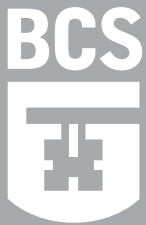


ISSN 0010-4620 (PRINT)
ISSN 1460-2067 (ONLINE)

2009
volume 52
number 4

the Computer *Journal*



Section B

NETWORKS & COMPUTER SYSTEMS



OXFORD JOURNALS
OXFORD UNIVERSITY PRESS

www.comjnl.oxfordjournals.org

the Computer *Journal*

2009

volume 52 number 4

OXFORD

Editor-in-Chief

Prof Erol Gelenbe
Department of Electrical and
Electronic Engineering
Imperial College London
South Kensington Campus
London SW7 2AZ, UK

Previous Editors

H. Gearing, A. McG. Leckie, E. N. Mutch,
P. Hammersley, C. J. van Rijsbergen, F. Murtagh

Editorial Assistant

A. Bentley
email: comjnl.editorialoffice@oxfordjournals.org

Associate Editors

Prof Manfred Broy
The Technical University of Munich, Germany
Software Engineering and Formal Methods
Prof Zvi Kedem
Courant Institute, New York University,
USA Database Systems
Prof Vladimiro Sassone
University of Southampton,
UK Theory of Computation and Formal Methods

Editorial Board

Prof Yu Chee Tseng
National Chiao Tung University, Taiwan
Networks & Wireless Networks

Prof Ethem Alpaydin
Bogaziçi University, Turkey
Machine Learning and its Applications

Prof Alberto Apostolico
Georgia Tech, Atlanta, USA
Algorithms and Computational Complexity

Dr Javier Barria
Electrical and Electronic Engineering Department,
Imperial College, London
Computer Networks and their Performance

Prof Suchi Bhandarkar
University of Georgia, USA
Image Processing/Computer Vision

Prof Martin Campbell-Kelly
University of Warwick, UK
Computer Science History

Prof Ing-Ray Chen
Virginia Polytechnic Institute, USA
Mobile Communications

Dr Ben Goldberg
Courant Institute, New York University, USA
Programming Languages and Compilers

Prof Peter Harrison
Imperial College, UK
Performance Analysis of Systems and Networks

Prof Jane Hillston
University of Edinburgh, UK
Systems Biology, Computer/Network System Performance
Evaluation Methods and Tools

Prof Mark Josephs
London South Bank University, UK
Formal Methods & Concurrency Theories

Dr Taskin Koçak
University of Bristol, UK
Neural Networks

Prof Leonid Libkin
University of Edinburgh, UK
Database Theory

Prof Yannis Manolopoulos
University of Thessaloniki, Greece
Data Mining

Prof Chris Mitchell
Royal Holloway, University of London, UK
Computer Security

Dr Simon Moore
University of Cambridge, UK
Computer Architecture

Prof Maja Pantic
University of Twente, Holland & Imperial College, London
Affective Computing and Machine Analysis of Human Behaviour

Prof Jong Hyuk Park
Kyungnam University, Korea
Computer Security

Prof Peter Robinson
University of Cambridge, UK
Human Computer Interaction

Prof Iain A. Stewart
University of Durham, UK
Algorithms and Complexity

Prof Franco Zambonelli
Università di Modena Reggio Emilia, Italy
Multi-Agent Systems

Book Review Editors
Prof M. Dezani, Prof R. Meo, Prof J. Sproston
University of Torino, Italy

Selection of Best Papers (Wilkes Award)
Dr D. J. Cooke
Loughborough University, UK

Capsule Reviews Editor
Prof Fairouz Kamareddine
Herriott-Watt University, UK

Special Area Editors**Subscription Rates**

A subscription to *The Computer Journal* comprises 8 issues. All prices include postage, and for subscribers outside the UK delivery is by Standard air. *The Computer Journal* Advanced Access contains papers that have been finalized, but have not yet been included within an issue. Advance Access is updated monthly. Annual Subscription Rate (Volume 52, 8 issues, 2009) *Institutional*: Print edition and site-wide online access: £758.00/\$1516.00/€1137.00; Print edition only: £720.00/\$1440.00/€1080.00; Site-wide online access only: £720.00/\$1440.00/€1080.00. *Personal* (print edition and individual online access): £720.00/US\$1440.00/€1080.00. Please note: US\$ rate applies to US & Canada, Euros applies to Europe, UK£ applies to UK and Rest of World.

