

# COMMUNICATIONS

CACM.ACM.ORG OF THE

# ACM

08/2012 VOL.55 NO.8

## Quantum Money



IT and  
Outsourcing  
in North Korea

Cosmic Simulations

The Loss of  
Location Privacy  
in the Cellular Age

OpenFlow: A Radical New  
Idea in Networking

# MATCH YOUR SERVER TO YOUR BUSINESS. ONLY PAY FOR WHAT YOU NEED!



**With a 1&1 Dynamic Cloud Server, you can change your server configuration in real time.**

- Independently configure CPU, RAM, and storage
- Control costs with pay-per-configuration and hourly billing
- Up to 6 Cores, 24 GB RAM, 800 GB storage
- 2000 GB of traffic included free
- Parallels® Plesk Panel 10 for unlimited domains, reseller ready
- Up to 99 virtual machines with different configurations

**1&1 DYNAMIC CLOUD SERVER**

**3 MONTHS  
FREE!\***

Base Configuration, Starting at \$49.99/month



- **NEW:** Monitor and manage your cloud server through 1&1 mobile apps for Android™ and iPhone®.



[www.1and1.com](http://www.1and1.com)



\*Offer valid for a limited time only. 3 months free only applies to \$49.99 base configuration. Set-up fee of \$49.00 applies. Base configuration includes 1 processor core, 1 GB RAM, 100 GB Storage. Other terms and conditions may apply. Visit [www.1and1.com](http://www.1and1.com) for full promotional offer details. Program and pricing specifications and availability subject to change without notice. 1&1 and the 1&1 logo are trademarks of 1&1 Internet, all other trademarks are the property of their respective owners. © 2012 1&1 Internet. All rights reserved.

# Call for Nominations

## The ACM Doctoral Dissertation Competition

### Rules of the Competition

ACM established the Doctoral Dissertation Award program to recognize and encourage superior research and writing by doctoral candidates in computer science and engineering. These awards are presented annually at the ACM Awards Banquet.

### Submissions

Nominations are limited to one per university or college, from any country, unless more than 10 Ph.D.'s are granted in one year, in which case two may be nominated.

### Eligibility

Please see our website for exact eligibility rules. Only English language versions will be accepted. Please send a copy of the thesis in PDF format to [emily.eng@acm.org](mailto:emily.eng@acm.org).

### Sponsorship

Each nomination shall be forwarded by the thesis advisor and must include the endorsement of the department head. A one-page summary of the significance of the dissertation written by the advisor must accompany the transmittal.

### Deadline

Submissions must be received by **October 31, 2012** to qualify for consideration.

### Publication Rights

Each nomination must be accompanied by an assignment to ACM by the author of exclusive publication rights. (Copyright reverts to author if not selected for publication.)

### Publication

Winning dissertations will be published by ACM in the ACM Digital Library.

### Selection Procedure

Dissertations will be reviewed for technical depth and significance of the research contribution, potential impact on theory and practice, and quality of presentation. A committee of individuals serving staggered five-year terms performs an initial screening to generate a short list, followed by an in-depth evaluation to determine the winning dissertation.

The selection committee will select the winning dissertation in early 2013.

### Award

The Doctoral Dissertation Award is accompanied by a prize of \$20,000 and the Honorable Mention Award is accompanied by a prize of \$10,000. Financial sponsorship of the award is provided by Google.

### For Submission Procedure

See <http://awards.acm.org/html/dda.cfm>



## Departments

5 **Letter from the ICPC Executive Director  
Giving Students  
the Competitive Edge**  
*By Bill Poucher*

7 **Letters to the Editor  
Composable Trees  
for Configurable Behavior**

10 **BLOG@CACM  
Machine Learning and Algorithms;  
Agile Development**  
John Langford poses questions about the direction of research for machine learning and algorithms. Ruben Ortega shares lessons about agile development practices like Scrum.

