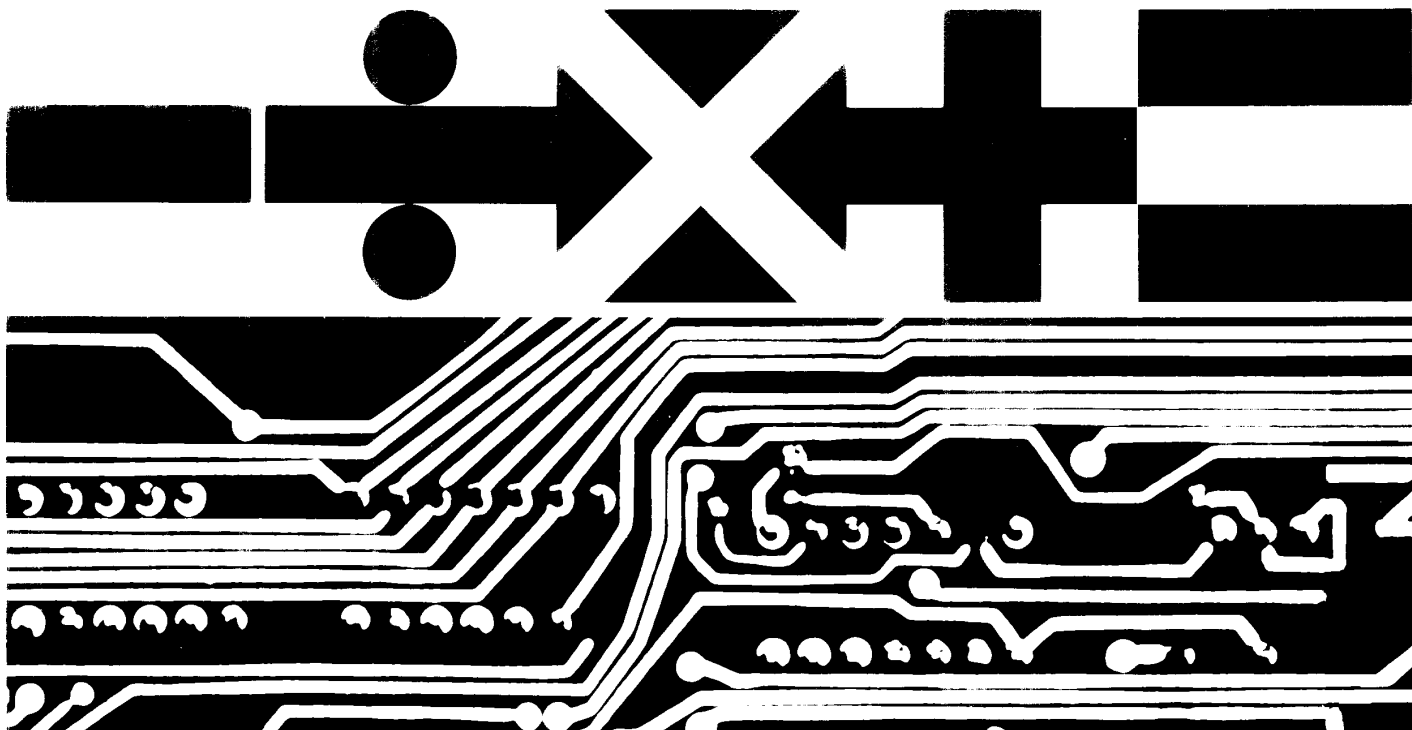


PROCEEDINGS

COMPUTER ARITHMETIC



1951-1991



IEEE COMPUTER SOCIETY PRESS



THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

Proceedings

**10th IEEE Symposium on  
COMPUTER ARITHMETIC**

June 26-28, 1991

Grenoble, France

Edited by:  
Peter Kornerup  
David W. Matula

Sponsored by  
IEEE Computer Society  
IEEE Technical Committee on VLSI

In cooperation with  
Centre National de la Recherche Scientifique (CNRS)  
Institut d'Informatique et de  
Mathématiques Appliquées de Grenoble (IMAG)

1951-1991



IEEE Computer Society Press  
Los Alamitos, California

Washington • Brussels • Tokyo

The papers in this book comprise the proceedings of the meeting mentioned on the cover and title page. They reflect the authors' opinions and, in the interests of timely dissemination, are published as presented and without change. Their inclusion in this publication does not necessarily constitute endorsement by the editors, the IEEE Computer Society Press, or the Institute of Electrical and Electronics Engineers, Inc.



