



**EDITOR IN CHIEF** 

Gerardo Con Diaz, University of California, Davis condiaz@ucdavis.edu

# **ASSOCIATE EDITOR IN CHIEF**

David Hemmendinger, Union College hemmendd@union.edu

### **ASSOCIATE EDITORS**

Mar Hicks, Illinois Institute of Technology Jeffrey R. Yost, Charles Babbage Institute

### **DEPARTMENT EDITORS**

Anecdotes: Alex Magoun, IEEE History Center

annals-anecdotes@computer.org

Biographies: David Brock, Computer History Museum,

annals-biographies@computer.org

Events and Sightings: annals-es@computer.org Interviews: Dag Spicer, Computer History Museum, annals-interviews@computer.org Reviews: Theodora Dryer, Al Now Institute,

annals-reviews@computer.org

Think Piece: Colette Perold, University of Colorado,

colette.perold@colorado.edu

### FORMER EDITORS IN CHIEF

Bernard A. Galler, 1979–1987 J.A.N. Lee, 1987–1995 Michael R. Williams, 1996–2000 Tim Bergin, 2000–2003 David A. Grier, 2004–2007 Jeffrey R. Yost, 2008–2011 Lars Heide, 2012–2014 Nathan Ensmenger, 2015–2018

# **IEEE ANNALS OF THE HISTORY OF COMPUTING STAFF**

Peer Review Administrator: annals-ma@computer.org Publications Portfolio Manager: Carrie Clark

Publisher: Robin Baldwin

Executive Director: Melissa Russell

Senior Advertising Coordinator: Debbie Sims

IEEE Computer Society Executive Director: Melissa Russell

## **IEEE PUBLISHING OPERATIONS**

Senior Director, Publishing Operations: Dawn Melley Director, Editorial Services: Kevin Lisankie Director, Production Services: Peter M. Tuohy Manager, Journals Production: Katie Sullivan Journals Production Manager: AndreAnna McLean Associate Director, Information Conversion and Editorial Support: Neelam Khinvasara

Publications Staff Editor: Cathy Martin

Publications Operations Project Specialist: Christine

Anthony

Content Quality Assurance Manager: Jennifer Carruth Publications Portfolio Manager: Kimberly Sperka

Publications Portfolio Manager: Kil Publisher: Robin Baldwin

Executive Director: Melissa Russell Senior Advertising Coordinator: Debbie Sims

Cover Design: Janet Dudar

### **COMPUTER SOCIETY OFFICE**

10662 Los Vaqueros Circle, Los Alamitos, CA 90720 USA; +1 (714) 821-8380

### **EDITORIAL BOARD**

Gerard Alberts, University of Amsterdam
Martin Campbell-Kelly, University of Warwick
James W. Cortada, Charles Babbage Institute
Liesbeth de Mol, French National Research Foundation
Peter Denning, Naval Postgraduate School
Stephanie Dick, University of Pennsylvania
Guy Fedorkow, Juniper Networks
David Alan Grier, George Washington University
Thomas Haigh, University of Wisconsin
Ulf Hashagen, Munich Center for the History
of Science and Technology
Chigusa Kita, Kyoto University
Jennifer Light, Massachusetts Institute of Technology

Elizabeth Petrick, Rice University

Mark Priestley, The National Museum of Computing, Bletchley Park, U.K.

Brian Randell, Newcastle University

Sarah Roberts, University of California, Los Angeles Corinna Schlombs, Rochester Institute of Technology Hallam Stevens, Nanyang Technological University Lee Vinsel, Virginia Tech

David Walden, Waterside Publishing

### **CS MAGAZINE OPERATIONS COMMITTEE**

**Diomidis Spinellis (Chair),** Lorena Barba, Irena Bojanova, Shu-Ching Chen, Gerardo Con Diaz, Lizy K. John, Marc Langheinrich, Torsten Möller, Ipek Ozkaya, George Pallis, Sean Peisert, VS Subrahmanian, Jeff Voas

## CS PUBLICATIONS BOARD

M. Brian Blake (VP of Publications), David Ebert, Elena Ferrari, Hui Lei, Timothy Pinkston, Antonio Rubio Sola, Diomidis Spinellis, Tao Xie, Ex officio: Robin Baldwin, Sarah Malik, Melissa Russell, Forrest Shull



IEEE Annals of the History of Computing (ISSN 1058-6180) is published quarterly by the IEEE Computer Society, 10662 Los Vaqueros Circle, Los Alamitos, CA 90720, USA; phone +1 714 821-8380. IEEE Computer Society Headquarters, 1730 Massachusetts Ave. NW, Washington, D.C. 20036, USA; IEEE Headquarters, 345 East 47th St., New York, NY 10017, USA. Subscribe to IEEE Annals by visiting www.computer.org/annals. Postmaster: Send undelivered copies to IEEE

Annals of the History of Computing, IEEE, Membership Processing Dept., 445 Hoes Lane, Piscataway, NJ 08855, USA. Periodicals postage paid at New York, NY, and at additional mailing offices. Canadian GST Registration No. 125634188. Canada Post Publications Mail Agreement Number 0487880. Return undeliverable Canadian addresses to P.O. Box 122, Niagara Falls, ON L2E 668. Printed in the United States. Reuse Rights and Reprint Permissions: Educational or personal use of this material is permitted without fee, provided such use 1) is not made for profit, 2) includes this notice and a full citation to the original work on the first page of the copy, and 3) does not imply IEEE endorsement of any third-party products or services. Authors and their companies are permitted to post the accepted version of IEEE-copyrighted material on their own Web servers without permission, provided that the IEEE copyright notice and a full citation to the original work appear on the first screen of the posted copy. An accepted manuscript is a version that has been revised by the author to incorporate review suggestions, but not the published version with copyediting, proofreading, and formatting added by IEEE. For more information, please go to www.ieee.org/publications\_standards/publications/rights/paperversionpolicy.html. Permission to reprint/republish this material for commercial, advertising, or promotional purposes or for creating new collective works for resale or redistribution must be obtained from IEEE by writing to the IEEE Intellectual Property Rights Office, 445 Hoes Lane, Piscataway

NJ 08854, USA or pubs-permissions@ieee.org. ©2021 IEEE. All rights reserved. Abstracting and Library Use: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy for private use of patrons, provided the per-copy fee indicated in the code at the bottom of the first page is paid through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923, USA. Editorial: Unless otherwise stated, bylined articles, as well as product and service descriptions, reflect the author's or firm's opinion. Inclusion in IEEE Annals of the History of Computing does not necessarily constitute endorsement by the IEEE or the IEEE Computer Society. All submissions are subject to editing for style, clarity, and length. For submissions, go to www.computer.org/annals/write-for-us. IEEE prohibits discrimination, harassment, and bullying. For more information, visit www.ieee.org/about/corporate/governance/p9-26.html.