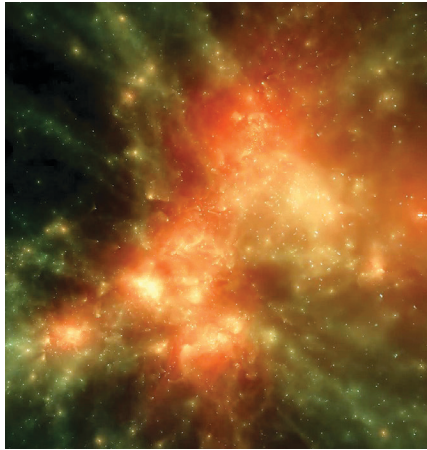
31 **Calendar**

117 **Careers**

## Last Byte

120 **Puzzled  
Find the Magic Set**  
*By Peter Winkler*

## News



13 **Cosmic Simulations**  
With the help of supercomputers, scientists are now able to create models of large-scale astronomical events.  
*By Jeff Kanipe*

16 **DARPA Shredder Challenge Solved**  
The eight-person winning team used original computer algorithms to narrow the search space and then relied on human observation to move the pieces into their final positions.  
*By Tom Geller*

18 **Advertising Gets Personal**  
Online behavioral advertising and sophisticated data aggregation have changed the face of advertising and put privacy in the crosshairs.  
*By Samuel Greengard*

21 **Broader Horizons**  
ACM's Committee for Women in Computing (ACM-W) is widening its reach to involve women in industry as well as academia, including community college faculty and students.  
*By Karen A. Frenkel*

## Viewpoints

22 **Emerging Markets  
Inside the Hermit Kingdom:  
IT and Outsourcing in North Korea**  
A unique perspective on an evolving technology sector.  
*By Paul Tjia*

26 **Education  
Will Massive Open Online  
Courses Change How We Teach?**  
Sharing recent experiences with an online course.  
*By Fred G. Martin*

29 **Privacy and Security  
The Politics of "Real Names"**  
Power, context, and control in networked publics.  
*By danah boyd*

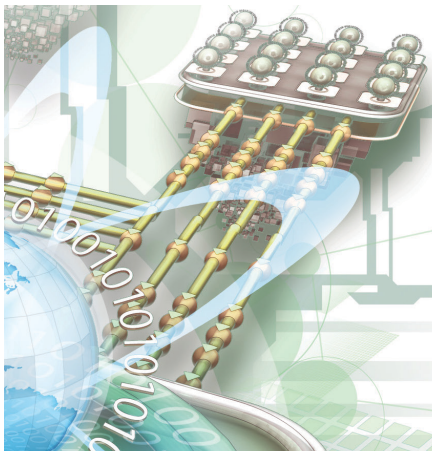
32 **Kode Vicious  
A System Is Not a Product**  
Stopping to smell the code before wasting time reentering configuration data.  
*By George V. Neville-Neil*

34 **Economic and Business Dimensions  
The Internet Is Everywhere,  
but the Payoff Is Not**  
Examining the uneven patterns of Internet economics.  
*By Chris Forman, Avi Goldfarb,  
and Shane Greenstein*

36 **Viewpoint  
Internet Elections:  
Unsafe in Any Home?**  
Experiences with electronic voting suggest elections should not be conducted via the Internet.  
*By Kai A. Olsen and  
Hans Fredrik Nordhaug*

39 **Viewpoint  
The Ethics of Software Engineering  
Should be an Ethics for the Client**  
Viewing software engineering as a communicative art in which client engagement is essential.  
*By Neil McBride*

Practice



- 42 **OpenFlow: A Radical New Idea in Networking**  
An open standard that enables software-defined networking.  
*By Thomas A. Limoncelli*

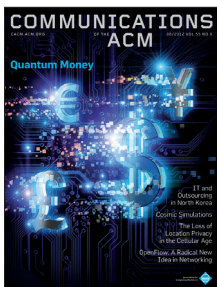
---

- 48 **Extending the Semantics of Scheduling Priorities**  
Increasing parallelism demands new paradigms.  
*By Rafael Vanoni Polanczyk*

---

- 53 **Multitier Programming in Hop**  
A first step toward programming 21<sup>st</sup>-century applications.  
*By Manuel Serrano and Gérard Berry*

**Q** Articles' development led by [acmqueue.queue.acm.org](http://queue.acm.org)



**About the Cover:** Imagine money you can spend without a trace and without the worry of loss or counterfeit. Enter quantum information as the basis for a better kind of money. This month's cover story (p. 84) explores what it would take to realize quantum money. Cover illustration by Spooky Pooka at Début Art.