Published by the  
IEEE Computer Society Press  
10662 Los Vaqueros Circle  
PO Box 3014  
Los Alamitos, CA 90720-1264

© 1991 by the Institute of Electrical and Electronics Engineers, Inc. All rights reserved.

Copyright and Reprint Permissions: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limits of US copyright law, for private use of patrons, those articles in this volume that carry a code at the bottom of the first page, provided that the per-copy fee indicated in the code is paid through the Copyright Clearance Center, 29 Congress Street, Salem, MA 01970. Instructors are permitted to photocopy, without fee, isolated articles for noncommercial classroom use. For other copying, reprint, or republication permission, write to the Director of Publishing Services, IEEE, 345 East 47th Street, New York, NY 10017.

IEEE Computer Society Press Number 2151  
IEEE Catalog Number 91CB0013-5  
Library of Congress Number 88-6-1437  
ISBN 0-8186-9151-4 (casebound)  
ISBN 0-7803-9187-0 (library binding)  
ISBN 0-8186-0151-8 (microform)

#### Additional copies can be ordered from

IEEE Computer Society Press  
Customer Service Center  
10662 Los Vaqueros Circle  
PO Box 3014  
Los Alamitos, CA 90720-1264

IEEE Service Center  
445 Hoes Lane  
PO Box 1331  
Piscataway, NJ 08855-1331

IEEE Computer Society  
13, avenue de l'Aquilon  
B-1200 Brussels  
BELGIUM

IEEE Computer Society  
Ooshima Building  
2-19-1 Minami-Aoyama  
Minato-ku, Tokyo 107  
JAPAN

Editorial production: Wally Hutchins

Printed in the United States of America by Braun-Brumfield, Inc.



THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

# Symposium Committee

## General Chairman

Jean-Michel Muller  
*LIP-IMAG, École Normale Supérieure de Lyon*

## Program Co-Chairmen

Peter Komerup  
*Odense University, Denmark*  
David W. Matula  
*Southern Methodist University, Dallas, TX*

## Program Committee

M.A. Bayoumi, *Univ. of Southwestern Louisiana, LA*  
T.M. Carter, *University of Utah, UT*  
L. Ciminiera, *Politecnico di Torino, Italy*  
W.J. Cody, *Argonne Nat. Laboratory, IL*  
M.D. Ercegovac, *UCLA, CA*  
J. Fandrianto, *Integrated Information Technology, CA*  
W.E. Ferguson, *Cyrix Corp., Dallas, TX*  
T.E. Hull, *University of Toronto, Canada*  
M. Iri, *University of Tokyo, Japan*  
M-J. Irwin, *Penn. State, PA*  
G.A. Jullien, *University of Windsor, Canada*  
S. Knowles, *INMOS, Great Britain*  
U. Kulisch, *Universität Karlsruhe, Germany*  
J-M. Muller, *LIP-IMAG, Lyon, France*  
S.M. Rump, *Tech. Univ. Hamburg-Harburg, Germany*  
H.J. Sips, *Delft Tech. Univ., The Netherlands*  
R. Stefanelli, *Politecnico di Milano, Italy*  
E.E. Swartzlander, *University of Texas at Austin, TX*  
N. Takagi, *Kyoto University, Japan*  
G. Taylor, *MIPS, CA*  
P.R. Turner, *U.S. Naval Academy, MD*  
J. Vignes, *Univ. Pierre et Marie Curie, France*  
J. Vuillemin, *DEC-PRL, France*

