

IEEE

January/February 2016

# micro

*The magazine for chip and silicon systems designers*

# NEAR-DATA PROCESSING



IEEE @ computer society  
CELEBRATING 70 YEARS

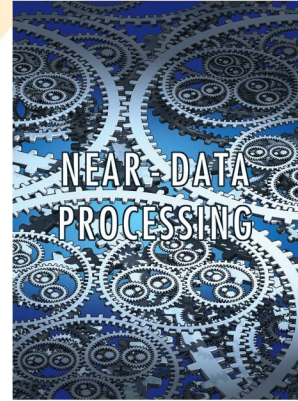
<http://www.computer.org/micro>

January/February 2016

Volume 36 Number 1

## Features

- 4** Guest Editors' Introduction: Near-Data Processing  
*Rajeev Balasubramonian and Boris Grot*
- 14** HAMLLeT Architecture for Parallel Data Reorganization in Memory  
*Berkin Akin, Franz Franchetti, and James C. Hoe*
- 24** Near-DRAM Acceleration with Single-ISA Heterogeneous Processing in Standard Memory Modules  
*Hadi Asghari-Moghaddam, Amin Farmahini-Farahani, Katherine Morrow, Jung Ho Ahn, and Nam Sung Kim*
- 35** Resilient Chip Multiprocessors with Mixed-Grained Reconfigurability  
*Ioannis Sourdis, Danish Anis Khan, Alirad Malek, Stavros Tzilis, Georgios Smaragdos, and Christos Strydis*
- 46** Automated Algorithmic Error Resilience Based on Outlier Detection  
*Amoghavarsha Suresh and John Sartori*



Cover artwork by Giacomo Marchesi  
[www.GiacomoMarchesi.com](http://www.GiacomoMarchesi.com)

## Departments

- 2** From the Editor in Chief  
Lieven Eeckhout  
*Looking Forward to the 2016 Theme Issues*
- 6** Expert Opinion  
Babak Falsafi  
*Near-Memory Data Services*  
Mircea Stan and Kevin Skadron  
*Automata Processing: The Memory Is the Processor!*  
Nuwan Jayasena  
*Overcoming Challenges to Near-Data Processing*  
Yunji Chen and Jinhua Tao  
*Near-Data Processing of Neural Networks*  
Ravi Nair and Jaime Moreno  
*The Active Memory Cube*  
Naveen Muralimanohar  
*In-Situ Computing Through an Analog Dot-Product Engine*  
Karthikeyan Sankaralingam and Cristian Estan  
*Memory Processing Units*
- 60** Awards  
Onur Mutlu and Rich Belgard  
*The 2014 MICRO Test of Time Award Winners: From 1978 to 1992*  
Nick Tredennick  
*Evolution of Microprocessor Logic Design*  
Michael Schlansker  
*Efficient Code Generation Schema for Modulo Loops*

Computer Society Information, p. 1  
Advertising/Product Index, p. 59

## On the Web

[www.computer.org/micro](http://www.computer.org/micro)

For more information on computing topics,  
visit the Computer Society Digital Library at  
[www.computer.org/csdl](http://www.computer.org/csdl).

*IEEE Micro* (ISSN 0272-1732) is published bimonthly by the IEEE Computer Society, IEEE Headquarters, Three Park Ave., 17th Floor, New York, NY 10016-5997; IEEE Computer Society Headquarters, 2001 L St., Ste. 700, Washington, DC 20036; IEEE Computer Society Publications Office, 10662 Los Vaqueros Circle, PO Box 3014, Los Alamitos, CA 90720.

Subscribe to *IEEE Micro* by visiting [www.computer.org/micro](http://www.computer.org/micro).

**Postmaster:** Send address changes and undelivered copies to IEEE, Membership Processing Dept., 445 Hoes Ln., Piscataway, NJ 08855. Periodicals postage is paid at New York, NY, and at additional mailing offices. Canadian GST #125634188. Canada Post Corp. (Canadian distribution) Publications Mail Agreement #40013885. Return undeliverable Canadian addresses to 4960-2 Walker Road; Windsor, ON N9A 6J3. Printed in USA.

**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 which has been revised by the author to incorporate review suggestions, but not the published version with copy-editing, proofreading, and formatting added by IEEE. For more information, please go to [www.ieee.org/publications\\_standards/publications/rights/paperversionpolicy.html](http://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 08854-4141 or [pubs-permissions@ieee.org](mailto:pubs-permissions@ieee.org). Copyright © 2016 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.

**Editorial:** Unless otherwise stated, bylined articles, as well as product and service descriptions, reflect the author's or firm's opinion. Inclusion in *IEEE Micro* does not necessarily constitute an endorsement by IEEE or the Computer Society. All submissions are subject to editing for style, clarity, and space. IEEE prohibits discrimination, harassment, and bullying. For more information, visit [www.ieee.org/web/aboutus/whatis/policies/p9-26.html](http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html).



SUSTAINABLE  
FORESTRY  
INITIATIVE

Certified Sourcing

[www.sfiprogram.org](http://www.sfiprogram.org)  
SFI-01042