Contributed Articles



- 60 **The Loss of Location Privacy in the Cellular Age**  
How to have the best of location-based services while avoiding the growing threat to personal privacy.  
*By Stephen B. Wicker*

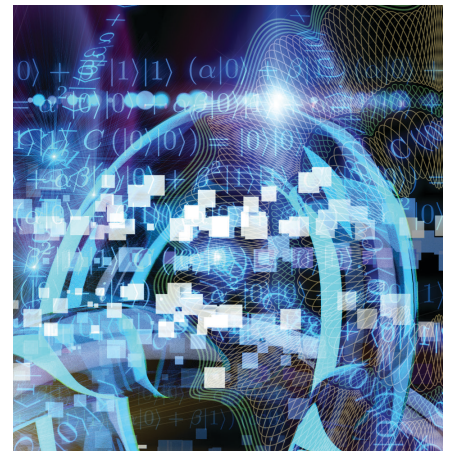
---

- 69 **To Be or Not To Be Cited in Computer Science**  
Traditional bias toward journals in citation databases diminishes the perceived value of conference papers and their authors.  
*By Bjorn De Sutter and Aäron van den Oord*

---

- 76 **Process Mining**  
Using real event data to X-ray business processes helps ensure conformance between design and reality.  
*By Wil van der Aalst*

Review Articles



- 84 **Quantum Money**  
Imagine money you can carry and spend without a trace.  
*By Scott Aaronson, Edward Farhi, David Gosset, Avinatan Hassidim, Jonathan Kelner, and Andrew Lutomirski*

Research Highlights

- 96 **Technical Perspective**  
**Example-Driven Program Synthesis for End-User Programming**  
*By Martin C. Rinard*

---

- 97 **Spreadsheet Data Manipulation Using Examples**  
*By Sumit Gulwani, William R. Harris, and Rishabh Singh*

---

- 106 **Technical Perspective**  
**Proving Programs Continuous**  
*By Andreas Zeller*

---

- 107 **Continuity and Robustness of Programs**  
*By Swarat Chaudhuri, Sumit Gulwani, and Roberto Lubliner*



ACM, the world's largest educational and scientific computing society, delivers resources that advance computing as a science and profession. ACM provides the computing field's premier Digital Library and serves its members and the computing profession with leading-edge publications, conferences, and career resources.

**Executive Director and CEO**

- John White
- Deputy Executive Director and COO**  
Patricia Ryan
- Director, Office of Information Systems**  
Wayne Graves
- Director, Office of Financial Services**  
Russell Harris
- Director, Office of SIG Services**  
Donna Cappo
- Director, Office of Publications**  
Bernard Rous
- Director, Office of Group Publishing**  
Scott E. Delman

**ACM COUNCIL**

- President**  
Vinton G. Cerf
- Vice-President**  
Alexander L. Wolf
- Secretary/Treasurer**  
Vicki L. Hanson
- Past President**  
Alain Chesnais
- Chair, SGB Board**  
Erik Altman
- Co-Chairs, Publications Board**  
Ronald Boisvert and Jack Davidson
- Members-at-Large**  
Eric Allman; Ricardo Baeza-Yates;  
Radia Perlman; Mary Lou Soffa;  
Eugene Spafford
- SGB Council Representatives**  
Brent Hailpern; Joseph Konstan;  
Andrew Sears

**BOARD CHAIRS**

- Education Board**  
Andrew McGettrick
- Practitioners Board**  
Stephen Bourne

**REGIONAL COUNCIL CHAIRS**

- ACM Europe Council**  
Fabrizio Gagliardi
- ACM India Council**  
Anand S. Deshpande, PJ Narayanan
- ACM China Council**  
Jianguang Sun

**PUBLICATIONS BOARD**

- Co-Chairs**  
Ronald F. Boisvert; Jack Davidson
- Board Members**  
Marie-Paule Cani; Nikil Dutt; Carol Hutchins;  
Joseph A. Konstan; Ee-Peng Lim;  
Catherine McGeoch; M. Tamer Ozsu;  
Vincent Shen; Mary Lou Soffa

- ACM U.S. Public Policy Office**  
Cameron Wilson, Director  
1828 L Street, N.W., Suite 800  
Washington, DC 20036 USA  
T (202) 659-9711; F (202) 667-1066

- Computer Science Teachers Association**  
Chris Stephenson,  
Executive Director

# COMMUNICATIONS OF THE ACM

Trusted insights for computing's leading professionals.