## Local Arrangements

Jean-Michel Muller  
*LIP-IMAG, École Normale Supérieure de Lyon*

## List of Referees

Alt, R.  
Bayoumi, M.A.  
Birman, M.  
Bischof  
Bohlender, G.  
Briggs, W.S.  
Buchanani, J.L.  
Burgess, N.  
Carter, T.M.  
Chen, H.  
Chow, E.T.  
Ciminiera, L.  
Cody, W.J.  
Coonen, J.T.  
Cosnard, M.  
Dadda, L.  
Deprettere, E.F.  
Ercegovac, M.D.  
Fandrianto, J.  
Ferguson, W.  
Fraigniaud, P.  
Frandsen, G.  
Franklin, C.  
Gavrielov, M.  
Gladwell, I.  
Gonnella, J.  
Guyot, A.  
Hannon, G.  
Hekstra, H.  
Hinton  
Hull, T.E.  
Hutchings, B.  
Iri, M.  
Irwin, M-J.  
Jansson, C.  
Johansen, S.P.  
Jullien, G.  
Karageorgis, A.  
Kelliher  
Knowles, S.  
Kornerup, P.  
Kulisich, U.  
Lang, T.  
Lewis  
Lin, H.  
Lozier, D.  
M-Nielsen, P.  
Matula, D.W.  
Montuschi, P.  
Muller, J-M.  
Murota, K.  
Neff, R.  
Okabe, Y.  
Olver, F.W.J.  
Overbeek, R.  
Owens, R.M.  
Parikh, S.  
Piuri, V.  
Privat, G.  
Quach, N.  
Rump, S.M.  
Santoro, M.  
Seetharaman, G.  
Silverman, R.  
Sips, H.  
Skavantzios, A.  
Srinivasan, P.  
Stefanelli, R.  
Sturges, A.  
Swartzlander, E.  
Takagi, N.  
Tang, P.T.P.  
Taylor, G.  
Teufel, T.  
Turner, P.R.  
van Westrheuen, S.C.  
Vignes, J.  
Vishwanath, V.  
Vuillemin, J.  
Vuong, I.  
Wigley, N.W.  
Woods, R.  
Yamahata, H.  
Yves, R.

# Previous IEEE Symposia on Computer Arithmetic

1. June 16, 1969  
One-day workshop  
preceding the IEEE Computer Group Conference  
Minneapolis, MN  
Organized by R.R. Shively
2. May 15-16, 1972  
One-and-a-half-day symposium (SCA-2)  
University of Maryland, College Park, MD  
Organized by H.L. Garner and D.E. Atkins
3. Nov. 19-20, 1975  
Two-day symposium (SCA-3)  
Southern Methodist University, Dallas, TX  
Organized by T.R.N. Rao and D.W. Matula
4. Oct. 25-27, 1978  
Two-and-a-half-day symposium (SCA-4)  
UCLA, Los Angeles, CA  
Organized by A. Avizienis and M.D. Ercegovac
5. May 18-19, 1981  
Two-day symposium plus tutorial (SCA-5)  
University of Michigan, Ann Arbor, MI  
Organized by K.S. Trivedi and D.E. Atkins
6. June 20-22, 1983  
Three-day symposium (ARITH6)  
Aarhus University, Aarhus, Denmark  
Organized by T.R.N. Rao and P. Kornerup
7. June 4-6, 1985  
Two-and-a-half-day symposium (ARITH7)  
University of Illinois, Urbana, IL  
Organized by K. Hwang, D.D. Gajski, and A. Sameh
8. May 19-21, 1987  
Two-and-a-half-day symposium (ARITH8)  
Villa Olmo, Como, Italy  
Organized by Luigi Dadda, Mary-Jane Irwin,  
and R. Stefanelli
9. Sept. 6-9, 1989  
Two-and-a-half-day symposium (ARITH9)  
Santa Monica, CA  
Organized by A. Avizienis, M.D. Ercegovac,  
and E.E. Swartzlander