. The subscription price (excluding VAT) of Volume 20, 2010, which includes print and electronic access, is £470 net (UK), (USA, Canada and Mexico US \$885). The electronic-only price available to institutional subscribers is £425 (USA, Canada and Mexico US \$775). Single parts cost £79 net (USA, Canada and Mexico US \$148). Prices include delivery by air. Six parts form a volume. EU subscribers (outside the UK) who are not registered for VAT should add VAT at their country's rate. VAT registered subscribers should provide their VAT registration number. Orders, which must be accompanied by payment, may be sent to any bookseller, subscription agent or to the publisher: Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 8RU, or in the USA, Canada and Mexico to Cambridge University Press, Journals Fulfillment Department, 100 Brook Hill Drive, West Nyack, New York 10994-2133. Japanese prices for institutions are available from Kinokuniya Company Ltd, P.O. Box 55, Chitose, Tokyo 156, Japan. Periodicals postage is paid at New York, NY and at additional mailing offices.

POSTMASTER: send address changes in USA, Canada and Mexico to *MSCS-Mathematical Structures in Computer Science*, Cambridge University Press, 100 Brook Hill Drive, West Nyack, New York 10994-2133.

Claims for missing issues should be made immediately on receipt of the subsequent issue.

INTERNET ACCESS. This journal is included in the Cambridge Journals Online service which can be found at <http://journals.cambridge.org>. For further information on other Press titles access <http://www.cambridge.org>.

COPYING. This journal is registered with the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, USA. Organisations in the USA who are also registered with the C.C.C. may therefore copy material (beyond the limits permitted by sections 107 and 108 of the US copyright law) subject to payment to C.C.C. of the per-copy fee of \$16.00. This consent does not extend to multiple copying for promotional or commercial purposes. Code 0960-1295/2010 \$16.00.

ISI Tear Sheet Service, 3501 Market Street, Philadelphia, Pennsylvania 19104, USA, is authorised to supply single copies of separate articles for private use only.

Organisations authorised by the Copyright Licensing Agency may also copy material subject to the usual conditions.

For all other use, permission should be sought from Cambridge or the American branch of Cambridge University Press.

This journal issue has been printed on FSC-certified paper and cover board. FSC is an independent, non-governmental, not-for-profit organization established to promote the responsible management of the world's forests. Please see www.fsc.org for information.

Printed in the United Kingdom at the University Press, Cambridge.