*Communications of the ACM* is the leading monthly print and online magazine for the computing and information technology fields. *Communications* is recognized as the most trusted and knowledgeable source of industry information for today's computing professional. *Communications* brings its readership in-depth coverage of emerging areas of computer science, new trends in information technology, and practical applications. Industry leaders use *Communications* as a platform to present and debate various technology implications, public policies, engineering challenges, and market trends. The prestige and unmatched reputation that *Communications of the ACM* enjoys today is built upon a 50-year commitment to high-quality editorial content and a steadfast dedication to advancing the arts, sciences, and applications of information technology.

**STAFF**

**DIRECTOR OF GROUP PUBLISHING**  
Scott E. Delman  
publisher@cacm.acm.org

**Executive Editor**  
Diane Crawford  
**Managing Editor**  
Thomas E. Lambert  
**Senior Editor**  
Andrew Rosenbloom  
**Senior Editor/News**  
Jack Rosenberger  
**Web Editor**  
David Roman  
**Editorial Assistant**  
Zarina Strakhan  
**Rights and Permissions**  
Deborah Cotton

**Art Director**  
Andrij Borys  
**Associate Art Directors**  
Margaret Gray  
Alicia Kubista  
**Assistant Art Directors**  
Mia Angelica Balaquiot  
Brian Greenberg  
**Production Manager**  
Lynn D'Addesio  
**Director of Media Sales**  
Jennifer Ruzicka  
**Public Relations Coordinator**  
Virginia Gold  
**Publications Assistant**  
Emily Williams

**Columnists**  
Alok Aggarwal; Phillip G. Armour;  
Martin Campbell-Kelly;  
Michael Cusumano; Peter J. Denning;  
Shane Greenstein; Mark Guzdial;  
Peter Harsha; Leah Hoffmann;  
Mari Sako; Pamela Samuelson;  
Gene Spafford; Cameron Wilson

**CONTACT POINTS**

**Copyright permission**  
permissions@cacm.acm.org  
**Calendar items**  
calendar@cacm.acm.org  
**Change of address**  
acmhelp@acm.org  
**Letters to the Editor**  
letters@cacm.acm.org

**WEB SITE**  
<http://cacm.acm.org>

**AUTHOR GUIDELINES**  
<http://cacm.acm.org/guidelines>

**ACM ADVERTISING DEPARTMENT**  
2 Penn Plaza, Suite 701, New York, NY  
10121-0701  
T (212) 626-0686  
F (212) 869-0481

**Director of Media Sales**  
Jennifer Ruzicka  
jen.ruzicka@hq.acm.org  
**Media Kit** [acmm mediasales@acm.org](http://acmm mediasales@acm.org)

**Association for Computing Machinery (ACM)**  
2 Penn Plaza, Suite 701  
New York, NY 10121-0701 USA  
T (212) 869-7440; F (212) 869-0481

**EDITORIAL BOARD**

**EDITOR-IN-CHIEF**  
Moshe Y. Vardi  
eic@cacm.acm.org

**NEWS Co-Chairs**  
Marc Najork and Prabhakar Raghavan  
**Board Members**  
Hsiao-Wuen Hon; Mei Kobayashi;  
William Pulleyblank; Rajeev Rastogi;  
Jeannette Wing

**VIEWPOINTS Co-Chairs**  
Susanne E. Hambrusch; John Leslie King;  
J Strother Moore  
**Board Members**  
P. Anandan; William Aspray;  
Stefan Bechtold; Judith Bishop;  
Stuart I. Feldman; Peter Freeman;  
Seymour Goodman; Shane Greenstein;  
Mark Guzdial; Richard Heeks;  
Rachelle Hollander;  
Richard Ladner; Susan Landau;  
Carlos Jose Pereira de Lucena;  
Beng Chin Ooi; Loren Terveen

**PRACTICE Chair**  
Stephen Bourne  
**Board Members**  
Eric Allman; Charles Beeler; Bryan Cantrill;  
Terry Coatta; Stuart Feldman; Benjamin Fried;  
Pat Hanrahan; Marshall Kirk McKusick;  
Erik Meijer; George Neville-Neil;  
Theo Schlossnagle; Jim Waldo  
The Practice section of the CACM  
Editorial Board also serves as  
the Editorial Board of *COMMUNIQUE*.

