



MSCS

Mathematical Structures in Computer Science

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

DECEMBER 1996 VOLUME 6 NUMBER 6

Cambridge University Press



EDITOR-IN-CHIEF

Giuseppe Longo

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

ASSOCIATE EDITORS

P. L. Curien

LIENS, 45 rue d'Ulm, 75230 Paris, Cedex 05, France
e-mail: curien@dmi.ens.fr

EDITORIAL BOARD

S. Abramsky

Department of Computer Science, University of Edinburgh

M. Barr

Department of Mathematics, McGill University, Montreal, Quebec

G. Berry

Ecole des Mines, Valbonne, France

H. Ehrig

Technische Universität, Berlin

P. J. Freyd

Department of Mathematics, University of Pennsylvania, Philadelphia

J. Y. Girard

CNRS, Laboratoire de Mathématiques Discrete, 163 Avenue de Luminy,
case 930 13288 Marseille cedex 9

J. Goguen

Computing Laboratory, Oxford University

S. Hayashi

Department of Computer & Systems Engineering, Kobe University, Kobe, Japan

C. A. R. Hoare

Computing Laboratory, Oxford University

M. Hyland

Department of Mathematics, University of Cambridge

J. Lambek

Department of Mathematics, McGill University, Montreal, Quebec

R. Milner

Computer Laboratory, University of Cambridge

G. Mints

Department of Philosophy, Stanford University, California

J. C. Mitchell

Computer Science Department, Stanford University, California

A. Pitts

University of Cambridge, Computer Laboratory, New Museums Site,
Pembroke Street, Cambridge CB2 3QG, e-mail: ap@cl.cam.ac.uk

U. Montanari

Dipartimento de Informatica, Università di Pisa

G. D. Plotkin

Department of Computer Science, University of Edinburgh

Vaughan Pratt

Department of Computer Science, Stanford University, California

J. C. Reynolds

School of Computer Science, Carnegie Mellon University, Pittsburgh, Pennsylvania

Vladimir Yu. Sazonov

Institute of Programmable Systems, AS, Russia

A. Scedrov

Department of Mathematics, University of Pennsylvania, Philadelphia

D. S. Scott

School of Computer Science, CMU, Pittsburgh, Pennsylvania

P. J. Scott

Department of Mathematics, University of Ottawa, Ontario

R. A. G. Seely

Department of Mathematics, John Abbott College, Montreal, Quebec

J. Tiuryn

Institute of Mathematics, University of Warsaw

E. G. Wagner

IBM T. J. Watson Research Center, Yorktown Heights, New York

Mitchell Wand

Computer Science Department, Northeastern University, Boston,
Massachusetts

C. Wells

Department of Mathematics and Statistics, Case Western Reserve University,
Cleveland, Ohio

G. Winskel

Computer Science Department, Aarhus University, Denmark

© CAMBRIDGE UNIVERSITY PRESS 1996

SUBSCRIPTIONS. *MSCS-Mathematical Structures in Computer Science* (ISSN: 0960-1295) is published bimonthly in February, April, June, August, October and December. The subscription price (excluding VAT) of Volume 6, 1996, is £144 net (UK), (USA, Canada and Mexico US \$248) post free; single parts cost £26 net (USA, Canada and Mexico US \$44) plus postage. 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 2RU, or in the USA, Canada and Mexico to Cambridge University Press, Journals Department, 40 West 20th Street, New York, NY 10011-4211, USA. Copies of the journal for subscribers in the USA, Canada and Mexico are sent by air to New York to arrive with minimum delay. 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, 110 Midland Avenue, Port Chester, NY 10573-4930, USA.

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

Information on *Mathematical Structures in Computer Science* and all other Cambridge journals can be accessed via <http://www.cup.cam.ac.uk/> and in North America via <http://www.cup.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 \$11.00. This consent does not extend to multiple copying for promotional or commercial purposes. Code 0960-1295/96 \$11.00 + .10.

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.