Reduced rates are available to members of the British Computer Society and all other CEPIS societies. For a complete listing please visit http://www.oxfordjournals.org/our_journals/computer_journal/access_purchase/price_list.html. Reduced rate subscribers should apply to: The British Computer Society, First Floor, Block D, North Star House, North Star Avenue, Swindon, SN2 1FA, UK

Full prepayment, in the correct currency, is required for all orders. Orders are regarded as firm and payments are not refundable. Subscriptions are accepted and entered on a complete volume basis. Claims cannot be considered more than FOUR months after publication or date of order, whichever is later. All subscriptions in Canada are subject to GST. Subscriptions in the EU may be subject to European VAT. If registered, please supply details to avoid unnecessary charges. For subscriptions that include online versions, a proportion of the subscription price may be subject to UK VAT. Personal rate subscriptions are only available if payment is made by personal cheque or credit card and delivery is to a private address. The current year and two previous years' issues are available from Oxford University Press. Previous volumes can be obtained from the Periodicals Service Company, 11 Main Street, Germantown, NY 12526, USA. Email: psc@periodicals.com. Tel: +1 (518) 537 4700. Fax: +1 (518) 537 5899.

CEPIS

The Council of European Professional Informatics Societies has adopted *The Computer Journal* and encourages all member societies to promote it to their membership.

Further information

Journals Customer Service Department, Oxford University Press, Great Clarendon Street, Oxford OX2 6DP, UK. Email: jnl.cust.serv@oxfordjournals.org. Tel (and answerphone outside normal working hours): +44 (0)1865 353907. Fax: +44 (0)1865 353485. **In the US, please contact:** Journals Customer Service Department, Oxford University Press, 2001 Evans Road, Cary, NC 27513, USA. Email: jnlorders@oupjournals.org. Tel (and answerphone outside normal working hours): 800 852 7323 (toll-free in USA/Canada). Fax: 919 677 1714. **In Japan, please contact:** Oxford Journals, Oxford University Press, Tokyo4-5-10-8F Shiba, Minato-ku, Tokyo 108-8386, JAPAN. Email: okudaoup@po.ijnet.or.jp. Tel: +81 3 5444 5858. Fax: +81 3 3454 2929. E-mail: okudaoup@po.ijnet.or.jp

Methods of payment

(i) Cheque (payable to Oxford University Press, to Oxford University Press, Cashiers Office, Great Clarendon Street, Oxford OX2 6DP, UK) in GBE Sterling (drawn on a UK bank), US\$ Dollars (drawn on a US bank), or EU€ Euros. (ii) Bank transfer to Barclays Bank Plc, Oxford Group Office, Oxford (bank sort code 20-65-18) (UK), overseas only Swift code BARC GB 22 (GB£ Sterling to account no. 70299332, IBAN GB89BARC20651870299332; US\$ Dollars to account no. 66014600, IBAN GB27BARC2065186601460; EU€ Euros to account no. 78923655, IBAN GB16BARC2065187892365). (iii) Credit card (Mastercard, Visa, Switch or American Express).

The Computer Journal (ISSN 0010-4620) is published in February, March, April, June, July, August, October and November by Oxford University Press, Oxford, UK. Annual subscription price is £758.00/\$1516.00/€1137.00. *The Computer Journal* is distributed by Mercury International, 365 Blair Road, Avenel, NJ 07001, USA. Periodicals postage paid at Rahway, NJ and at additional entry points. US Postmaster: send address changes to *The Computer Journal*, c/o Mercury International, 365 Blair Road, Avenel, NJ 07001, USA.

Permissions

For information on how to request permissions to reproduce articles/information from this journal, please visit http://www.oxfordjournals.org/access_purchase/rights_permissions.html.

Oxford journals environmental and ethical policies

Oxford Journals is committed to working with the global community to bring the highest quality research to the widest possible audience. Oxford Journals will protect the environment by implementing environmentally friendly policies and practices wherever possible. Please see <http://www.oxfordjournals.org/ethicalpolicies.html> for further information on Oxford Journals' environmental and ethical policies.

Advertising

Advertising, inserts and artwork enquiries should be addressed to Advertising and Special Sales, Oxford Journals, Oxford University Press, Great Clarendon Street, Oxford, OX2 6DP, UK. Tel: +44 (0)1865 354767; Fax +44 (0)1865 353774; E-mail: jnladvertising@oxfordjournals.org.

Disclaimer

Statements of fact and opinion in the articles in *The Computer Journal* are those of the respective authors and contributors and not of *The Computer Journal* or Oxford University Press. Neither Oxford University Press nor *The Computer Journal* make any representation, express or implied, in respect of the accuracy of the material in this journal and cannot accept any legal responsibility or liability for any errors or omissions that may be made. The reader should make his/her own evaluation as to the appropriateness or otherwise of any experimental technique described. © The British Computer Society 2009

All rights reserved; no part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise without prior written permission of the Publishers, or a licence permitting restricted copying issued in the UK by the Copyright Licensing Agency Ltd, 90 Tottenham Court Road, London W1P 9HE, or in the USA by the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923. The issue date is June 2009.