**CONTRIBUTED ARTICLES**

**Co-Chairs**  
Al Aho and Georg Gottlob  
**Board Members**  
Robert Austin; Yannis Bakos; Elisa Bertino;  
Gilles Brassard; Kim Bruce; Alan Bundy;  
Peter Buneman; Erran Carmel;  
Andrew Chien; Peter Druschel; Blake Ives;  
James Larus; Igor Markov; Gail C. Murphy;  
Shree Nayar; Bernhard Nebel; Lionel M. Ni;  
Sriram Rajamani; Marie-Christine Rousset;  
Avi Rubin; Krishan Sabnani;  
Fred B. Schneider; Abigail Sellen;  
Ron Shamir; Yoav Shoham; Marc Snir;  
Larry Snyder; Manuela Veloso;  
Michael Vitale; Wolfgang Wahlster;  
Hannes Werthner; Andy Chi-Chih Yao

**RESEARCH HIGHLIGHTS**

**Co-Chairs**  
Stuart J. Russell and Gregory Morrisett  
**Board Members**  
Martin Abadi; Sanjeev Arora; Dan Boneh;  
Andrei Broder; Stuart K. Card; Jon Crowcroft;  
Alon Halevy; Monika Henzinger;  
Maurice Herlihy; Norm Jouppi;  
Andrew B. Kahng; Xavier Leroy;  
Mendel Rosenblum; Ronitt Rubinfeld;  
David Salesin; Guy Steele, Jr.; David Wagner;  
Alexander L. Wolf; Margaret H. Wright

**WEB Chair**  
James Landay  
**Board Members**  
Gene Golovchinsky; Marti Hearst;  
Jason I. Hong; Jeff Johnson; Wendy E. Mackay



**ACM Copyright Notice**  
Copyright © 2012 by Association for Computing Machinery, Inc. (ACM). Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and full citation on the first page. Copyright for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, to republish, to post on servers, or to redistribute to lists, requires prior specific permission and/or fee. Request permission to publish from permissions@acm.org or fax (212) 869-0481.

For other copying of articles that carry a code at the bottom of the first or last page or screen display, copying is permitted provided that the per-copy fee indicated in the code is paid through the Copyright Clearance Center; [www.copyright.com](http://www.copyright.com).

**Subscriptions**  
An annual subscription cost is included in ACM member dues of \$99 (\$40 of which is allocated to a subscription to *Communications*); for students, cost is included in \$42 dues (\$20 of which is allocated to a *Communications* subscription). A nonmember annual subscription is \$100.

**ACM Media Advertising Policy**  
*Communications of the ACM* and other ACM Media publications accept advertising in both print and electronic formats. All advertising in ACM Media publications is at the discretion of ACM and is intended to provide financial support for the various activities and services for ACM members. Current Advertising Rates can be found by visiting <http://www.acm-media.org> or by contacting ACM Media Sales at (212) 626-0686.

**Single Copies**  
Single copies of *Communications of the ACM* are available for purchase. Please contact [acmhelp@acm.org](mailto:acmhelp@acm.org).

**COMMUNICATIONS OF THE ACM** (ISSN 0001-0782) is published monthly by ACM Media, 2 Penn Plaza, Suite 701, New York, NY 10121-0701. Periodicals postage paid at New York, NY 10001, and other mailing offices.

**POSTMASTER**  
Please send address changes to *Communications of the ACM*  
2 Penn Plaza, Suite 701  
New York, NY 10121-0701 USA



Association for Computing Machinery



Printed in the U.S.A.

# research highlights

---

P. 96

**Technical  
Perspective  
Example-Driven  
Program Synthesis  
for End-User  
Programming**

By Martin C. Rinard

P. 97

**Spreadsheet Data Manipulation  
Using Examples**

By Sumit Gulwani, William R. Harris, and Rishabh Singh

---

P. 106

**Technical  
Perspective  
Proving Programs  
Continuous**

By Andreas Zeller

P. 107

**Continuity and Robustness  
of Programs**

By Swarat Chaudhuri, Sumit Gulwani, and Roberto Lublineran

---